A GIS-BASED LID FRAMEWORK FOR SUSTAINABLE URBAN RUNOFF MANAGEMENT

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ABSTRACT

Low Impact Development (LID) is one of the most popular sustainable techniques for runoff reduction in urban areas. LID mimics nature by retaining or detaining the runoff at the source. Examples of LID include bioretention cells, green roofs, and porous pavements. While the primary purpose of LID is runoff reduction, several lateral benefits (environmental and socioeconomic) are accrued from LID.

Even though many studies have shown the effectiveness of LID on runoff reduction, investigation around many other aspects of LID has remained limited. Out of all these aspects, there is a significant lack of a systematic decision-making model to rank LID solutions (suggest where to implement LID and what type of LID to use) to maximize the LID benefits. The objective of this dissertation is to develop an innovative simplified geospatial model (referred to as LID-Solution Evaluation and Ranking ApproacH (SERAH)) to rank the LID solutions. SERAH develops a Hydrological-Hydraulic Index (HHI) and integrates it into a Multi Criteria Decision Making (MCDM) model considering the key criteria contributing to the ranking LID solutions.

In this research, the application and effectiveness of SERAH and its corresponding indices were examined under various case scenarios and case studies (e.g., City of Toronto as the study site). Also, SERAH was validated against physical models such as HEC-HMS and PCSWMM. Further, the HHI was used for modelling climate change and urbanization scenarios for three Canadian metropolitans (Toronto, Montreal, and Vancouver).

The results of this study show that, unlike the traditional methods which use stormwater modeling for ranking LID solutions, SERAH effectively ranks LID solutions using geospatial analysis. SERAH and its corresponding indices are universally applicable since they have been deductively developed and like many similar methods are not induced and custom-built around a sample dataset. The results of this research lend themselves to the strategic planning of multifunctional sustainable infrastructures (LID); give a holistic insight about current and future demands for LID; integrate multiple disciplines (socioeconomic, environmental, geography, and hydrology) to find comprehensive sustainable solutions; and suggest a future need for similar multidisciplinary research by highlighting the gaps and limitations.

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ABBREVIATIONS

DEM	Digital Elevation Model
Dr	Depth to restrictive layer
Dg	Depth to groundwater
ENI	Environmental Index
GI	Green Infrastructure
GIS	Geographical Information System
HEC-HMS	Hydrologic Engineering Center- Hydrologic Modelling System
HHI	Hydrologic-Hydraulic Index
HHCI	Hydrologic-Hydraulic Cost Index
HSE	Hydrological-hydraulic Socioeconomic Environmental
IT	Infiltration Trench
K_s	Saturated hydraulic conductivity
LID	Low Impact Development
LIDDI	LID Demand Index
MADM	Multi Attribute Decision Making
MADA	Multi Attribute Decision Analysis
MCDM	Multi Criteria Decision Making
MCDA	Multi Criteria Decision Analysis
MODM	Multi Objective Decision Making
MODA	Multi Objective Decision Analysis
n	Soil porosity
PP	Porous Pavement
R	Rainfall intensity
RG	Rain Garden
S	Slope
SAW	Simple Additive Weighting
SERAH	LID-Solution Evaluation and Ranking ApproacH

SCN	Stormwater Collection Network
SEI	Socio Economic Index
PCSWMM	Personal Computer Stormwater Management Model
t_c	Time of concentration
TSS	Total Suspended Solid
TRCA	Toronto and Region Conservation Authority

CHAPTER 1: INTRODUCTION

1.1. BACKGROUND AND MOTIVATION

Climate change and urbanization are two key drivers increasing the surface runoff and consequently the risk of flood. Urbanization modifies the land terrain and replaces the natural soil and vegetation with impervious surfaces. Both cause a change in the hydrologic behaviour and response of catchments [1]. The extension of the impervious surfaces increases the surface runoff quantity [2]–[5] and deteriorates water quality in receiving water bodies [6], [7]. Urbanization also results in the centralization of assets and population, which aggravates the impact of the flood and causes more severe and costly consequences. It is being more exacerbated due to the historical and projected urban growth trends [8], [9]. In addition, climate change significantly impacts the intensity and frequency of runoff generation and resulting in flood occurrence and is increasing dramatically [9], [10]. As a result, the risk of the future flood (as a leading global concern) is being intensified by climate change and urbanization [9].

Like other natural hazards, floods have detrimental effects on the quality of life causing casualties, financial losses, and deterioration of the ecological system [9]. During two studied decades (1995-2015), floods have caused the loss of 157,000 lives worldwide (about a quarter of all weather-related disasters). It has affected the life quality of 2.3 billion people (the highest share among weather-related disasters with a percentage of 56 %) [11]. During a studied period (2006 to 2016) the global flood losses were approximately 50 billion USD annually (the highest among natural disasters) [12].

In Canada, in 1948, the Fraser River flood (located in British Columbia) cost about 22 million CAD. Two years later in 1950 again Red River flood had a 25 million CAD cost, four years later in 1954 Hurricane Hazel in Ontario cost 25 million CAD. Since then, these costs have consistently grown. From 1948 to 2021, the Federal Government of Canada has expended about 714 million CAD for flood disaster compensation [13]. These are measurable reported losses resulted from floods whereas there are also significant immeasurable hardships such as mental health support or physical needs [14].

Urban sources of runoff alleviate the flood in the downstream receiving water bodies [15]. Urbanization changes the hydrological behaviour of catchments which is caused by several factors [16]. Some of these factors include removal or reduction of the tree and/or shrub canopy and root systems, developing new impervious surfaces, including streets, driveways, roofs, sidewalks, etc., as well as the direct connection of these surfaces to the stormwater systems [16]. Many studies have been focused on investigating the effect of urbanization on increasing the amount of surface runoff (e.g., [2]–[4], [17]) and exploring methods for its mitigation [5] (e.g., [18] [19] [20]).

An innovative solution for reducing the effect of urban surface runoff on the flood is a smart and sustainable urban development approach commonly known as Low Impact Development (LID) [21]–[23]. LID is also known with other terms such as SUDS (Sustainable

Urban Drainage Systems) [24], which is mostly used in the U.K.; WSUD (Water Sensitive Urban Design) [23], which began to be used in the 1990s in Australia [25], and sometimes Green Infrastructure (GI). Among mentioned terms, “LID” is used in this research as it is more common across the world, particularly in North America.

LID is one of the most popular solutions for urban runoff reduction [25]. LID utilizes hydrological approaches to mitigate the surface urban runoff. These approaches include increasing infiltration, maintaining t_c (time of concentration: the time needed for stormwater to flow from the furthest point in a catchment to the hydrological outlet [26]), retention (holding water with no surface release), detention (holding water with slower surface release) [27]. To practice LID, there are two main types of measures, conservation and construction [27]. The conservation measures aim for minimizing urbanization impacts to the extent practicable by conserving natural resources and ecosystems, reducing imperviousness, maintaining natural drainage courses, reducing the use of pipes, minimizing clearing and grading [28]. Construction measures follow the LID goals with the use of engineered structures [28]. Urban infrastructure such as porous pavements, green roofs, rain barrels, and bioretention cells [28] are some examples of these structures.

In addition to the runoff reduction benefit of LID [29], there are several lateral benefits associated with using some types of LID [30]. These lateral benefits-include environmental [29], [31], [32] and socioeconomic [33], [34] benefits. Examples of environmental benefits are preserving the natural hydrological cycle [30] particularly recharging groundwaters [35], reduction in energy demands [36], [37], improving microclimates [38], mitigating urban heat island [39], [40], use of environmental friendly material [41], improved water quality [29], [31], [36], [42]–[46], decreased air pollution [32], [47]–[52] and enhanced biodiversity [32], [53]–[59]. Examples of socioeconomic benefits include access to amenities such as green spaces, easing the imbalance between water supply and demand [30], [41], enhancing health [60]–[62], provisioning services [63], and improving educational results [64]. The types of LID which introduce the most lateral benefits are generally known as Green Infrastructure (GI). Examples of GI include bioretention cells, green roofs, and tree canopy [28], [65].

LID also assists the stormwater collection networks (SCN). SCNs are the conventional approach for managing surface runoff in urban areas. Runoff flows from surfaces into the SCN through inlets and pipelines. SCN rapidly transfers it to lower elevation areas (downstream) to a point of discharge which is typically natural water bodies (e.g., rivers, lakes, or ponds) [66]. SCNs are well-known and well-documented [67] but their evident problems have necessitated a demand for more novel approaches for urban flood management. SCNs are designed for a level of performance and have a maximum capacity. Thus, in the case of extreme rainfalls, the limited capacity of SCNs fails to manage these events. The severity of this problem is increasing due to climate change, urbanization, and the existing SCN ageing and performing at a lower capacity. The use of SCNs is criticized for providing long-term sustainability [68], and for collecting and transferring to water bodies the polluted runoff from surfaces (e.g., car oils from pavements), as well as sanitary sewage in combined sewers [69].

Despite the considerable benefits presented by LID, the progress toward more sustainable urban development using LID has been gradual [29]. Out of all drawbacks, this gradual progress has been due to the uncertainties associated with the unexplored aspects of LID [70]. Some of the common aspects which have been investigated in recent research include: improving the numerical modelling tools to enhance the physical simulation of LID processes [71]; improving the water quality modelling [46]; increasing the complexity of numerical modelling (e.g., 2D water quantity modelling [72]); cost-benefit analysis [73], [74]; designing geospatial planning systems [75], [76], and investigating the effectiveness of LID under climate change [77], and decision support systems that facilitate optimal planning of LIDs incorporating modelling and optimization (e.g. SUSTAIN) [78].

LID is a novel concept and the majority of the focus of the literature has gone toward exploring the “hydrological-hydraulic benefit” of LID through the traditional stormwater modelling approach (e.g., [79]). In these approaches, some combinations of “LID types” (e.g., bioretention cell and green roof) at some “LID sites” (wherein LID will be implemented) are selected as scenarios. The scenarios are simulated using a hydrological model and based on the hydrological performance the best scenario is introduced as the priority “LID solution”. In this traditional trial and error process, the decision of selecting the combinations of “site” and “type” of LID is mainly based on the “intuitive criteria” and constraints of guidelines. This decision is not made through a knowledge-based model that systematically incorporates most of the key contributing criteria (e.g., LID cost, benefit, geospatial constraints). Out of all contributing criteria, lateral benefits of LID have been mainly overlooked in the traditional approaches.

The systematic decision making is conducted through Multi-Attribute Decision Models (MCDM). MCDM is the general class of the decision-making models and is further divided into Multi-Attribute Decision Making (MADM) (also known as Multi Attribute Decision Analysis (MADA)) and Multi-Objective Decision Making (MODM) (also known as Multi Objective Decision Analysis (MODA)). MADM copes with discrete problems whereas MODM focus is on continuous or stochastic problems [80], [81]. MCDM models use decision rules to determine the optimal decision. Decision rules are mathematical algorithms that integrate the criteria in a way that reflects the human decision-making process [81]. Some examples for the MODM models are multi-objectives programming algorithms, Heuristic search/evolutionary/genetic algorithms, and

Goal programming/reference point algorithms. Also, examples of these rules for MADM models are weighted sum, Boolean overlay, Ideal/reference point (TOPSIS, MOLA), Analytical Hierarchy Process (AHP), and Outranking methods (ELECTRE, PROMETHEE). Some intuitive or mathematical constraints can be incorporated into these rules to limit some possible decisions [80]. An example is assigning weights to the objectives which first has been suggested by Zionts and Wallenius (1976) [82].

Likewise, GIS-based multicriteria decision models (GIS-MCDM) have become popular for solving many geospatial decision problems [83]. The coupled capability of GIS and MCDM allows for the integration and processing of geographical data to make systematic judgments [81]. According to a survey (duration of the study was 1990-2004) by Malczewski (2006) [81], the number of studies using GIS-MCDM models for environmental studies has one of the largest shares among all fields of science. According to the same study, the most popular GIS-MCDM integration rule is the weighted sum model which was present in about 40% of studies [81]. Following with the Analytical Hierarchy Process (AHP) (GIS-AHP models) [81] as the second popular model. The popularity of these models is mainly due to their simplicity, being easy to understand, and their capability in reflecting human behaviour in the decision-making process [81]. To decrease the complexity of the decision-making model in this research we selected the weighted sum model in the GIS context to develop a simplified geospatial model to rank LID solutions.

There are previous decision-making models that have been developed to address this issue and vary in many different aspects such as their selected contributing criteria (e.g., LID cost, benefit, geospatial constraints) and decision-making models. However, there is still a remarkable gap for a model that integrates the key criteria in a geospatial context. Wu et al. (2020) has identified such a significant gap for a comprehensive model that ranks LID solutions in a review research [84].

To cope with this, a knowledge-based and systematic model that incorporates multiple geospatial criteria to rank LID solutions (combination of LID type and sites) is required [85]. Such a model needs to account for the key criteria contributing to the rank of LID types and sites to meet the urban runoff management goals. Multi Criteria Decision Making (MCDM) [80] (also known as Multi Criteria Decision Analysis (MCDA) [81]) models are the systematic approach for decision-making where the decision-maker is facing multiple conflicting criteria and objectives [80]. MCDM has gained popularity in real-world decision-making problems where it used to be unknown or perceived as mathematic when it was suggested as a managerial decision-making solution [80].

1.2. RESEARCH OBJECTIVES

Based on the needs and gaps identified in the previous literature, the overall objective of this research has been determined as a GIS-based LID framework for sustainable urban runoff management. This objective was further divided into the following sub-objectives:

1.2.1. Developing a simplified geospatial index for ranking LID sites

The objective is to develop an innovative and simplified geospatial index for ranking "LID sites". The traditional focus on "sites" usually goes toward identifying "feasible sites" (the locations that are suitable for implementing LID). Whether there is a need or "demand" for LID in a site has been less investigated in the previous research [86]. This "demand" is the need for “primary (hydrological)” and “lateral benefits (environmental and socioeconomic)” of LID at each site. The high hydrological demand for LID highlights the potential of sites in runoff generation and the demand for LID at the site for runoff reduction, whereas the high environmental and socioeconomic is the demand of site for such benefits of LID (e.g., decreasing air pollution). Thus, the framework quantifies the demand for hydrological-hydraulic, environmental, and socioeconomic benefits of LID at each LID site and ranks the sites on this basis. The goal is to explore and establish a geospatial relationship between the key contributing criteria and the optimal sites for LID using the physics of runoff generation and MCDM models.

To meet this objective the “hydrological-hydraulic demand” needs to be quantified through developing a heuristic relationship between hydrological-hydraulic contributing criteria (e.g., rainfall, terrain slope, etc.) using geospatial analysis and considering the physical principles governing runoff generation phenomenon. High hydrologic-hydraulic demand at a site is associated with a high potential for runoff generation and high demand for capturing that runoff at the site (source control). Note that proposing such a heuristic relationship helps with highlighting the sites with high potential for runoff generation. Also, it facilitates the incorporation of runoff reduction benefits into lateral benefits of LID. The traditional method for quantifying the demand for LID is using the results of Storm Water Models (SWM), with which the flood-prone areas downstream are highlighted and demand for runoff reduction upstream is reported. Which sites upstream reduce the runoff more effectively and are a priority for implementing LID is a question that is answered in this research.

This priority will be also determined based on the demand for the lateral benefit of LID (“environmental demand” and “socioeconomic demand”). This demand will be quantified by identifying the key criteria and using them as an input of an MCDM model in a geospatial context

(GIS-MCDM model). The demand for lateral benefits of LID will be integrated into the demand for the primary benefit (hydrological-hydraulic demand) using a heuristic relationship. Note that the suggested model addresses the gap of an MCDM model that comprehensively establishes a geospatial relationship among the key contributing criteria; quantifies and integrates these key criteria; and ranks the sites for implementing LID. Such a model goes beyond accruing the primary benefit of LID and aims for implementing multifunctional LID that also maximizes lateral benefits simultaneously.

1.2.2. Applying the proposed index under climate change and urbanization

Using the results of the previous research, this objective investigates how the hydrological-hydraulic demand for LID will change under future scenarios. In this objective, 12 scenarios (combinations of future urbanization and climate change) for three cities in Canada (Toronto, Montreal, and Vancouver), 36 scenarios in all, will be developed. It will answer the question that under unplanned and unsustainable urbanization and future climate, how the demand for LID will change. Also, it will suggest the sole contribution of climate change and urbanization on LID demand. In addition, it will investigate how city characteristics (e.g., rainfall intensity or permeability) impact overall LID demand and modify it. Note that the quantification of LID demand (representing runoff generation potential) using GIS-based analysis, and under future scenarios is novel among similar studies. The results of this part of the dissertation will provide us with a comprehensive insight into the effect of climate and urbanization on the demand for LID. The outcome of the proposed index can be used for stormwater management, urban planning, and the sustainable development of cities. Also, this objective highlights the importance of sustainable development using LID and the future need for such a development.

1.2.3. Developing a simplified geospatial model for ranking LID solutions

This objective is to innovatively rank the LID solutions (combination of LID type and site) based on the site demand and LID benefits (primary and lateral benefit and costs of LID types). The ranking will be through developing a novel simplified geospatial model (referred to as LID-Solution Evaluation and Ranking ApproacH (SERAH)) and using the results of objectives 1.2.1 and 1.2.2. SERAH will integrate key contributing criteria to comprehensively rank LID types as well as LID sites. Ranking LID types and sites enhance the performance of the stormwater network by introducing high rank and effective LID solutions.

To demonstrate the applicability of SERAH for a real set of data, it will be applied in an actual case study for a catchment in the City of Toronto. The prioritized LID solutions will be used to ameliorate the performance of the SCN in the catchment using a stormwater modelling process.

SERAH ranks the LID solutions through geospatial maximization of runoff reduction (primary benefit) integrated into the lateral LID benefits and minimization of cost. Note that the traditional method for ranking LID solutions is based on conventional stormwater modeling which ranks the LID solutions based on their hydrological or water quality performance. In such traditional methods, the solutions are mainly identified using intuitive judgment rather than relying on a systematic approach that quantifies the key contributing criteria and identifies the LID solution. In this objective, a simplified, systematic GIS-MCDM model will be developed. This model relates the demand for LID at each feasible site to the cost and benefit offered by each type of LID to rank LID types at each feasible site and rank feasible LID sites.

1.3. CONTRIBUTIONS

This dissertation will propose a simplified geospatial model for sustainable urban runoff management. The innovation and novel contributions of this research lie in proposing several innovative physics-based GIS-MCDM indices to rank LID sites and LID types. The proposed model integrates key contributing criteria including LID cost, LID benefits (the primary (hydrological-hydraulic) and lateral (environmental and socioeconomic) benefits), LID demand and feasibility of sites. The effectiveness and application of this ranking will be demonstrated by enhancing the performance of a stormwater network.

The objective of this research will be achieved through proposing novel indices (e.g., physics-based index, MCDM-based indices). The indices will establish heuristic geospatial relationships between the key contributing variables to rank LID solutions. The established relationships for the physics-based indices will be validated against physical models. A wide range of climate and urbanization scenarios as new datasets will be studied to demonstrate the applicability of the proposed indices.

1.4. DISSERTATION OUTLINE

This is a paper-based dissertation. Thus, each chapter includes its introduction, literature review, specific objectives, methods, results, and discussion. *Chapter 2* begins with the development of a simplified geospatial index (LID Demand Index (LIDDI)) generated using a systematic framework for ranking sites for LID. Following with an application of LIDDI for the City of Toronto as a case study, and validation of the hydrological-hydraulic component of the framework against a stormwater model are presented. *Chapter 3* further uses the hydrological-hydraulic index (HHI) of Chapters 2 to explore the change in demand for LID under current and future urbanization and climate change scenarios. This demand is quantified, explored, and contrasted for three Canadian cities (Toronto, Montreal, and Vancouver). *Chapter 4* uses the framework used in Chapter 2 to suggest a novel simplified geospatial model (referred to as LID-Solution Evaluation and Ranking ApproacH (SERAH)) to rank the LID solutions (combination of LID type and sites). Using a stormwater model, the applicability of the proposed framework is examined in a catchment within the Don River watershed in the City of Toronto. *Chapter 5* presents information about the input data including the sources and the sensitivity analysis of the input data (parameters and weights). *Chapter 6* summarises the major conclusions from each chapter, discusses the limitation of the developed model, introduces the novel contributions of this dissertation, and recommendations for future research. Following Chapter 6 the *Bibliography* is presented. Then, Appendices include complementary information about the research. Appendices A to C presents the developed codes for Chapters 2 and 4. Following by Appendix D, which includes the proof of the concept tested by generating 100 scenarios for a synthetic catchment. Appendix E presents the code and input data used for the sensitivity analysis of Chapter 5. Lastly Appendix F presents the design parameters of the Chapter 4.

CHAPTER 2: THE LOW IMPACT DEVELOPMENT DEMAND INDEX: A NEW APPROACH TO IDENTIFY LOCATIONS FOR LID

2.1. PREFACE

This Chapter addresses the first sub-objective, which is developing a simplified geospatial index for ranking LID sites (referred to as LID Demand Index (LIDDI)). LIDDI is developed through a systematic framework and applied to the City of Toronto as a case study. The validation of the LIDDI and its sub-indices is discussed and demonstrated in this chapter. Particularly, the hydrological-hydraulic index of LIDDI (referred to as HHI) is compared against a stormwater model and its effectiveness is demonstrated.

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Contributions:

The contributions of authors in the current chapter are as follows, **Sarah Kaykhosravi**: has conducted the literature review, performed the data collection and curation, developed the method, used the required software to perform the analysis and modelling, validated and visualized the results, and wrote the original manuscript of this publication. **Karen Abogadil** has contributed to the literature review, writing, reviewing, and editing the original draft. **Usman Khan** has supervised the research, provided the funding, contributed to the development of the method, writing, and editing the manuscript. **Mojgan A. Jadidi** has supervised the research, provided the funding, contributed to the development of the method, writing, and editing the manuscript.

2.2. ABSTRACT

The primary goal of Low Impact Development (LID) is to capture urban stormwater runoff; however, multiple indirect benefits (environmental and socioeconomic benefits) also exist (e.g., improvements to human health, and decreased air pollution). Identifying sites with the highest demand or need for LID ensures the maximization of all benefits. This is a spatial decision-making problem that has not been widely addressed in the literature and is the focus of this research. Previous research has focused on finding feasible site for installing LID, whilst only considering insufficient criteria which represent benefits of LID (either neglecting hydrological-

hydraulic benefit or indirect benefits). This research considers the hydrological, environmental and socioeconomic benefits of LID to identify sites with the highest demand for LID. Specifically, a geospatial framework is proposed that uses publicly available data, hydrological-hydraulic principles, and a Simple Additive Weighting (SAW) method within a hierarchical decision-making model. Three indices were developed to determine the LID demand: (1) hydrological and hydraulic index (HHI), (2) socioeconomic index (SEI), and (3) environmental index (ENI). The HHI was developed based on a heuristic model using hydrological-hydraulic principles and validated against the results of a physical model (HEC-HMS). The other two indices were generated using the SAW hierarchical model and then incorporated into the HHI index to generate the LID demand index (LIDDI). The framework was applied to the City of Toronto, yielding results that are validated against historical flooding records.

2.3. INTRODUCTION

Increased urbanization has led to a significant increase of impervious surfaces. This has led to higher levels of stormwater runoff, resulting in higher flood risk, overflowing sewer systems, and damage to existing stormwater infrastructure [87]. This situation is made worse by the impacts of climate change, causing more intense rainfall events and droughts, which threaten urban water security. Social implications suggest that these risks will disproportionately affect more vulnerable populations [88].

Low Impact Development (LID) has became one of the most popular methods for managing stormwater and mitigating floods [25], [89]. Examples of LID include bioretention cells, green roofs, detention tanks, and permeable pavement systems [28], [44], [65], [90]–[92]. From a water and stormwater management perspective the main purpose of most types of LID is runoff mitigation [21], [25], [29], [57], [93], [94] multiple environmental and socioeconomic benefits of LID also exist [30]. Additional environmental benefits include improved water quality [29], [31], [42]–[45], decreased air pollution [32], [47]–[51], and enhanced biodiversity [32], [53]–[59]. Socioeconomic benefits [33], [34] include provisioning services [63], educational improvements [64], enhanced immune functioning [60]–[62] and aesthetics. Not all types of LID provide all additional benefits. The types which provide these additional benefits are generally known as Green Infrastructure (GI). Examples of GI include bioretention cells, green roofs, and tree canopy [28], [44], [65], [90]–[92]. Whereas other types of LID such as cisterns (or underground tanks) mostly provide hydrological (flood control and rainwater harvesting) benefits. Despite the fact that LID such as cisterns provide less environmental or socioeconomic benefits (compared with GI) and have maintenance issues [95] their high efficiency in runoff management preserves it as one of the LID types [96], [97].

During the strategic planning stage of stormwater or flood management projects, decision-makers select sites for LID under limited financial resources [98]. Since LID benefits are spatially dependent, maximizing these benefits requires careful planning when selecting sites for LID implementation [86], [99]. This can be done through the use of geospatial data such as topography, precipitation, land cover, and multiple physical phenomena (e.g., hydrological and hydraulic processes). Without a systematic geospatial framework, selecting sites that can maximize the benefits of LID (need or demand for LID) becomes difficult. Indeed, in a comprehensive review of spatial allocation of LID, Kuller et al. (2017) [100] determined that the lack of such a geospatial framework is one of the biggest gaps in this field.

2.3.1. Existing Geospatial Decision Models

Determining sites for LID has two sides of suitability: f*easibility*: referred to as LID needs site to be implemented, and d*emand*: referred to as a site wherein the needs or demands for benefits of LID is high [86], [100]. In the literature, three types of LID geospatial decision-making models exist. The first prioritizes different hydraulic solution scenarios using stormwater models, which allows for modelling LID [101]. The second conducts geospatial analysis using geographical information systems (GIS). The third combines the use of both stormwater models and GIS.

The first type of decision-making models use stormwater modeling along with a multi-criteria decision analysis (MCDA), or multi-attribute decision-making (MADM) [102]. In these type of models MCDM or MADM are used to rank LID solutions in predetermined locations e.g. [103]–[107]. In these types of studies, the method for determining which LID sites or types are more effective to include are based solely on the results of the stormwater model and are not through geospatial analysis (e.g. Lee et al. (2012) [78] used a stormwater modeling to determine the best GI solution).

Models that conduct geospatial analysis through GIS have mostly focused on determining feasible sites, and outputting maps for each type of LID. The criteria used to determine feasibility are often based on specific technical guidelines (e.g., suitable slope or distance to existing infrastructure), and rarely concentrate on maximizing LID benefits (an example of this type of study is [108]). Another study by Kuller et al. (2019) [86] proposes a decision-making framework to determine the feasibility and demand for LID. For the demand, which is the focus of our research, they selected five criteria which were grouped in three categories, including: provisioning (proximity to water demand), regulating (heat vulnerability, connected impervious area, floods), and cultural (visibility). However, their selected criteria for determining demand do not account for the hydrological-hydraulic demand for LID nor is this demand integrated with the other benefits (i.e., provisioning, regulating, and cultural) of LID. Thus, there is an opportunity to expand on a previously proposed framework (such as [46] or others highlighted below) to incorporate a physically based approach to capture the impacts of the hydrological-hydraulic demand of LID.

The third type of decision-making model combines both GIS and SWM. Models of this type identify sites based on feasibility and prioritize them according to either a specified decision-making system (MCDA model) or discrete prioritization (MADA model); the former may include geospatial analysis while the latter typically does not. Examples of criteria that have been used include slope, water table, hydrological soil group, and runoff volume [109]. Others also consider stakeholder opinion and technical experts [107]. For example, one study, [110], did consider three classes of benefits of LID (the environmental, economic and social benefits), though these were done independently (i.e., in isolation of each other) rather than using a holistic approach. With these three different classes of decision-making criteria, identical rankings of the sites were obtained [110]. Thus, as concluded by Kuller et al. (2017) [100], although a set of GIS-MCDA tools and frameworks have been developed, none of them are sufficient and comprehensive. In addition, in another review by Lerer et al. (2015) [111], they concluded that there is a lack for a comprehensive model that covers all physical-based aspects (referred to as “How Much models”), human aspects (referred to as “Where and Which” models).

2.3.2. Geospatial Physical-Based Framework

Among previous studies in this field the strategical allocation of LID and prioritizing sites on this basis, particularly through considering hydrological and hydraulic parameters is less frequently addressed. Of those that have addressed it, there remains multiple limitations that have significant environmental and socioeconomic impacts. One recent study by Martin-Miklea et al. [112] used the concept of hydrologically sensitive areas (HSA) [60]. Since HSA was originally used for pollution transport risk [113], the HSA procedure and the criteria used do not match the physical processes that occur in LID. For example, in their study [112], the slope is considered to have an inverse impact on the priority of a site in terms of need for LID. Meaning that sites with higher slope has lower priority for installing LID (in their study includes rain-barrel, green roof, porous pavement, rain garden, vegetated swale, detention and retention pond, and riparian buffer). This is incorrect from a hydrological perspective. Sites with high slope generate lower time of concentration (t_c). Most LID types (such as grass swales) can be used to increase the t_c (and hence reduce runoff related issues). Though types of LID without out flow do not affect the t_c (e.g., drainage boxes), still capturing the runoff of a high slope site prevents joining a runoff with low t_c to the downstream runoff. Thus, steep sloped sites should have high priority (or high demand) for implementing LID for runoff management. Also, the method proposed by Martin-Miklea et al. [112] does not consider the geospatial or temporal distribution of rainfall. In hydrological models the importance of spatial and temporal distribution of rainfall is noted by many researchers [114]. There are several studies (such as [115]) that present different methods for accurate modelling of rainfall distribution over watersheds. Thus, including the spatial rainfall distribution over the study area, particularly large-scale ones, is necessary. In addition, the geospatial distribution of land cover and impervious area were also neglected in the Martin-Miklea et al. study [112] - in urban areas a significant portion of the natural land-cover is modified. This modification of the land-cover is important to be considered if the study area is under the influence of human activities and has experienced land-cover changes. Moreover, Martin-Miklea et al. [112] approach has multiple mathematical limitations. For example, in their study to avoid mathematical errors, sites where the hydraulic conductivity is zero, the calculated index has been reassigned somewhat arbitrarily to -3. This value of -3 is a number that is lower than the highest calculated index in the case study. Therefore, this number is a replacement for the actual calculations and depends on the case study and needs justification for each specific case. Finally, in the Martin-Miklea et al. [112] study, only the hydrological-hydraulic demand or need for LID is considered, whilst the environmental and socioeconomic benefits are largely ignored.

Overall, as demonstrated in previous studies, the strategic planning stage of LID projects significantly lack a comprehensive GIS-MCDA framework to determine where to install LID [100] based on the “demand” or “need” – including hydrological-hydraulic demand, and demand due to other indirect benefits. In previous studies, prioritizing sites based on their potential to generate stormwater runoff is one of the least addressed subjects. In addition, prior studies either overlook integrated hydrological-hydraulic benefit with other indirect benefits of LID (including socioeconomic or environmental status [116], use inadequate type and number of assessment criteria [86] (e.g. either hydrological- hydraulic benefit or indirect benefits of LID are overlooked). Also, many of previous studies are based on a stormwater models model. In these types of studies, the scale of the study area is limited to the stormwater models itself, which limits the extent of the study area. This restriction is due to the complexity (in terms of required input data) of developing SWMs for large-scale regions. Thus, as recommended by other studies such as [29], [111], [117],

[118], more investigation to address the indirect benefits of LID should be integrated into GIS-MCDA models for LID to identify the demand for LID that can include future climate, land-use and socioeconomic scenarios.

Therefore, the objective of our study was to develop a physical-based geospatial decision-making framework to answer the need for the strategical planning of the LID, through identifying the *demand* of sites for LID. This *demand* is comprehensively evaluated in our framework by integrating all main and indirect benefits of LID. In our framework we developed two heuristic geospatial relationships to incorporate all benefits of LID. The first heuristic relationship is based on hydrological- hydraulic principles (building on Martin-Miklea et al. (2015) [112] approach) and uses actual values of data in the overlaying process (data are not rescaled). As it represents the physical processes that occur within LID, we validated its results against a physical-based model. Using this relationship, we generated an index (HHI), which ranks the sites based on their potential in runoff generation. Also, using a GIS-MCDA model we developed two other indices (ENI and SEI) to rank the sites based on their *demand* for indirect benefits of LID. From the stormwater management perspective, we considered the runoff control as the direct benefit of LID. Thus, through an innovative heuristic relationship, the indirect benefits of LID (environmental and socioeconomic) are incorporated into the proposed framework as additive value. Meaning that if HHI is not zero (there is a hydrological- hydraulic demand) the indirect benefit adds a value to HHI value to estimate the demand for LID holistically. But, if HHI (direct benefit) is zero, even though indirect benefits are not zero, the demands for LID are estimated equal to zero.

In our proposed framework there is no mathematical limitations, and actual values of all parameters can be used as inputs. Finally, unlike models relying on the SWM, the proposed framework has no limits on the scale of the study area, since the number of input data is independent from the scale of the area, and thus, the only cost is the computational time, which can increase based on the size of the area.

This paper is organized as follows: Section 2.4 presents the materials and methods including the case study, geospatial data, and the development of three new indices: the Hydraulic-Hydrologic Index (HHI), the Environmental Index (ENI), and the Socioeconomic Index (SEI), an approach to combine these indices into the proposed LID Demand Index (LIDDI). Section 2.5 includes the results and discussion including the generation of the HHI, ENI, and SEI maps for the case study and their validation as well as LIDDI map. Section 2.6 follows with conclusion.

2.4. MATERIALS AND METHODS

To address the inadequacies of existing approaches for the spatial allocation of LID, a geospatial physical-based framework is proposed which is then combined with a multi-criteria decision-making model. This framework was developed to identify sites with the greatest *demand* or *need* for LID, and to maximize both the direct and indirect benefits of LID.

To do this, three indices were developed to consider the direct (stormwater runoff reduction) and indirect (environmental and socioeconomic) benefits of LID. The first index, HHI was developed based on the physical principles governing stormwater runoff. HHI ranks the sites based on their potential for runoff generation. The second and third indices are ENI and SEI, respectively, which were generated using a SAW method within a hierarchical decision- making model. ENI and SEI identify sites with the highest demand of LID in terms of environmental and socioeconomic needs. Combining these three indices, the LID Demand Index (LIDDI) is then produced. The LIDDI ranks all sites within the study area based on their demand or need for LID based on all hydraulic-hydrological, environmental, and socioeconomic benefits.

The conceptual framework of the method described above is presented in Figure 2.1. In this figure, the *variables* represent the physical-based parameters (for HHI) and geospatial criteria or indicators (for ENI and SEI). These variables, the secondary and primary indices are described in detail in the following sections.

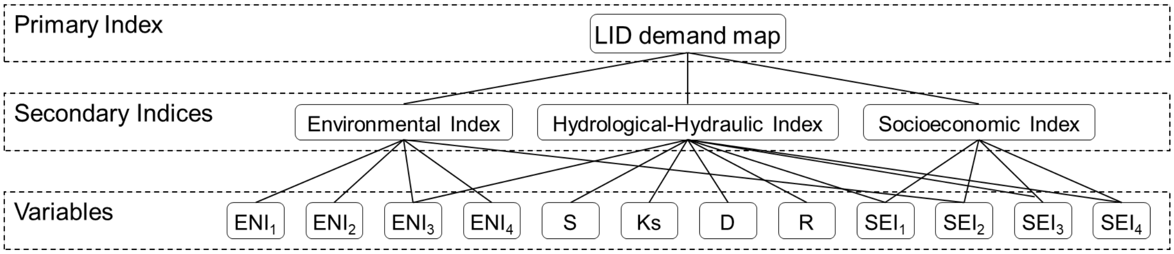


Figure 2.1 The schematic of the conceptual framework of LIDDI generation, where S is the slope (degree), K_s is saturated hydraulic conductivity (mm/hr), D is depth to restrictive layer (mm), and R is rainfall intensity mm/hr)

2.4.1. Study area

The utility of the proposed framework is demonstrated through case study: the study area used for this research is the City of Toronto which is located in Southern Ontario, Canada and covers an area of 630.2 km^2 with a population of approximately 2.73 million. The land-use varies from residential, commercial, and industrial to green spaces. Eleven major rivers pass through the city, dividing the city into eleven watersheds. Figure 2.2 presents the watersheds and their intersection with the administrative border of the City of Toronto. The use of LID has been growing in Toronto over the last several years [119]. Toronto is experiencing a transition period from grey (end of pipe methods) to green (using LID) infrastructure. This is done through developing and implementing a range of policy instruments, by-laws, and regulations, which include developing and re-designing existing policies associated with land-use, environmental, water, infrastructure, and planning [94]. Some examples include the Green Roof By-law and Downspout Disconnection By-law [94].

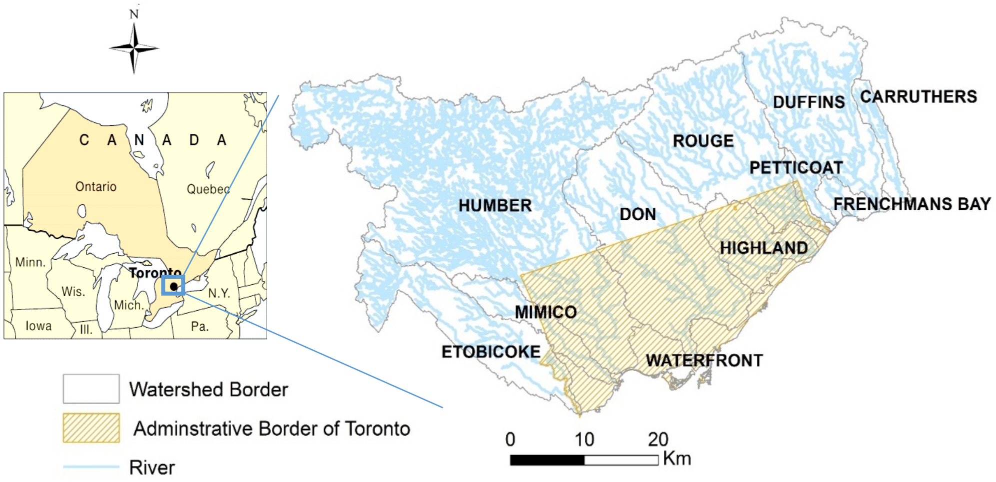


Figure 2.2 The extent of the study area (hatched in orange colour), which is the administrative boundary of the City of Toronto and its intersection with the eleven watersheds in Toronto

2.4.2. Geospatial data

In this study, data from open, publicly available sources were used and is listed in Table 2.1. This geospatial data was used to derive each of the parameters used for three indices; the rationale for selecting each data is discussed in detail below for each index. Each dataset was converted into raster format with a ground resolution of 5 m x 5 m (to align with the digital elevation model, DEM, resolution which was used as the reference resolution for this research). The framework was developed and implemented in ArcGIS.

The proposed framework, and specifically the application presented in this research, is restricted by the resolution of available data. Here, a raster resolution of 5 m x 5 m was used due to the available DEM data. Higher or lower resolutions can be chosen, however this should be done with intent, as it can impact the accuracy and reliability of the results.

Table 2.1 The raw data downloaded from publicly available sources, including the structure/geometry of the data, and the source of the data.

ID	Data	Data structure/geometry	Data Source
1	Air pollution (TPM2.5)	Vector/point	Ministry of Environment, Conservation and Parks
2	Bedrock layer	Vector/polygon	Ministry of Northern Development and Mines
3	Census tract boundaries 2016	Vector/polygon	Statistics Canada
4	Demographics data - Census 2016	Tabular data	Statistics Canada
5	Digital elevation model (DEM)	Raster/5 mx 5 m	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit
6	Ecozones of Ontario	Vector/polygon	Scholars Geoportal
7	Groundwater table	Vector/point	Groundwater Information Network (GIN)
8	Land cover	Raster/0.6 m x 0.6 m	City of Toronto
9	Toronto rivers	Vector/polyline	Toronto and Region Conservation Authority (TRCA)
10	Surficial geology and saturated hydraulic conductivity (K_s)	Vector/polygon	Government of Canada open data website
11	Toronto precipitation data	Vector/point	Government of Canada open data website
12	Educational institute	Vector/point	City of Toronto
13	Hospital	Vector/point	Google Earth

Note: Missing data were ignored in the calculations.

2.4.3. Hydrological-hydraulic index (HHI) development

HHI ranks the cells (i.e., the pixels of the raster data) by their runoff or flood generation potential. Cells with higher HHI generate higher volume and peak runoff flow rate (referred to as High Runoff Cells). These cells should be the first target for implementing LID. However, wherein it is not feasible to implement LID, next target should be selected based on several parameters including the topography of the catchment amongst other parameters [104]. The selection of the *feasible* sites is out of scope of this research and requires another investigation which incorporates results of this study (*demand*) to the feasibility.

To generate HHI, the geospatial variables that are representative of the runoff hydrograph were identified and quantified. Then, a geospatial overlaying heuristic relationship (Eq. 2.1) was developed according to the physical principles. The variables were then spatially overlaid based on the proposed relationship (Eq. 2.1).

To identify the variables, the runoff generation process, and the associated relationships (mathematical equations) were considered. Four variables were identified and quantified for HHI: rainfall intensity (R), hydraulic conductivity (Ks), water storage capacity of soil (D), and catchment slope (S).

Runoff is dependent on rainfall and infiltration. Rainfall intensity, denoted by R and measured in mm/hr, is especially important in large scale study areas where uneven spatial distribution of rainfall can be an important factor. By a simplification assumption we neglected the temporal distribution of R, and it was considered as constant. The value of R is obtained from the intensity-duration-frequency (IDF) curve for the City of Toronto and represents the extreme rainfall event. For this research, the intensity of the 100-yr 5-minute duration event was selected as R to represent extreme events. This rainfall is a sample of a low probability and intense rainfall event, though any other R value may be used since the focus is on the difference of R across the study area (rather than the magnitude itself).

Infiltration is a function of the soil moisture, porosity, hydraulic conductivity and water storage capacity of the soil. The Green-Ampt equation [120] demonstrates that if the antecedent soil moisture is saturated, the infiltration rate is equal to the saturated hydraulic conductivity (K_s). This allows to estimate the infiltration rate using K_s data: cells with higher K_s values have higher infiltration rates, and consequently, generate less runoff. Note that urban areas contain significant impervious surfaces whose K_s is essentially zero, resulting in an infiltration rate that is also zero. Thus, the land-use data (specifically the impervious surface layer) was combined with the K_s of surficial geology data using the minimum geospatial operation tool in ArcGIS. With the minimum operation, in each cell the K_s of impervious surfaces (assumed to be 0 mm/hr) and the K_s of the surficial geology layer (which is greater than or equal to 0 mm/hr) is compared and the lower value is assigned to each cell. In addition, streams, rivers and other waterbodies within the study area were excluded from K_s layer and potential LID sites. Through geospatial subtraction operation, K_s values were subtracted from the rainfall intensity, R, resulting in an indicator for the runoff generation potential for each cell.

Infiltration volume is also dependent on the water storage capacity of the soil, which is further dependent on soil characteristics (e.g., soil porosity and moisture) and the thickness of the soil layers. Capacity, denoted by D, is quantified through three variables: the depth to groundwater table (D_g) and the depth to the first impermeable soil layer (bedrock) (D_r), and the soil porosity (n). The value of D takes the minimum of either D_g or D_r and represents the distance between the soil surface and the first restrictive layer. Capacity is then multiplied by the soil porosity, n, which quantifies the porous storage volume in the vertical direction. The calculated volume allows for additional quantification of runoff generation potential that considers both the infiltration rate and the water storage capacity. For instance, a cell with a high infiltration rate can be restricted by an impermeable soil layer, resulting in decreased infiltration.

The time of concentration (t_c) is another contributing variable to runoff generation; LID can be used to increase t_c in urban areas to reduce damage resulting from stormwater runoff. Two cells with the same values of K_s, R and D can generate the same runoff volume, however, the t_c

may be different. Using Kirpich's formula [121] t_c can be estimated using the catchment length and slope (S). When using cells with equal areas, the t_c is non-linear exponential function of the slope to the power of 0.385. To represent this nonlinear relationship of t_c and S, we generated the slope layer from the DEM data in ArcGIS and estimated the $S^{0.385}$ value using for each 5 x 5 m cell.

By identifying the contributing variables (R, K_s, D, and S), we developed a heuristic relationship (Eq. 2.1) to geospatially overlay the runoff contributing variables. Our relationship is developed based on the theoretical concepts of runoff generation. The validation of the relationship is presented in Section 2.5.4.Using this relationship, a value for each cell is calculated based on the potential of cells to generate runoff. The cells within the study area can then be compared in terms of their need or demand for LID. Cells with higher HHI have higher demand for LID; installing LID in a cell with a higher HHI captures more runoff or prevents the generation of runoff at that site, and attenuates t_c:

$$\mathrm{HHI_j} = \begin{cases} \left[\mathrm{R_j} - \left((\mathrm{K}_s)_\mathrm{j} \cap (\mathrm{K}_i)_\mathrm{j}\right) \cap \left(\mathrm{n_j} \times \left((\mathrm{D}_g)_\mathrm{j} \cap (\mathrm{D}_r)_\mathrm{j}\right)\right)\right] \times [1 + (\tan S)^{0.385}] & \text{for} \quad \mathrm{R_j} > \mathrm{Ks_j} \\ 0 & \text{for} \quad \mathrm{R_j} \leq \mathrm{Ks_j} \end{cases} \qquad \text{(Eq. 2.1)}$$

where j is the cell number, HHI_j is the HHI at cell j, R_j is rainfall intensity (mm/hr) at cell j, and $(K_s)_j$ is saturated hydraulic conductivity of surficial geology layer (mm/hr) at cell j, $(K_i)_j$ is the hydraulic conductivity of impervious areas (e.g. roads, parking lots and building roof tops) at cell j, set equal to zero for impervious cells, n_j is the soil porosity at cell j, $(D_g)_j$, $(D_r)_j$ are respectively, depth to groundwater (mm) and depth to the first restrictive soil layer (mm) at cell j, and S is the terrain slope (degrees) at cell j. Note that since physics-based variables were used to formulate this heuristic relationship, dimensional consistency was ensured for all parameters considered. Also, in the lack of soil data still can be used. Whereas the data for K_s and D does not exist, there are two ways of using the relationship. Either K_s and D can be assumed based on known characteristics of the study area or assuming the worst-case scenario which is value of zero for these parameters (K_s= 0 and D=0).

To generate the HHI map for the City of Toronto, the four variables in Eq. 2.1 (R, K_s, D, and S) were generated from the available raw data (Table 2.1) and converted to raster layers. Rainfall intensity, R, was derived from the IDF tables of three meteorological stations within the City of Toronto: Oshawa, Oakville Southeast, and Toronto Buttonville. The raster rainfall data for the study area were generated by geospatial interpolation using the point data from the three meteorological stations. The hydraulic conductivity, K_s, was derived from the surficial geology and land cover data as explained above (Table 2.1). To generate rainfall storage capacity of the soil (D), D_g was generated using groundwater level data of wells (in point data format). Using the geospatial interpolation within the study area and groundwater level data from the wells, the raster data layer of D_g was produced. D_r was generated from the bedrock data (in polygon data format). Using these two variables and a minimum geospatial operation tool in ArcGIS, the raster map of D was generated. The soil porosity (n) was assumed to be 0.5 for the entire study area due to the lack of available porosity data. According to Chow et al. [122], this is an average estimate of porosity for different soil types (sand, loam, silt, and clay). Terrain slope (S) was derived from DEM data using the slope tool in ArcGIS. In addition to these variables, a data layer consisting of the existing LID (using only existing tree canopy was considered which was derived from the land-cover data) was also generated in order to eliminate these sites as potential sites for implementing LID. Due to the lack of data of actual LID currently installed within the study area, other types of

LID such as green roofs, raingardens, etc. are neglected in this study. Due to this, the existing LID facilities are still considered as potential LID sites; however, if this data were available existing LID sites may be eliminated from the analysis if required.

2.4.4. Environmental index (ENI) development

The ENI quantifies the relative demand of cells for LID (specially GI) in terms of environmental needs. ENI is associated with mitigating or preventing environmental damage that result from anthropogenic sources such as urbanization. The environmental criteria were selected based on the DPSIR (Drivers, Pressures, State, Impact and Response) model developed by the European Environment Agency [123]. Based on DPSIR, urbanization is the "driving force" causes "pressures" that include pollution, and changes in land-use and habitat population. These "pressures" cause changes to the "state" of the environment (air quality, biodiversity, water quality and soil quality). These changes lead to negative "impacts" on public health and ecosystems, which can elicit a positive or negative response feeding back into the "driving forces" (or to the "impacts" and "states" directly). GI are considered as a "response" model of intervention to these "impacts"; other "responses" such as environmental laws can also be applied. The criteria for ENI represent the environmental "states"; the four sample environmental states used for this research are: air quality, bio-habitat, water quality, and soil quality. Specifically, the criteria include air pollution denoted by ENI_1, biodiversity denoted by ENI_2, water quality denoted by ENI_3, and soil contamination denoted by ENI_4 all of which are caused by urbanization and for which GI can be used as response to mitigate the impacts.

Higher ENI_1 values were assigned to sites with higher concentration of air pollution, as they were considered to receive the greatest benefit from the GI in terms of air quality [32], [47]–[49]. In particular, LID (planted-based types) reduces the concentrations of a variety of air pollutants that are known to increase health risks, such as PM2.5 [124], [125]. In the proposed framework, PM2.5 concentration was chosen as the indicator of overall air pollution, as is often done in the literature.

Higher ENI_2 values were assigned to sites with higher biodiversity to ensure the existing bio-habitats are maintained. GI provides potential bio-habitat and consequently prevents the impact of urbanization on existing habitats [32], [53]–[59]. For example, previous studies have shown that green roofs can host diverse plants and animals, as well as function as stepping stones to other nearby habitats, particularly for immobile organisms [126]. In another study, this effect is highlighted when a 41 % increase in forest coverage led to an increase of 81 bird species – highlighting that tree-based LID or GI may have a positive impact on bird species [127]. Thus, the ecozones of Ontario (collected from the Scholars Geoportal website, http://geo2.scholarsportal.info) was used an indicator of the biodiversity within the study region.

GI are intended to capture and treat stormwater at the source (often referred to as "source control"). In doing so, GI can effectively capture contaminants (e.g., sediment which themselves contain other chemicals such as metals) [36]. Previous research has shown that GI such as bioretention cells can treat stormwater through physical, chemical and biological processes. Specifically, they provide filtration, sedimentation, adsorption as well as plant and microbial uptake [128]. Through these processes, pollutant concentrations of metals (zinc and copper), total suspended solids, total phosphorus, and total nitrogen have been reduced by more than 90% [128]–[130]. Capturing these contaminants at the source (i.e. upstream of the drainage point or outlets to rivers) prevents the contaminants from flowing downstream and also reduces the spread of contaminants within the watershed [131]–[133]. Thus, for this research, higher ENI_3 values were assigned to sites farthest from rivers as an indicator of "source control" to improve water quality in the rivers. Areas closer to the rivers were given lower priority (lower ENI_3), whereas areas farther upstream were given higher priority in terms of LID (specially GI) need or demand.

Sites with GI installed maintain neutral pH, increased metal retention, and reduced risk of diffusion, all of which are attributed to the enhancement of biochemical processes in the soil by GI [43], [134]–[136]. To prevent the contamination of soil, stormwater runoff and sites closest to pavements were assigned higher ENI_4 values (and thus higher priority). Roads and parking lots were considered to be the sources of the soil contamination yielding high concentrations of pollutants such as zinc, copper, lead and cadmium, most often found at inflow points [129].

For the City of Toronto, the ENI_1 values were derived from point data of eleven air quality monitoring stations from the Ministry of Environment, Conservation and Parks. The air quality data layer was interpolated and converted to raster layer using an Inverse-Distance-Weight method. The ENI_2 values were derived from the total population of terrestrial bird, mammal, reptile & amphibian, and tree species per unit area of the according ecozone (from the Ecozones of Ontario database). The ENI_3 were calculated using the Euclidean distance, river cells have distance equal to zero and cells farther from the river have higher Euclidean distance. For ENI_4 values, road and parking lot surfaces were extracted from the land cover map, assigned as sources, and distances from these sources were estimated using the Euclidean distance similar to the ENI_3 process.

All four selected criteria were standardized by applying the linear standardization method (Eq. 2.2).

$$\mathrm{SENC}_{j,k} = \frac{\mathrm{ENC}_{j,k}}{(\mathrm{ENC}_k)_{\max}} \qquad \text{(Eq. 2.2)}$$

Where k is the total number of criteria (in this case, 4), j is the total number of cells in the study area, $SENC_{j,k}$ is the standardized environmental criteria k at cell j, $ENC_{j,k}$ is the actual value of environmental criteria k at cell j, and $(ENC_k)_{max}$ is the greatest possible value of environmental criteria k within the study area. After standardization, the overall ENI for each cell was calculated by overlaying all four criteria, using the simple additive weighting (SAW) method (shown in Eq. 2.3).

$$\mathrm{ENI_j} = \sum_1^k \mathrm{w_k}.\,\mathrm{FENC_{j,k}} \qquad \text{(Eq. 2.3)}$$

where ENI_j is the value of ENI at cell *j,* $FENC_{j,K}$: is the finalized environmental criteria *k* at cell *j,* which can be derived from Eq. 2.4, and w_k is the weight of criteria *k.*

$$FENC_{j,k} = \begin{cases} SENC_{j,k} & ,for\ direct\ distance\ criteria \\ 1 - SENC_{j,k} & ,for\ inverse\ distance\ criteria \end{cases} \qquad \text{(Eq. 2.4)}$$

2.4.5. Socioeconomic index (SEI) development

The SEI quantifies the LID demand of each cell in terms of the socioeconomic benefits of LID (specially GI and planted-based LID). In addition to the hydrological and environmental benefits, GI also improves socioeconomic status in a variety of ways, including increasing access to green spaces, enhancing academic performance in schools, enhancing public health, and social resilience [33], [34], [63], [137]–[141]. To address these benefits, priority was assigned to cells using four sample socioeconomic factors: population density (SEI_1), distance to green spaces (SEI_2), distance to educational centers (SEI_3), and distance to hospitals (SEI_4).

Higher SEI_1 were assigned to sites with a higher population density in order to serve a higher population to serve a serving higher population with indirect benefits of GI. The second criteria (SEI_2) prioritizes sites that are farthest from existing green spaces; this creates an even distribution of green spaces. Areas with sparse landscaping, more deprived neighborhoods, and low public transport availability are identified as having the greatest demand for the benefits associated with LID (specially GI types) [61], [139]–[141].

The third criteria (SEI_3) gives priority to sites closest to educational centers and schools. Studies have shown that LID and GI improve the educational performance, and socioemotional, behavioral and cognitive development of students [142], [143]. In particular, preschoolers at educational risk were found to have greater development of independence and social skills when enrolled to schools with higher levels of plant-based LID [142]. The fourth criteria (SEI_4) assigns priority to sites that are closer to hospitals to improve the health status of patients. Studies have shown that patients with green window views recovered significantly faster and required less medication compared to patients with urban views [144]. Indeed, green spaces are widely associated with enhanced immune functioning, and greater mental well-being [62], [141]. Furthermore, green spaces have been shown to lower fasting blood glucose levels in both adults and children, effectively lowering the risk of diabetes, which is now recognized as one of the leading causes of illness and death [140].

A fifth socioeconomic benefit is social resilience, which comes in the form of provisioning services. Provisioning services yield products such as firewood, medicinal plants, and wild foods.

Studies have shown that poor households and vulnerable populations highly rely on GI to support their daily livelihood needs. One study found that 57 % of households on average use GI as a coping strategy as a response to co-variate shocks such as floods [138]. This benefit is harder to quantify due to the lack of available data. Because of this, quantifications of socioeconomic benefits often underestimate the actual benefits that can be obtained. Nevertheless, social resilience is highlighted as a great benefit to particularly vulnerable populations and could be included in future studies if relevant data is available.

For the City of Toronto, SEI_1 was estimated based on the 2016 census data, by dividing the population with the area of the corresponding census tract. SEI_2, the distance from existing green areas was estimated by the Euclidean distance; higher values were assigned to sites further away from existing green areas. The raster map of the third criteria (SEI_3) was also estimated by calculating the Euclidean distance, with the location of educational centers (in point data) assigned as sources. SEI_4 was also derived with the same process as SEI_2 and SEI_3.

As with ENI, the variables were standardized by applying the linear standardization method using Eq. 2.5.

$$\mathrm{SSE}_{\mathrm{j,m}} = \frac{\mathrm{SEC}_{\mathrm{j,m}}}{(\mathrm{SEC}_{\mathrm{m}})_{\mathrm{max}}} \qquad \text{(Eq. 2.5)}$$

where, k is the total number of criteria (in our study case, 4), j is the total number of cells in the study area, $SSEC_{j,m}$ is the standardized socioeconomic criteria k at cell j, $SEC_{j,m}$: is the actual value of socioeconomic criteria k at cell j, $(SEC_m)_{max}$: is the greatest possible value of environmental criteria k within the study area. After standardization, the overall SEI for each cell was calculated by overlaying all four criteria, using the simple additive weighting (SAW) method (shown in Eq. 2.6).

$$\mathrm{SEI_j} = \sum_1^m \mathrm{w_m}.\mathrm{FSEC_{j,m}} \quad \text{(Eq. 2.6)}$$

where, SEI_j: is the value of SEI at cell j, $FSEC_{j,m}$: is the finalized environmental criteria k at cell j, which is derived from Eq. 2.7, w_m is the weight of criteria k.

$$\mathrm{FSEC_{j,m}} = \begin{cases} \mathrm{SSEC_{j,m}} & \text{, for direct distance criteria} \\ 1 - \mathrm{SSEC_{j,m}} & \text{, for inverse distance criteria} \end{cases} \quad \text{(Eq. 2.7)}$$

2.4.6. LID demand index (LIDDI)

The LIDDI represents the sites ranked by their respective demand for LID, with the combined consideration of all hydrological and hydraulic, environmental, and socioeconomic variables. High LIDDI values represent sites with the highest demand or need for LID. To generate the LIDDI, the SEI and ENI were first geospatially overlaid using SAW method to generate SEENI (Eq. 2.8). The relationship between the weights of the method is shown in the Eq. 2.9. In this equation $\mathrm{W_{EN}}$ is the sum of $\mathrm{w_k}$ and $\mathrm{W_{SE}}$ is the sum of $\mathrm{w_m}$.

$$\mathrm{SEENI_j} = \mathrm{w_{EN}ENI_j} + \mathrm{w_{SE}SEI_j} \quad \text{(Eq. 2.8)}$$

$$\mathrm{W_{EN}} + \mathrm{W_{SE}} = \sum_1^k \mathrm{w_k}. + \sum_1^m \mathrm{w_m}. = 1 \quad \text{(Eq. 2.9)}$$

where, SEENI_j is the environmental-socioeconomic index at cell j, ENI_j is the environmental index at cell j, SEI_j is the socioeconomic index at cell j, w_{EN} is the corresponding weight of ENI, and w_{SE} is the corresponding weight of SEI. As demonstrated in Equations 3.2-8, the proposed framework to generate SEENI is not restricted by the number of environmental and socioeconomic criteria selected nor the assigned weight to each criterion. The number of criteria is considered, and the weights assigned to each criterion can be customized based on an end-user's needs, data availability, or other requirements. Thus, this framework has been developed in a way to be customizable to determine the need or demand for LID based on which benefits need to be considered or incorporated into the framework.

The resulting SEENI is proposed as an *additive value*, where it can be overlaid onto the HHI through a mathematical multiplication operation to generate the LIDDI, the overall demand for LID (Eq. 2.10).

$$\text{LIDDI}_j = \text{HHI}_j \times (1 + \text{SEENI}_j) \qquad \text{(Eq. 2.10)}$$

where LIDDI_j is the demand of cell j for LID.

SEENI was considered as an *additive value* due to the multiple advantages it provides. First, two cells with identical HHI but differing SEENI values can be ranked distinctly based on their environmental and socioeconomic demand for LID. This allows the main objective of this framework to be achieved: spatial allocation of LID with the combined considerations of hydrological and hydraulic, environmental, and socioeconomic factors. Table 2.2 shows a simple example to illustrate these concepts: the effect of SEENI on the HHI and final LID demand Rank of the three sample cells. Two areas with equal HHI but unequal SEENI (Cells 1 and 2), will result in different LIDDI, and the final rank is impacted by the cells with higher SEENI values. Secondly, since the primary goal of LID is stormwater runoff management, a site that does not generate runoff does not require LID (even if an environmental or socioeconomic demand for it exists, as shown in Table 2.2 Cell 3). In the framework, cells with HHI values equal to zero, but high SEENI values will result in LIDDI values of zero. This ensures that LID is not unnecessarily implemented in sites without a hydrological or hydraulic need.

Table 2.2 The effect of SEENI on the HHI in two sample cells

Cell #	**HHI**	**SEENI**	**LIDDI**	**Rank**
1	0.9	1	1.8	1st
2	0.9	0	0.9	2nd
3	0	1	0	3rd

2.4.7. Adaptability of the proposed framework

The proposed framework can be adapted in various ways for the intended application, project requirements or stakeholder opinions.

Our proposed framework can be used for all types of LID, generally categorized as detention (such as tanks), planted infiltration (e.g., raingarden) and dry infiltration (e.g., infiltration trenches) types [145]. Note that for our case study, we only use planted infiltration or GI types of LID for Toronto to demonstrate the utility of the proposed approach. Accordingly, all the associated co-benefits are those benefits that correspond to GI or planted infiltration LID techniques. If a different subset of LID is used, using the proposed approach, the co-benefits should be selected to be compatible with the actual co-benefits of those LID.

To generate HHI we did not standardize the data and actual values with consistent dimensions were used. Regarding the SEI and ENI, we standardized all criteria using linear value scaling method ranging between 0 and 1 (Eq. 2.2 and Eq. 2.5). This selection was based on several reasons: the exact correlation between each single criterion and result (the decision which is going to be made) is unknown. Despite that we know that each criterion has an increasing or decreasing influence on the results, but the exact linearity or nonlinearity of this change is not clearly proven. However, our framework allows the end-user to select among other standardization methods such as score range, value function, utility function, probabilistic and fuzzy. This selection, though should be based on the expert judgment (as it was performed in e.g., [86]), which is recommended and performed in literature such as [146], [147].

The weights used in the SAW hierarchical model for ENI and SEI in this research were chosen based on the particular study area, team judgement and expertise. However, these weights area adjustable, we suggest generating the weights through a systematic process such as Analytical Hierarchy Process (AHP) using weighting methods such as the Pairwise Comparison (PC) combined with a method like Delphi, which relies on a panel of experts.

Also, the four criteria used for ENI and SEI, respectively, are not restricted to the criteria we selected for this study: they can be customized according to the environmental and socioeconomic concerns of the study area, availability of data and be estimated and incorporated into HHI using Equations 3.2-8.

2.5. RESULTS AND DISCUSSION

To evaluate the effectiveness of the proposed framework, the three indices HHI, ENI and SEI were generated, followed by the SEENI and then the LIDDI for the City of Toronto. The resulting maps are color-coded to show the gradient from lowest (green) to highest (red) demand of LID. Additionally, the HHI map was compared to the historical flood data and further validated against a physical-based hydrological model (HEC-HMS). The results are presented, analyzed and discussed in this section.

2.5.1. HHI map

The resulting HHI map is presented in Figure 3(f), along with the data layers of the required variables R, K_s, D, and S. The map of existing LID is included as well. Figure 3(a) shows that overall, the City of Toronto has a low K_s (and therefore a high LID demand) across the city, though there are some high K_s areas in the eastern and western parts of the city. Figure 2.3 (b) indicates a relatively low slope for the city, with higher slopes located along riverbanks. Sites with slopes greater than 45 degree were excluded as potential LID sites. This was due to two reasons: first, the maximum long-term stable cut slope is 45 degree [148], second, to cope with the DEM data error, in which the difference between the elevations of some new urban developments (such as bridges) and surrounding area were falsely estimated as a high slope. Figure 2.3 (c) shows that D is higher at the same regions with high Ks, except for northern part of the city. Figure 2.3 (d) shows a 20 mm/hr difference in average rainfall intensity across the city. Figure 2.3 (e) shows the areas with existing tree canopies, which were eliminated from potential areas for LID implementation and excluded from further analysis. As described earlier, tree canopies were used as a proxy for existing GI due to the insufficient data available.

By geospatial overlaying of all variables using Eq. 2.1, the HHI map was generated, as presented in Figure 2.3 (f). Comparing the HHI map Figure 2.3 (f) with the input variable maps (Figure 2.3 (a) to (e)), high HHI areas are located in areas with low hydraulic conductivity (K_s), high precipitation intensity (R), low depths to restrictive layers (D) and high terrain slopes (S).

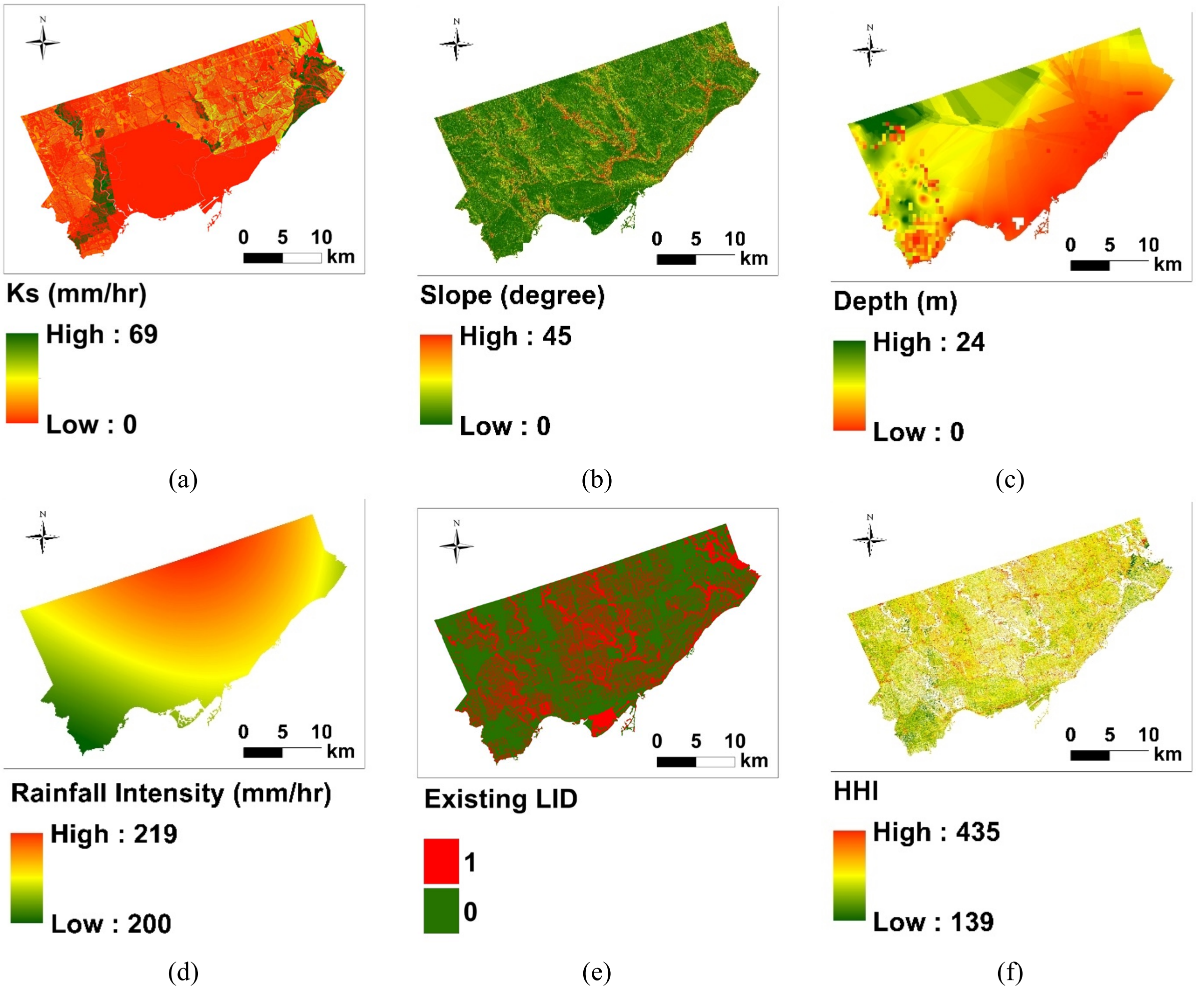


Figure 2.3 Input variables (a) hydraulic conductivity, K_s (b) terrain slope, S (c) depth to restrictive layer, D (d) rainfall intensity, R (e) existing LID, and (f) the generated HHI map (in all maps, red colour indicates high LID demand and green colour indicates low LID demand)

Assigning HHI values to an area allows filtering or ranking sites by their runoff generation potential. Identification of high HHI sites targets the main source of runoff generation for LID implementation, and thereby effectively maximizes runoff reduction. Furthermore, the HHI map can show the relationship between historically flood-prone areas and high HHI sites.

To demonstrate the application of filtering cells with high HHI, we considered the highest

2.3 % HHI (mean value plus two standard deviations of HHI) cells as the highest priority for LID implementation within the region. For Toronto, these are sites with HHI values of 0.56 or greater (if we linearly rescale HHI in range 0 and 1). Figure 4 presents the map of these highest 2.3 % HHI cells and also contains TRCA's data on historically flood-vulnerable areas [149], shown in dashed circles. The impact of upstream flood sources (i.e., areas with high HHI) on downstream areas (the encircled flood-vulnerable areas) is evident, illustrating the usefulness and utility of the proposed HHI. This is especially critical since significant parts of the upstream Humber and Don Rivers are outside the study area, and the contribution of these areas on downstream flood generation must also be considered.

From Figure 4, areas upstream the flood-prone areas are often, though not always, associated with higher HHI. Downstream of the confluence of the Don River branches, Figure 2.4 areas (a) and (b) (East Don, West Don and Taylor/Massey Creek) are historically vulnerable to flood. HHI values suggest this vulnerability originates from the upstream East Don River and the main inlet of Taylor/Massey Creek. However, high HHI areas of the western branch of the Don are lower and are mostly concentrated on the central parts of the city and may be the origin of the flooding at Figure 2.4 areas (a) and (c). In addition, upstream of areas (d) and (e) shows a high concentration of high HHI values.

West of the Don watershed, the Humber watershed shows flood vulnerable areas along and slightly east of the Black Creek River. High HHI sites are also seen along this branch (upstream of areas (f), (g) and (h)), decreasing downstream towards the confluence with Albion Creek (between areas (h) and (i)). This is in contrast to the lower HHI areas along Albion Creek (downstream of the area (k)), though there is a concentration of high HHI cells at the upstream and near (k).

On the eastern part of the city, the Highland watershed, also has flood vulnerable areas located along all four branches of the main river (Malvern, Bendale, Dorset Park, Centennial Creek), as marked by (l), (m), (n), (o), and (p) in Figure 4. HHI results shows that upstream of each of these four branches are areas with high values of HHI and therefore sources of runoff generation. The resulting HHI map combined with the historically flood vulnerable areas of the city demonstrates that the HHI can successfully identify areas with high runoff generation and its relationship to downstream flood-vulnerable clusters. Thus, the HHI is effective in correlating the geographical locations of potential sources of flood to observed flood locations.

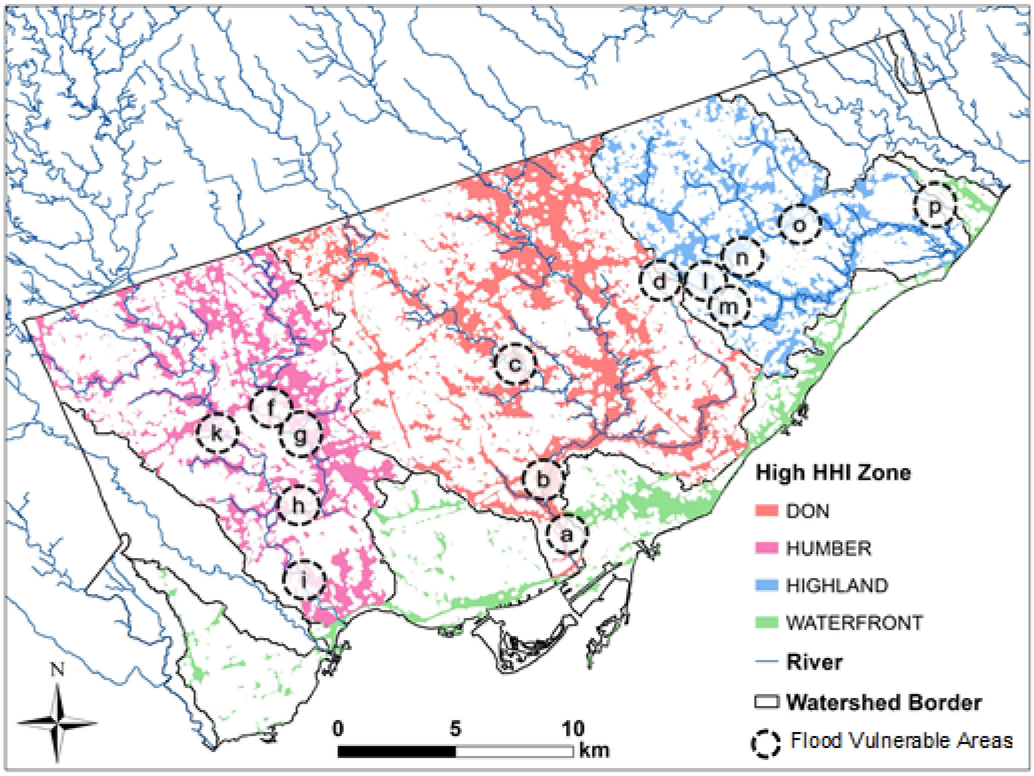


Figure 2.4 Top 2.3 percent ranked sites with a high standardized HHI of 0.56 and greater (these areas are presented for each watershed within the study area) and the location of historically flood vulnerable areas of the City of Toronto

The HHI results were then statistically analyzed for the entire study area and for each main watershed. Segmenting Toronto by cells (5 m by 5 m in size) resulted in 25.4 milion cells. By extracting the cells without available data, water bodies and existing LID 17.9 million potential LID cells remain. The mean calculated standardized HHI (if linearly rescaled between 0 and 1, which is not necessary and we only performed it for comparison purposes) for all cells is 0.4 with a standard deviation of 0.079. Figure 5 shows a plot of the HHI values versus the normalized count of cells within the entire study area and each watershed. By investigating the watersheds individually, Figure5 demonstrates that the Don has the highest mean HHI of 0.427, whereas Etobicoke has the lowest mean HHI of 0.374. Thus, in terms or runoff generation potential, the HHI values for each watershed can show the relative demand for LID in each watershed. In this case, the demand for LID in the Don (a highly urbanized watershed and centrally located within the city) is highest, and lowest in Etobicoke. Further validation and verficiation of the HHI is provided in the Section 2.5.4 that calculates the HHI for a site and directly compares it to runoff generation volumes from a hydrological model.

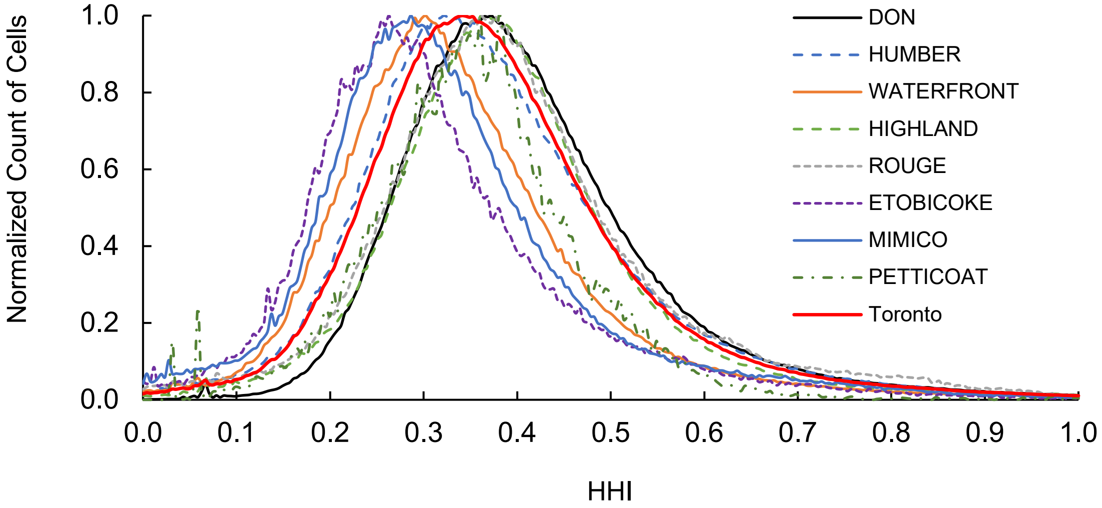


Figure 2.5 Normalized frequencies of HHI within 8 watersheds and City of Toronto.

Normalization of each watershed is performed by dividing the HHI frequency of each watershed by its maximum HHI frequency

The resulting HHI from geospatial analysis of physical-based processes is a quantification of the sources of runoff generation. This allows decisions to be made about micro-scale sites (25 m^2) within a bigger macro-scale study area (630.2 km^2). HHI highlights areas that contribute the most to flood, here high HHI areas are shown to produce flood vulnerable areas downstream. Selecting these sites for LID implementation improves the effectiveness of LID while efficiently allocating resources in stormwater management.

2.5.2. ENI map

To generate the ENI map for the City of Toronto, data for the four criteria (ENI1 to ENI4) were collected, converted to raster format (gridded cells) and standardized (using Eq. 2.2 and Eq. 2.3). The resultant maps are presented in Figure 2.6. Figure 2.6 (a) shows that the concentration of air pollution (ENI1) is located at the central areas of Toronto. ENI2 (Figure 2.6 (b)) indicates that Toronto contains four different ecozones with one being significantly more dominant, covering the majority of the city. ENI3 (Figure 2.6 (c)) shows the distance to rivers with river boundaries clearly noticeable. ENI4 (Figure 2.6 (d)) shows highly developed areas while less developed areas are around rivers and green spaces. All four layers (ENI1 to ENI4) were combined using the method described in Section 2.4.4 in order to generate the ENI map (Figure 6(e)). The resultant ENI map assigned higher priorities to areas farthest from the rivers, located in the central part of the city. The highest ENI are seen in the Waterfront, Humber, Don and western regions of the Highlands.

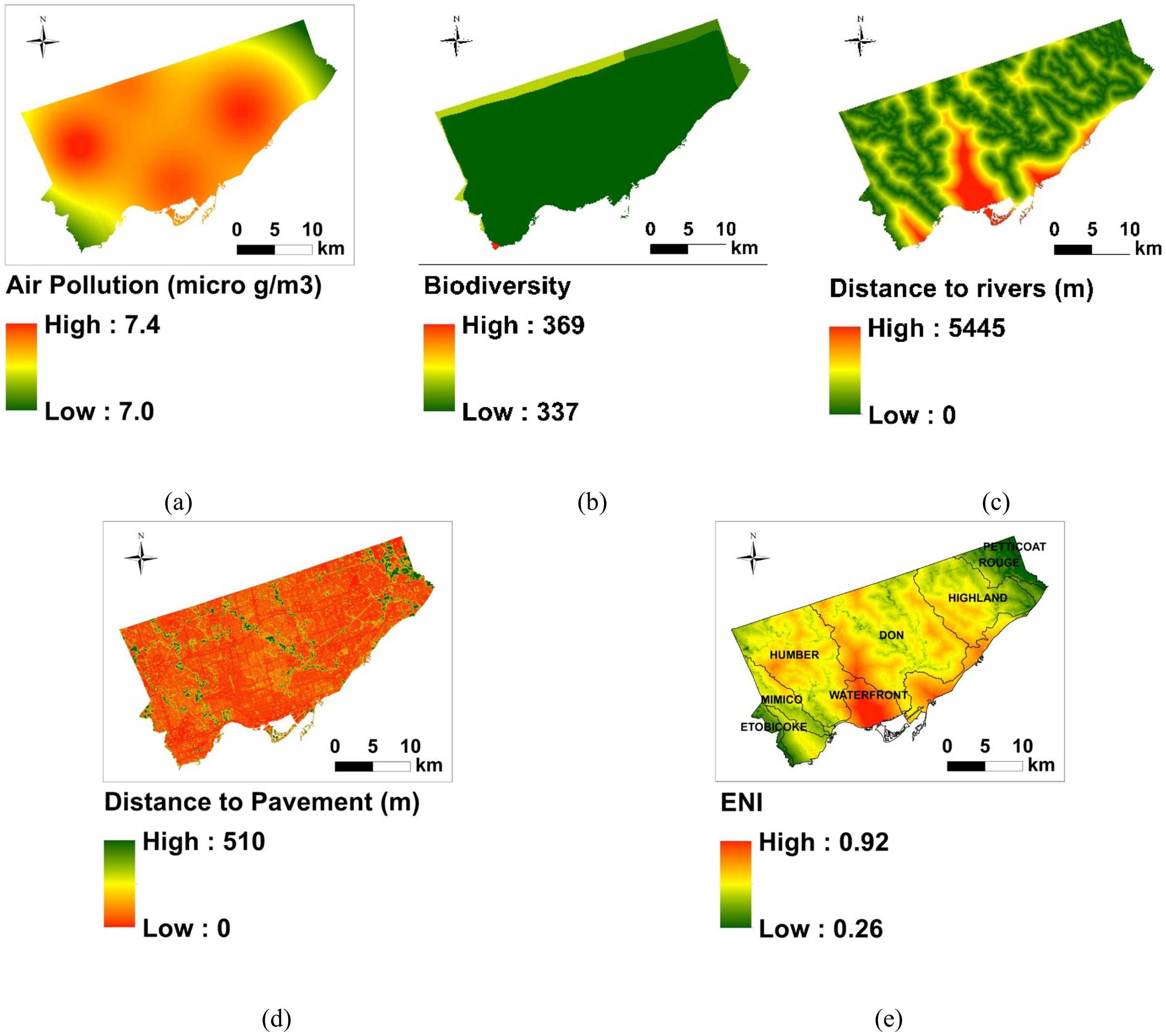
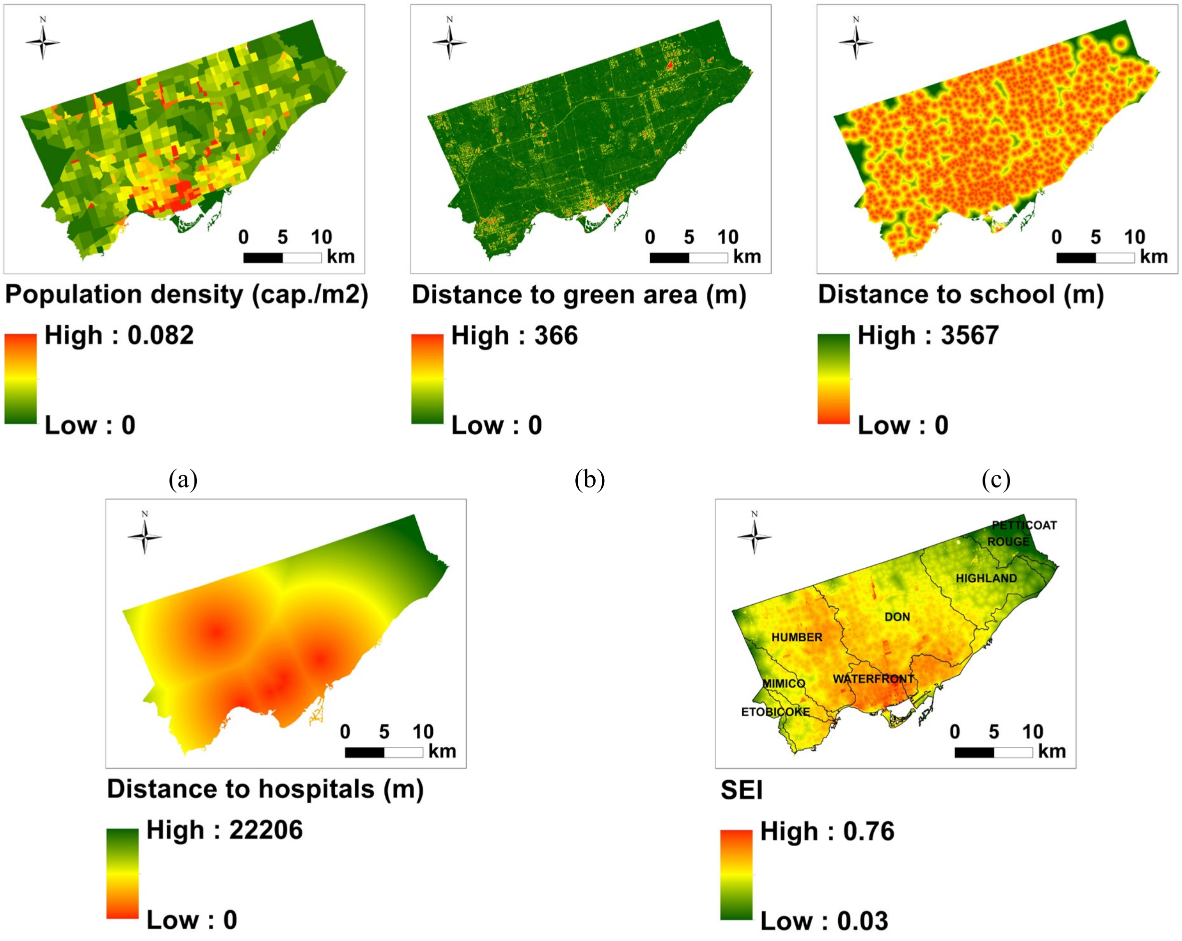


Figure 2.6 Input environmental variables (a) air pollution (ENI_1), (b) biodiversity (ENI_2), (c) distance to rivers (ENI_3), (d) distance to pavements (ENI_4), and (e) the generated ENI map of City of Toronto. In all maps, red color indicates high LID demand and green color indicates low LID demand.

2.5.3. SEI map

To generate SEI, all four criteria maps (SEI_1 to SEI_4) were created from the raw data, standardized and overlaid (Eq. 2.5 and Eq. 2.6). Each map is shown in Figure 2.7. SEI_1 (Figure 2.7 (a)) indicates that the highest populated areas are located in Downtown Toronto. Similarly, multiple census tracts with high population densities are scattered across the city. SEI_2 (Figure 2.7 (b)) shows that the LID demand for green spaces is higher downtown. Other high priority areas that are scattered across the city shows impervious areas, some of which are used for industrial land. SEI_3 (Figure 2.7 (c)) shows a high and evenly distributed pattern of educational institutes throughout the city. SEI_3 (Figure 2.7 (d)) shows hospitals mostly concentrated on the south-western part of the city. All four generated maps were overlaid to generate the SEI map (Figure 2.7 (e)) with highly urbanized areas showing the greatest socioeconomic demand for LID.



(a) (b) (c)

(d) (e)

Figure 2.7 Socioeconomic variables (a) Population density, (b) Distance to green area, (c) distance to educational institutes, (d) distance to hospitals, and (e) the generated SEI. In all maps, red indicates high LID demand and green indicates low LID demand.

2.5.4. Validation

HHI validation

We developed the HHI heuristic relationship based on the hydrological-hydraulic principals. HHI is a GIS-based index representing the runoff generation potential of each cell. Thus, HHI should be able to rank various catchments with different hydrological-hydraulic characteristic (R, D, Ks, and S). To examine the HHI performance we validate the HHI against a physical-based model. The validation was done by comparing the results of HHI to a physical-based hydrological numerical model, the Hydrologic Modelling System (HEC-HMS) developed by the U.S. Army Corps of Engineers [150] – a commonly used hydrological model. A sensitivity analysis was conducted by calculating the HHI using extreme cases for each of the variable used to develop the HHI (which are listed in Table 2.3) and running the HEC-HMS model for the same values. A combinatorics approach was used to define 16 variants of catchments (or scenarios), and these are illustrated in Figure 2.8.

Table 2.3 Variable Values considered for 16 scenarios

	Low	**High**
R (mm/h)	50[1]	220
D (mm)	0	24000[2]
K_s (mm/h)	0.3	117.8
S (m/m)	0.0001	0.15[3]

[1] Minimum R was not considered zero allowing for generating a low amount of runoff

[2] Maximum D layer is selected according to maximum D of the study area

[3] Maximum S was considered to be 0.15 (= tan 9 °), which is the greatest maximum proposed slope for all types of LID [109]

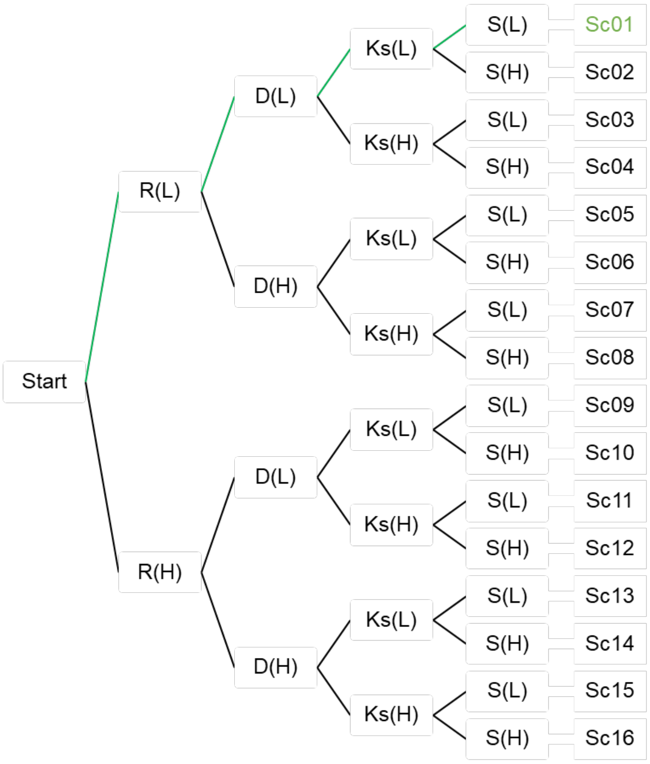


Figure 2.8 The 16 scenarios considered based on combinatorics concept

The resultant hydrographs from HEC-HMS for all 16 scenarios were created and normalized and each scenario was ranked based on the peak flow and flow volume. On the other hand, the HHI were calculated for all 16 scenarios as well, and subsequently these scenarios were ranked based on the HHI values. Results from both methods were compared and contrasted and are presented in Figure 2.9.

The methods show near identical results, with the exception of scenarios 9, 11, and 13. As expected, Sc10, Sc12 and Sc14 (High R and S, low K_s, or D) show the highest potential for runoff generation, whereas Sc07 and Sc08 (Low R and S, High K_s, and D) do not generate any runoff. HHI values are lower than the HEC-HMS values only for the flatter catchments, which is expected. Since HHI accounts for slope, runoff volume and peak flow, HHI of steep catchments are expected to be higher than the HHI of catchments with low slop. Thus, the flat catchments should be considered lower priority than steeper catchments with other parameters being identical. This demonstrates how HHI is incorporates the slope with the peak flow and runoff volume in order to rank each scenario.

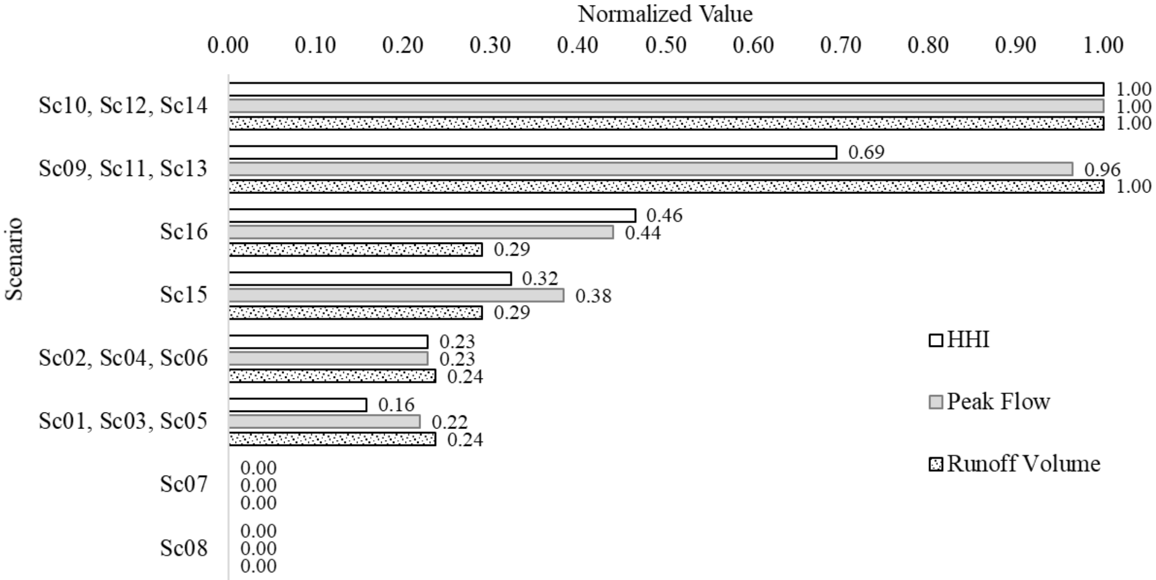


Figure 2.9 Comparison of HHI with HEC-HMS for 16 extreme scenarios

The hydrographs of each catchment were compared in the following criteria: peak flow, runoff volume, and time of concentration, as shown in Figure 2.10. From this figure, the normalized hydrographs show approximately three types of runoff volume: high, medium, and low peaks. The ranking obtained from Figure 2.10 are identical to the rankings obtained from HHI. The highest peaks are also the scenarios that obtained high HHI rankings. Within each grouping, the scenarios with the steeper slopes but similar other variables, are ranked higher than those with lower slopes. From the agreement between the HHI and HEC-HMS, HHI demonstrates its capability to rank scenarios based on the hydrological and hydraulic demands, using publicly available geospatial data and geospatial analysis.

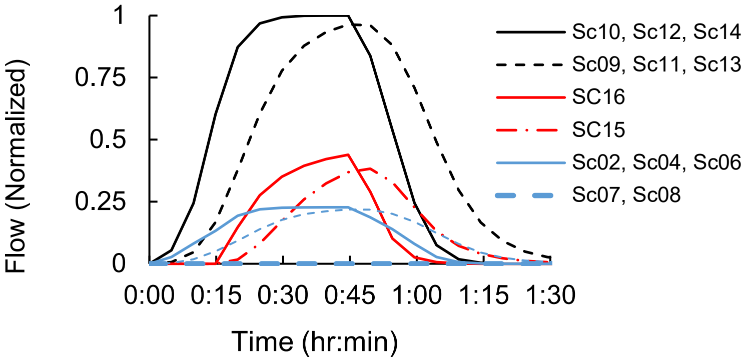


Figure 2.10 The normalized hydrograph of all 16 catchments resulted from modelling in the HEC-HMS

ENI and SEI validation

Validation of decision-making models is not practical since these models are not representing an actual phenomenon, which is extensively discussed in Kuller et al. (2019) [86].

2.5.5. LIDDI map

To generate the LIDDI map, the SEENI was first calculated by combining SEI and ENI (Eq. 2.8), as presented in Figure 2.11. SEENI was then overlaid with HHI (Eq. 2.10) to generate the LIDDI map, presented in Figure 2.12 (a). Values of LIDDI range from 0 to 1.62, with a mean of 0.63 and standard deviation of 0.125. The top 2.3 % that represent sites with values greater than two standard deviations are those with an LIDDI value of 0.88 or greater as shown in Figure 2.12 (b).

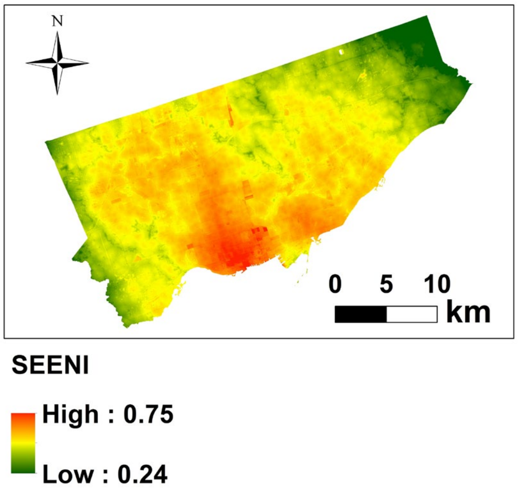
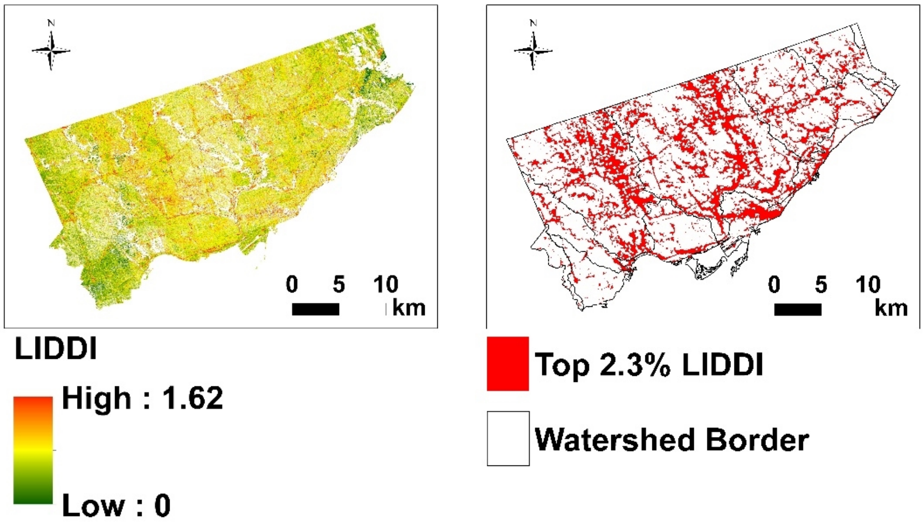


Figure 2.11 The generated SEENI map resulting from geospatial overlaying of ENI and SEI



(a) (b)

Figure 2.12 (a) LIDDI map generated from geospatial overlaying of SEENI, and HHI (b) top 2.3 percent sites ranked with the highest demand for LID

By comparing the map shown in Figure 2.12 (b) with the HHI map shown in Figure 2.4, the influence of SEENI on HHI can be observed. In particular, they show the sites that were excluded (or included) due to the lack of consideration for the socioeconomic and environmental demands (i.e., the impact of SEI and ENI or overall LID demand) that would have otherwise been obtained from SEENI.

To clearly demonstrate this, two regions with low and high values of SEENI are shown in Figure 2.13. Figure 2.13 shows HHI overlaid with LIDDI. Figure 2.13(c) (area with high SEENI), the cells that were previously excluded as high priority under HHI, are now included as priority under LIDDI, as shown in red. In contrast, in the low SEENI regions (Figure 2.13 (b)), cells that were ranked as high priority under HHI are now excluded from high LIDDI, as shown in blue.

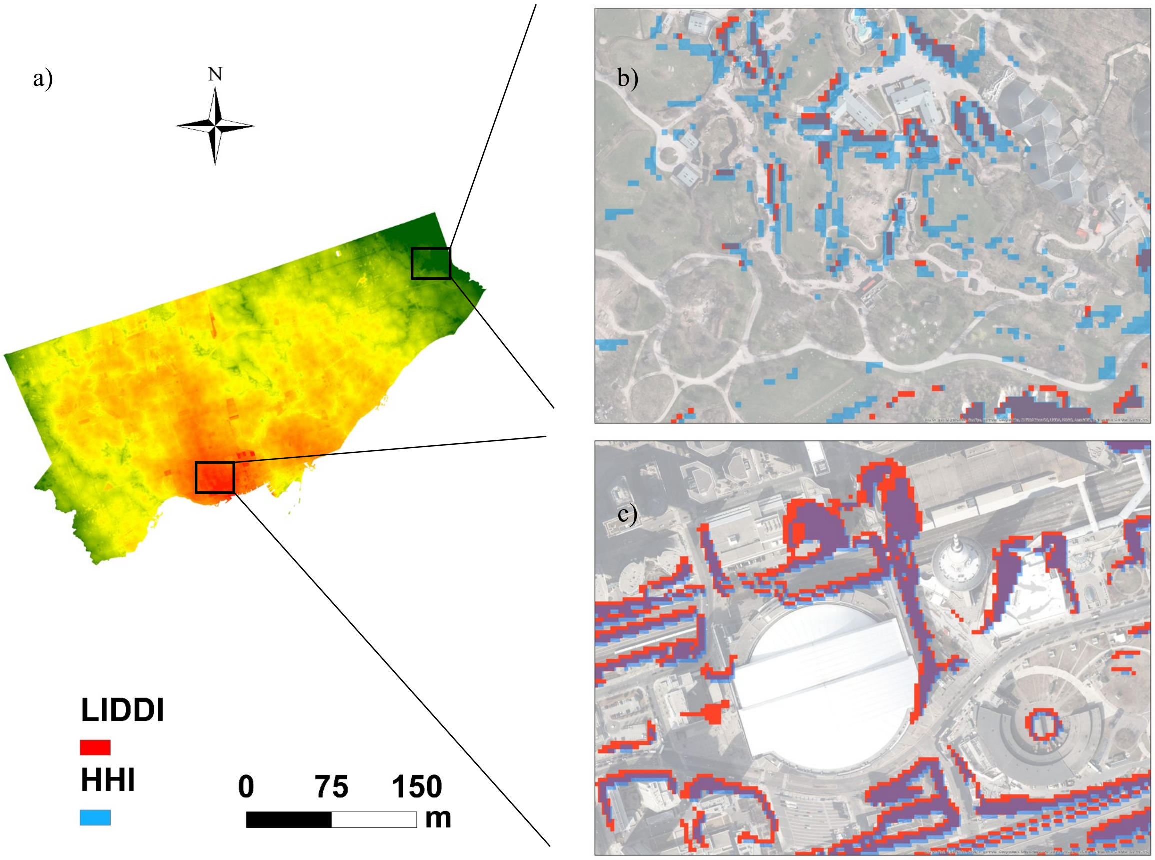


Figure 2.13 The effect of SEENI (a) on HHI and changing the priority of sites in LIDDI in two high and low SEENI areas, the area with low SEENI: Toronto Zoo area (b), area with high SEENI: the area around CN tower (c)

The LIDDI map allows visualization of the LID demand across a study area, which would otherwise be a complex geospatial problem. The results of this framework allow decision-makers to observe the main sources of flood with consideration of the socioeconomic and environmental factors using a physics based, robust, and easily implementable index, the HHI. The distribution of LIDDI across the study area helps visualize the need for LID in different regions in a large-scale study area. This visualization provides users with a simple expression of a complex and multi-criteria geospatial problem: it highlights the connections between the sources of runoff generation, flood prone areas, and areas that need higher socioeconomic and environmental benefits of LID. In addition, the LIDDI allows us to filter top ranked sites for implementing LID. Thus, with limited time and financial resources, presence of such a tool can saves our resources while maximizes the earned benefits of LID.

2.6. CONCLUSIONS

In this research, a physical-based geospatial framework was developed to identify sites with the highest LID demand, in terms of their flood generation potential, along with socioeconomic and environmental factors. To develop this framework, hydrological-hydraulic, socioeconomic and environmental criteria were identified and generated using publicly available geospatial data. Through geospatial analysis and the SAW method within a hierarchical decision-making model, the variables were overlaid, resulting in three different indices: HHI, ENI and SEI. These indices rank the sites based on the demand or need for LID with respect to each index. By combining these indices, a LID demand index (LIDDI) was generated, which ranks the sites based on HHI, ENI and SEI and identifies locations where LID should be installed to meet the multiple objectives (hydrological, environmental, and socioeconomic).

A heuristic equation was created to develop the hydrological-hydraulic index (HHI). To validate this equation and the generated HHI, we compared the results against a hydrological model (HEC-HMS) and historical flood-vulnerable locations within the study area.

The proposed framework was applied to the City of Toronto. The results showed that the framework for generating LIDDI has multiple advantages. It addresses the lack of a systematic geospatial allocation of LID methods and includes environmental and socioeconomic factors, in addition to the hydrological factors. This helps flood mitigation strategies in future land-use planning by allowing the decision-makers to rank the sites based on their demand for LID rather than using an ad hoc approach. Furthermore, this framework is specifically developed for LID objectives, unlike other existing models which are adapted from other objectives (e.g., water quality). Thus, many processes and benefits directly associated with LID are considered in the proposed framework. The three indices can also be used separately if only one aspect (hydrological, environmental, or socioeconomic) is needed. Moreover, publicly available data was used for the geospatial analysis, which allows for the wide use of our proposed framework. There is no limitation on the scale of the study area; modelling of a micro-scale, meso-scale and macro-scale study areas are all possible. Unlike previous studies where multiple mathematical limitations exist for the physical-based index (HHI), the proposed framework does not require modification or customization to use raw input data for this index. Thus, the actual values of all input data layers can be used as input data. Finally, the proposed framework is generalized to be applicable in any study area or region of interest. The proposed framework can be used to develop strategies for future flood risk attenuation, stormwater management, urban development and planning, retrofitting stormwater infrastructure, or to develop cost-effective development plans. In particular, it supports spatial decision-making and flood risk reduction strategies and enhances the overall effectiveness of LID practices.

CHAPTER 3: THE EFFECT OF CLIMATE CHANGE AND URBANIZATION ON THE DEMAND FOR LOW IMPACT DEVELOPMENT FOR THREE CANADIAN CITIES

3.1. PREFACE

This chapter focuses on the second sub-objective, applying the hydrological-hydraulic index (HHI) proposed in Chapter 2 under climate change and urbanization. HHI is used to study the change in demand for LID under these future scenarios (12 combination of climate change and urbanization). The demand for LID is quantified, investigated, and contrasted for three Canadian cities (Toronto, Montreal, and Vancouver).

The content of this chapter was published in Water[1] in 2020 as follow:

Kaykhosravi, S., Khan, U. T., Jadidi, M. A. (2020). *The Effect of Climate Change and Urbanization on the Demand for Low Impact Development for Three Canadian Cities*. Water,

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Contributions:

The contributions of authors in the current chapter are as follows, **Sarah Kaykhosravi**: has conducted the literature review, performed the data collection and curation, developed the method, used the required software to perform the analysis and modelling, validated and visualized the results, and have prepared and wrote the original manuscript of this publication. **Usman Khan** has supervised the research, provided the funding, contributed to the development of the method, writing, and editing the manuscript. **Mojgan A. Jadidi** has supervised the research, provided the funding, contributed to the development of the method, writing, and editing the manuscript.

3.2. ABSTRACT

Climate change and urbanization are increasing the intensity and frequency of floods in urban areas. Low Impact Development (LID) is a technique which attenuates runoff and manages urban flooding. However, the impact of climate change and urbanization on the demand or need for LID in cities for both current and future conditions is not known. The primary goal of this research was to evaluate the demand for LID under different climate change and urban growth scenarios based on a physical-based geospatial framework called the hydrological-hydraulic index (HHI). To do this, 12 scenarios considering four climate change and three urbanization conditions were developed. The HHI for three cities in Canada (Toronto, Montreal, and Vancouver) were estimated, evaluated, and compared for these scenarios. The results show that both urbanization and climate change increase the demand for LID. The contribution of climate change and urbanization on LID demand, measured using HHI, varies for each city: in Toronto and Montreal, high rainfall intensity and low permeability mean that climate change is dominant, whereas, in Vancouver, both climate change and urbanization have a similar impact on LID demand. Toronto and Montreal also have a higher overall demand for LID and the rate of increase in demand is higher over the study period. The results of this study provide us with a comprehensive understanding of the effect of climate and urbanization on the demand for LID, which can be used for flood management, urban planning, and sustainable development of cities.

3.3. INTRODUCTION

Floods are a major growing natural hazard that causes the loss of human lives and properties. The proportion of flood occurrence was the highest of all types of natural disasters from 1995 to 2015 [11]. The frequency of flooding has increased during the last two decades (1995 to 2015) [9]. During the same period, floods caused 157,000 fatalities globally (accounting for 26 % of all weather-related disasters). In addition, it affected the quality of life of 2.3 billion people, which is the highest share (56 %) among weather-related disasters [11]. In terms of economic losses, based on UNISDR (2016), between 2006 and 2016, the average annual costs associated with flooding were about 50 billion USD. This ranks first among the natural disasters. These damages include all types of regions (i.e., land uses) including urban areas [12].

There exist several key drivers of urban flood risk such as urbanization, urban sprawl, increasingly unresponsive engineering, global climate change, and fluvial and pluvial changes [151]. Urbanization causes changes to terrains, slopes, soil type, and vegetative cover, which result in a change in the hydrologic behaviour of urbanized areas [1]. Among these changes, the expansion of impervious surfaces dramatically increases the volume of surface runoff [2]–[5]. The expansion of impervious surfaces can occur in two contexts: (1) within a constant area (by an increase of the imperviousness densification within a fixed area); and (2) by increasing the area of the city (expansion of impervious area). However, in our research, we only considered the first context. On the other hand, due to a higher population density and valuable properties in urban areas, the influence of floods on these environments is intensive and excessively costly. Thus, urban areas are more vulnerable to the effect of floods, and, by the growth of the urban population, therefore, vulnerability and exposure are also significantly higher [9]. Climate change and the increase of rainfall intensity have also increased flood risk associated with the frequency of the occurrence of the flood [9], and this trend is expected to continue in many regions.

To cope with this, the traditional and most common approach is using a stormwater collection network (SCN). The objective of SCN is to collect and rapidly convey surface runoff to a predetermined outfall (e.g., receiving water bodies such as rivers, lakes, or ponds) [66]. However, several issues are associated with SCN. SCN is designed for a specific rainfall event; thus, there is an evident limitation of the capacity to manage extreme flood events which are likely due to climate change. This issue is exacerbated by the fact that existing SCNs are aging and performing at a lower capacity. Besides, SCN collects polluted runoff from urban surfaces, which causes environmental damages and financial losses. These losses are either due to contamination of receiving waters or treating the collected runoff at stormwater treatment plants. Even though using SCN is a well-known and well-documented method [67], [68], it has several issues, which necessitate a different approach to managing runoff in urban areas.

The smart and sustainable urban growth approach commonly known as Low Impact Development (LID) is an innovative solution to complement SCN, which is increasingly being adopted in cities around the world [21], [22], [24], [25], [65]. LID can be incorporated with existing SCN to increase the capacity of the SCN and, thus, improve their performance. LID allows for reducing the risk of floods by reducing urban runoff [21], [25], [29], [57], [93], [94], [101]. This is achieved by reducing imperviousness, conserving natural resources and ecosystems, maintaining natural drainage courses, reducing the use of pipes, and minimizing clearing and grading during the development process. Structural techniques such as bioretention cells, rain gardens, green roofs, and permeable pavements are also used to increase infiltration, thereby decreasing the amount of runoff and delaying the time to peak [28], [65], [92].

Demand for LID in different locations varies based on different factors such as land cover type, topography, etc. [86], [100], [152]. From a hydrological-hydraulic point of view, this demand is associated with the extent of the runoff generated in each site. That is, the higher is the generated runoff, the higher is the demand for capturing the runoff at the source (the site) [101], [152]. The change in rainfall intensity and depth (caused by climate change) and land cover type (caused by urbanization) are the two main factors that affect the extent of this demand. In a specific site, if the rainfall or the land cover changes, the demand for LID will change accordingly [152]. This is due to the change in the volume of runoff generated at that site, which is a function of both climate and land cover.

At the city-scale additional complexity is introduced due to numerous LID sites, constant urban change (and growth), global climate change, and the non-uniform spatial distribution of land cover and rainfall [9], [153]–[157]. Thus, it is extremely important to be able to quantify this complexity to attain insight into how changes in climate and urban land cover influence the demand for LID. Such information is useful for urban planning, designing multifunctional urban infrastructure, policymaking regarding urban growth, and the optimal assignment of financial resources for runoff and flood risk management. Therefore, the objective of our study was to investigate the effect of climate change and urbanization on the demand for LID.

The results of such an investigation will provide us with an insight into the effect of climate and urbanization on the demand for LID. This article holistically covers the scenarios under which either only one change takes place (i.e., climate or urbanization) or both (i.e., climate and urbanization), and discusses the causes and effects of the future demand for LID for three selected Canadian cities. It also discusses the contribution of climate change and urbanization factors on the change of hydrological and hydraulic processes. The manuscript is organized as follows. Section 3.4 presents the methods including the study area, the geospatial data, and the development of climate change and urban growth scenarios. Sections 3.5 and 3.6 include the results and discussion, respectively, followed with the conclusion in Section 3.7.

3.4. METHODS

In our study, we used a physical-based geospatial index called the hydrological-hydraulic index (HHI) [152]. We estimated HHI for three Canadian cities (Toronto, Montreal, and Vancouver) using the approach proposed Kaykhosravi et al. [25]. The HHI was generated for these cities under various climate and urbanization scenarios. For urbanization, we developed different land cover scenarios to represent different degrees of future urbanization, by modifying existing pervious areas to impervious areas. For the climate change scenarios, we created spatial rainfall distribution maps based on the projected Intensity–Duration–Frequency (IDF) curves for each city. These maps included historical data as well as three future climate change scenarios. The urbanization and climate change scenarios were integrated and used to estimate, evaluate, and compare the HHI (a measure of LID demand [152]) for each city.

3.4.1. Description of the Three Canadian Cities

The study area in this research includes three metropolitan Canadian cities: Toronto, Montreal, and Vancouver. The location of all cities and their administrative border are presented in Figure 3.1. The figure illustrates the current status of land cover in all cities, categorized into three classes: impervious lands, pervious lands, and water bodies.

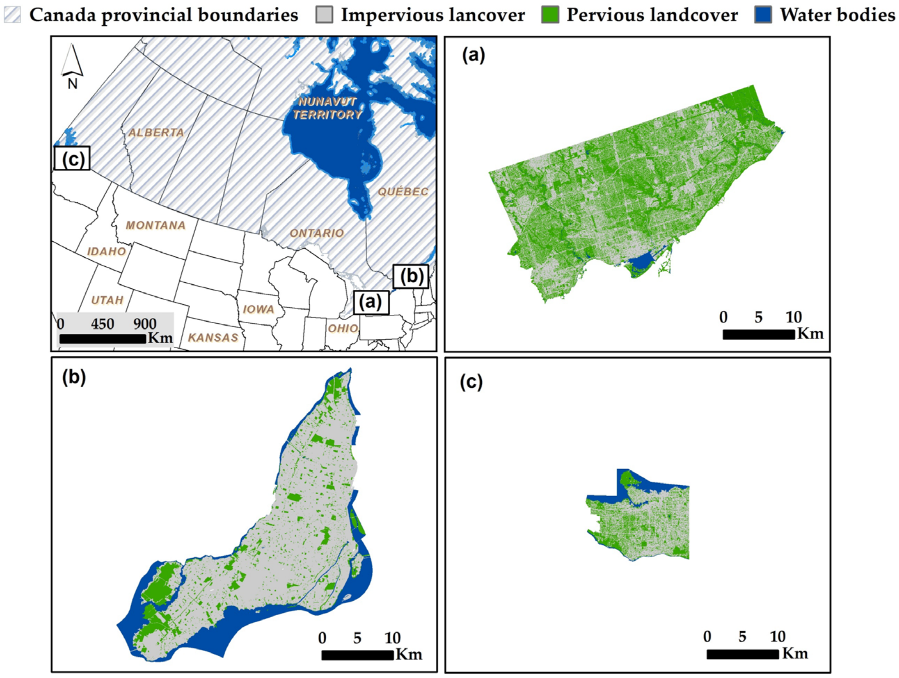


Figure 3.1 The location of the three case-study cities within Canada showing three land cover categories: (a) Toronto; (b) Montreal; and (c) Vancouver.

The area of Toronto is 633.5 km^2 and the population of the city in 2019 was 2.96 million [158]. The average annual precipitation of Toronto for the 1951–1980 period is 814 mm [159] which is the lowest precipitation among the three cities. The pervious to impervious ratio (PIR) (ratio of areas excluding water bodies) is about 1.17 based on the available land cover data (from 2007) meaning that land cover in Toronto is dominated by pervious land cover.

The area of Montreal is 624.4 km^2, slightly lower than Toronto, and the population of the city in 2016 (based on the most recent census data) is 1.96 million [160]. The average annual precipitation for the 1951–1980 period is 1028 mm [159], which is slightly higher than in Toronto. The PIR for Montreal is 0.21 which is the lowest among all three cities, meaning that the city is highly urbanized or, in other words, dominated by impervious land cover.

Vancouver area is 136.5 km^2 and the population of the city in 2016 (based on the most recent census year) is 2.55 million [161]. The average annual precipitation for the 1951–1980 period is 1569 mm [159], which shows the city has the highest precipitation depth among the three cities. The PIR for Vancouver according to the available land cover (from 2014) is 0.64, which is higher than Montreal but lower than Toronto. In addition, this indicates that the land cover of Vancouver is largely dominated by impervious land cover.

3.4.2. Geospatial Data Used for Generating the HHI

Our analysis in this study was conducted based on geospatial analysis. The HHI model was developed using Python and the ArcPy package was used to perform the analysis. The data used to estimate HHI included:

- Meteorological station data: To estimate rainfall intensity

- Surficial geology: To estimate the depth to restrictive layer and the hydraulic conductivity
- Groundwater tables: To estimate the depth to groundwater
- Digital Elevation Model (DEM) data: To estimate the slope

All geospatial data used in this study are publicly available and were downloaded from various open data sources [162]–[168]. All datasets were converted into raster format with a ground resolution of 5 m × 5 m (to align with the digital elevation model of Toronto). This resolution was used as the reference resolution for this research.

The raster maps that were derived from these data were overlaid using Equation 4.1 [152] to generate the HHI. HHI ranks the cells (i.e., the pixels of the raster data) by their runoff generation potential. Thus, cells with higher HHI generate higher volume and peak runoff flow rate. Ranking the cells based on HHI values highlights the cells that are the main source of runoff generation. On this basis, we can target the high HHI cells for LID implementation, and thereby effectively maximize runoff reduction [152]. Since the demand for implementation of LID corresponds to the HHI values, site with higher HHI values are considered as sites with higher demand for LID [152]. The HHI index accounts for seven variables, as presented in Eq. 3.1.

$$\mathrm{HHI_j} = \begin{cases} \left[\mathrm{R_j} - \left((\mathrm{K_s})_\mathrm{j} \cap (\mathrm{K_i})_\mathrm{j}\right) \cap \left(\mathrm{n_j} \times \left((\mathrm{D_g})_\mathrm{j} \cap (\mathrm{D_r})_\mathrm{j}\right)\right)\right] \times [1 + (\tan \mathrm{S})^{0.385}] & \text{for} \quad \mathrm{R_j} > \mathrm{Ks_j} \\ 0 & \text{for} \quad \mathrm{R_j} \leq \mathrm{Ks_j} \end{cases} \qquad \text{(Eq. 3.1)}$$

In Equation 4.1, j is the cell number; $\mathrm{HHI_j}$ is HHI at cell j; $\mathrm{R_j}$ is rainfall intensity (mm/h) at cell j; $(\mathrm{K_s})_\mathrm{j}$ is saturated hydraulic conductivity of the surficial soil (mm/h) at cell j; $(\mathrm{K_i})_\mathrm{j}$ is the hydraulic conductivity of impervious areas (e.g., roads, parking lots, and building rooftops) at cell j, which is set equal to zero for impervious cells; $\mathrm{n_j}$ is the soil porosity at cell j; $(\mathrm{D_g})_\mathrm{j}$ and $(\mathrm{D_r})_\mathrm{j}$ are, respectively, depth to groundwater (mm) and depth to the first restrictive soil layer (mm) at cell j; and S is the terrain slope (degrees) at cell j [152].

3.4.3. Developing Scenarios for Investigating the Integrated Effect of Climate Change and Urbanization

Climate Change Scenarios

The pattern of the effective rainfall (rainfall with losses deducted) can have a significant influence on the runoff hydrograph [169]. The pattern is typically determined by selecting the position of the maximum rainfall block (in the hyetograph) and rainfall duration [170]. For hydrological modelling of a catchment, it is important to determine the duration of the rainfall to which flood generation is assumed to occur [171]. Generally, for catchments above 40 km^2, the effective daily rainfall duration is in the order of 12 h (with the time of concentration between 4 and 12 h); for catchments larger than 500 km^2, or slow-reacting catchments, a sub-daily distribution is not needed. Smaller catchments are reactive to short but intensive rainfall events in producing their highest peaks [171]. For example, the recommended duration is 10 min inlet time for small (micro-scale) catchments, whereas the actual time of concentration should be used for larger-scale catchments, according to the Wet Weather Flow Management Guidelines for Toronto [172]. In this study, the catchments were generally small and, therefore, shorter durations (less than the time of concentration) were used for the analysis. However, due to the lack of such fine resolution data for all three cities, a duration of 60 min was used for effective rainfall for each city for the HHI analysis. In addition, a 10-year return period (RP) was selected because this is the most extreme scenario suggested by Canadian guidelines for the design of small wet weather systems including LID. The RPs suggested by these guidelines include 2 [172]–[174], 5 [173], or 10-year [172], [175].

For the projected IDF data, we used the IDF_CC Tool 4.0 (Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change—Version 4.0) [176]. The available range of IDF data available through this tool are the years 2006–2100. Generating IDF curves based on stationary historical data cannot capture the changing climate conditions; thus, this tool uses two other models: Global Climate Models (GCMs) and Regional Climate Models (RCMs) [177]. Both GCMs and RCMs need spatial and temporal downscaling, which relies on the historically observed data for the time-period of observations [177]. Downscaling links GCM/RCM grid scales and local study areas for the generation of IDF curves under changing climate conditions. For temporal downscaling of precipitation data, a modified version of the equidistant quantile-matching (EQM) method is used in this tool. For spatial downscaling, the tool utilizes a statistical downscaling method. The first future climate that this tool provides is for the period 2006–2036 (referred to as Scenario 2036 in this study), which was selected as our first future scenario [178]. In addition, projections for the period 2036–2066 (referred to as Scenario 2066 in this study) as the mid-term scenario and the period 2066–2096 (referred to as Scenario 2096 in this study) for the long-term period were also selected. Data from the Canadian Climate Model (CanESM 2) were selected from among several available climate models within the tool. The tool generates the IDF for three different values of the Representative Concentration Pathways (RCP) [179] including RCP2.6, RCP4.5, and RCP8.5. The comparison of IDF for these three RCPs for various RPs (2, 5, 10, 25, 50, and 100) provided by the tool shows that the lower the RP the smaller is the difference between IDFs with different RCPs [176]. Thus, for the RPs of 2–10 years, the difference between IDF for different RCPs is almost negligible.

Thus, we selected the 10-year RP and the highest RCP (8.5 W/m^2) to derive the projected IDF values for the selected scenarios (2036, 2066, and 2096).

Following the derivation of rainfall intensity using the IDF_CC Tool 4.0 at each meteorological station within or near the cities, the geospatial distribution of rainfall across each city was estimated using the stations listed in Tables 4.1–3 for each city. This process was as follows: First, using the IDF tables, the rainfall intensities for the 10-year RP and 60 min duration were derived. Second, a geospatial analysis (using Inverse Distance Weighted method, IDW) was used to develop the distribution of the rainfall intensity across the study areas based on the location of the stations. This resulted in 12 different rainfall distribution maps (four for each city for the selected years including historical IDF and projected IDF for Scenarios 2036, 2066, and 2096).

Table 3.1 Projected rainfall intensity for Toronto for Scenarios 2036, 2066, and 2096 [176], [180], 60 min duration, and 10-year RP. The coordinates are in NAD_1983_UTM_Zone_17N.

ID	Station Name	Historical Data Range	Coordinates		Rainfall Intensity (mm/h)			
			X (m)	Y (m)	Historical	2036	2066	2096
1	Oshawa WPCP	1970–2006	674,358.9	4,859,722	32.17	35.00	35.45	42.12
2	Toronto City	1940–2007	628,988.2	4,836,464	39.12	43.54	43.59	49.43
3	Toronto-INTL A	1950–2017	610,427.6	4,837,243	38.12	42.06	42.99	47.39
4	Toronto Buttonville A	1986–2007	630,991.4	4,857,614	37.50	39.56	39.94	45.49
5	Oakville Southeast	1965–1976	610,793.8	4,815,031	32.33	35.70	36.48	40.10
6	Etobicoke	1964–1980	618,586.5	4,831,829	36.05	39.77	40.09	45.12
7	Toronto Met Res Stn	1966–1987	616,643.0	4,850,681	36.91	40.62	41.62	45.96

Table 3.2 Projected rainfall intensity for Montreal for Scenarios 2036, 2066, and 2096, 60 min duration [176] , and 10-year RP. The coordinates are in NAD_1983_UTM_Zone_18N.

ID	Station Name	Historical Data Range	Coordinates		Rainfall Intensity (mm/h)			
			X (m)	Y (m)	Historical	2036	2066	2096
1	McGill	1906–1992	609,377.3	5,039,448	42.20	45.70	55.45	55.70
2	Mirabel Int. A.	1976–2008	575,554.5	5,057,840	32.41	33.70	40.93	41.58
3	P. E. T. Int. A.	1943–2014	598,491.9	5,035,934	34.90	36.66	45.37	45.66
4	St Hubert A.	1956–1995	623,396.3	5,041,931	34.60	36.42	44.99	44.81
5	Jean Brebeuf	1969–1984	609,377.3	5,039,448	32.50	33.91	41.70	42.14
6	Lafontaine	1973–1991	609,338.6	5,041,670	32.35	33.46	41.63	41.99
7	Jar Bot	1977–1989	613,143.1	5,047,295	39.35	39.54	50.80	49.64
8	Valleyfield	1986–1998	570,587.7	5,014,450	32.61	34.99	41.20	41.62
9	L'Assomption	1963–2017	621,983.8	5,074,136	36.28	38.29	47.44	47.43

Table 3.3 Projected rainfall intensity for Vancouver for Scenarios 2036, 2066, and 2096 [176], [181], 60 min duration, and 10-year RP. The coordinates are in NAD_1983_UTM_Zone_10N.

ID	Station Name	Historical Data Range	Coordinates		Rainfall Intensity (mm/h)			
			X (m)	Y (m)	Historical	2036	2066	2096
1	UBC	1958–1990	481,806.10	5,455,276	14.35	14.98	15.60	16.84
2	Lynn Creek	1964–1983	497,822.00	5,468,587	19.89	21.05	21.94	23.65
3	Ladner Bchpa	1963–1978	503,651.30	5,436,349	11.02	11.68	11.99	13.04
4	Surrey Kwantlen Park	1962–1999	510,200.90	5,448,586	15.79	16.59	17.27	18.53
5	Buntzen Lake	1969–1983	509,436.00	5,469,707	21.30	22.35	23.43	25.03

Urban Growth Scenarios

The projected land cover of each city was required to investigate the influence of future urbanization on runoff generation potential. To develop these projected scenarios, there were several limitations due to inconsistent and/or complete lack of data for the study periods. To account for the inconsistencies in the land cover categories, we generalized the land covers into three categories: impervious (buildings, roads, parking lots, and other paved surfaces), pervious (tree canopies, parks, golfs, grass shrubs, bare earth, etc.), and water body (lakes, ponds, streams, etc.). For example, in Toronto, all trees (street, park, and forest trees) are considered as one category (tree canopy), whereas, in other two cities, trees are not distinguished from other green spaces, and are part of open spaces or park areas. Thus, due to this inconsistency, comparing the land covers directly for each city is not feasible. Tables 4.4–6 illustrate these differences for each city. These tables show 8 categories of land cover for Toronto and Montreal and 13 for Vancouver, each with a different taxonomy.

Another limitation was that the future urban growth data (which were used to estimate future urbanization) for the selected years were not available. To address this, we used a systematic urban growth model to generate this data. In the proposed model, we estimated the future state of cells (i.e., locations within each city). Our model is a grid-based discretization method [182] which is different from conventional urban growth models such as cellular automata (CA), land use/transportation (LUT), or agent-based (ABM) models [183]. The selection and priority of the “converted lands” were made based on a combination of three parameters including the hydrological state of the lands (pervious or impervious) considering the land cover (i.e., pervious lands such as bare earth were selected for conversion); the functional importance of the land cover (e.g., tree canopy had priority to bare earth for conversion to impervious cover); and finally the total geometrical area of the selected land cover (e.g., tree canopy in Toronto has a significant share in the area of the city which is greater than the area of all other pervious lands such as grass shrubs, bare earth, etc.). We divided the conversion process into two steps. In Step 1 (Scenario 1, representing medium urbanization), a few land covers are converted to impervious surfaces, whereas in Step 2 (Scenario 2, representing high urbanization) more land covers follow (shown red colored text in Tables 4.4–6). Subsequently, the corresponding area of conversions is calculated, leading to different values for different cities. The PIR values for all three cities and scenarios are presented in Tables 4.4–6. Overall, as expected, PIR decreases with urbanization in all cities.

For Toronto, the impervious area increased by 28 % and 48 % for Scenarios 1 and 2, respectively. For Montreal, the impervious area increased by 5 % and 10 % for Scenarios 1 and 2, respectively. Lastly, for Vancouver, the impervious area increased by 19 % and 48 % for Scenarios 1 and 2, respectively. In each of these cases, the increase in impervious area is measured by comparison with the base scenario for each city. The difference among the "added impervious areas" of the cities for the same scenario is due to two reasons: (1) the limited capacity of the cities in terms of available pervious land cover; and (2) the inconsistency in the base maps in terms of the types of land cover (as described above). This limited the consistent conversion for the same scenario for all cities. For example, "grass shrub" in Toronto does not have a similar land cover type in Montreal ("Golf" can be considered a similar class), whereas "shrub", "modified grass herb", or "natural grass herb" can be considered as similar cover types in Vancouver.

In the highly urbanized state (Scenario 2), the PIR is 0.47, 0.10, and 0.11 for Toronto, Montreal, and Vancouver, respectively. These ratios reveal how far the cities are from the highly urbanized state. Both Montreal and Vancouver have similar PIR values for the most critical condition (i.e., Scenario 2) with the lowest pervious land cover, whereas Toronto has a significantly high proportion of pervious land cover. Overall, in Scenario 2, in all three cities, the area of impervious lands dominates the pervious area.

Table 3.4 Land cover data of Toronto at the year 2007 and its projected changes due to the urban growth for two scenarios.

ID	Land Cover	Area (km^2)	Base	Scenario 1	Scenario 2
1	Buildings	103	impervious	impervious	impervious
2	Roads	79.8	impervious	impervious	impervious
3	Paved surfaces	108	impervious	impervious	impervious
4	Tree canopy	179.2	pervious	pervious	impervious
5	Grass shrub	149.4	pervious	impervious	impervious
6	Agriculture	6.2	pervious	impervious	impervious
7	Bare earth	4.1	pervious	impervious	impervious
8	Water bodies	3.8	-	-	-
	Total	633.5			
	Added impervious		0	82.4 [1]	139 [1]
	Total impervious		290.7	373.1	429.7
	Total pervious		338.9	256.6	200.4
	PIR		1.17	0.69	0.47

[1] Pervious lands within a buffer of 500 m from the streams were not converted to impervious.

Table 3.5 Land cover data of Montreal at the year 2016 and its projected changes due to the urban growth for two scenarios.

ID	Land Cover	Area (ha)	Base	Scenario 1	Scenario 2
1	Buildings	264.6	impervious	impervious	impervious
2	Roads	103.5	impervious	impervious	impervious
3	Paved surfaces	47	impervious	impervious	impervious
4	Parks and open spaces	41.1	pervious	pervious	impervious
5	Golf	12.5	pervious	impervious	impervious
6	Agriculture	6.1	pervious	impervious	impervious
7	Bare earth	25.3	pervious	impervious	impervious
8	Water bodies	124.5	-	-	-
	Total	624.6			
	Added impervious		0	19.5 [1]	41.1 [1]
	Total impervious		415.1	434.6	456.2
	Total pervious		85.1	65.3	43.8
	PIR		0.21	0.15	0.10

[1] Pervious lands within a buffer of 500 m from the streams were not converted to impervious.

Table 3.6 Land cover data of Vancouver at the year 2014 [184] and its projected changes due to the urban growth for Scenario 1.

ID	Land Cover	Area (ha)	Base	Scenario 1	Scenario 2
1	Buildings	37.5	impervious	impervious	impervious
2	Other Built	0.1	impervious	impervious	impervious
3	Paved	33.3	impervious	impervious	impervious
4	Coniferous	6	pervious	pervious	impervious
5	Deciduous	21.8	pervious	pervious	impervious
6	Barren	1.9	pervious	pervious	impervious
7	Shrub	0.7	pervious	impervious	impervious
8	Shadow (considered as shrub)	1.5	pervious	pervious	impervious
9	Modified Grass-herb	13	pervious	impervious	impervious
10	Natural Grass-herb	0.2	pervious	impervious	impervious
11	Non-photosynthetic vegetation	0.1	pervious	pervious	impervious
12	Soil	0.3	pervious	pervious	impervious
13	Water	20.1	-	-	-
	Total			136.5	
	Added impervious		0	13.8	34.3 [1]
	Total impervious		71	84.8	105.3
	Total pervious		45.4	31.6	11.1
	PIR		0.64	0.37	0.11

[1] Pervious lands within a buffer of 500 m from the streams were not converted to impervious.

To verify that the urban growth scenarios do not overestimate future urban areas, the computed scenarios described above were compared to a population-based metric. This metric denoted as the Additional Required Impervious Lands (ARIL) is presented in Eqs. 4.2 and 4.3. ARIL estimates how much impervious area is needed on top of the base land cover (i.e., current conditions) to accommodate the projected population in the future. To calculate ARIL, a linear relationship between population growth and impervious area (km^2) was assumed using similar methods proposed in previous studies (e.g., [185], [186]). In addition, we assumed that the distribution of population over impervious lands is homogenous, the population density in the future remains the same, and the future area of impervious lands is a linear function of the current area and population density. In other words, future urbanization and urban growth will continue in the future as they are currently.

$$\text{PPI (capita/ha)} = P_{base}\text{ (capita)}/Ai_{base}\text{ (km}^2\text{)} \qquad \text{(Eq. 3.2)}$$

$$\text{ARIL} = (P_x - P_{base})/\text{PPI} \qquad \text{(Eq. 3.3)}$$

where Ai_{base} is the area of impervious lands at the base year, P_x is the projected population at year x, P_{base} is the population at year b, and PPI is the population per impervious land (Eq. 3.2).

The projected populations for Toronto, Montreal, and Vancouver are needed to estimate the ARIL (Table 3.8). The available data for these projections for each city had several inconsistencies creating a challenge in data integration, particularly due to missing data for the three future periods. To overcome this, the missing data were estimated using a linear function to the available data (which included historical population data for each city as well as projected data for certain future years), for each city. The project data are specified in Table 3.7, which also identifies which data were estimated using the linear function.

Table 3.7 The projected population for Toronto, Montreal, and Vancouver scenarios 2036, 2066, and 2096 [158], [160], [161].

		Scenario			
		Base	2036	2066	2096
Population (million)	Toronto	2.40 [2] (year 2007)	3.81 [1]	5.10 [2]	6.47 [2]
	Montreal	1.96 [3] (year 2016)	2.27 [1]	2.70[2]	3.14 [2]
	Vancouver	2.42 [3] (year 2014)	3.40 [1]	4.35 [2]	5.47 [2]

[1] Based on projected data. [2] Estimated using a linear function. [3] Based on available historical data.

Based on Equations 4.2 and 4.3, PPI in 2007 (the base year) for Toronto is estimated as 8255.9 capita/km^2. For Montreal, the PPI calculated in the year 2016, for which both population and land cover data are available, was estimated as 5159.8 capita/km^2. Vancouver had a PPI of 34,084.5 capita/km^2 in year 2016, for which both population and land cover data are available. Using PPI values, the ARIL of each city for all projected years were estimated and are presented in Table 3.8. We compared the ARIL against the developed scenarios. This revealed that the added impervious lands (by converting pervious lands) in two scenarios are not adequate to accommodate the projected population with an assumption of constant PPI. In all cases, the ARILs in Scenarios 2066 and 2096 are larger than the added impervious area presented in Tables 4.4–6. From this, we learned that for the future land cover scenarios, only converting the pervious to impervious lands is not sufficient to accommodate such projected populations and the PPI needs to increase. In other words, the current lifestyles will need to be modified in each city to account for the increase in population, e.g., through the vertical development of buildings (i.e., densification) or an increase in population density.

Table 3.8 Land cover data of Toronto, Montreal, and Vancouver on the base year (2007, 2016, and 2014, respectively for each city) and its projected changes due to the urban growth in the years 2030, 2066, and 2096.

		Base	**2036**	**2066**	**2096**
Toronto	ARIL (km^2)	0.0	170.8	327.2	493.1
	Total impervious (km^2)	290.7	461.5	788.6	1281.7
	Total pervious area (km^2)	338.9	168.1	−159.0	−652.1
Montreal	ARIL (km^2)	0	60.08	143.61	228.89
	Total impervious (km^2)	379.86	439.94	583.55	812.44
	Total pervious area (km^2)	120.13	60	−84	−312
Vancouver	ARIL (km^2)	0	28.75	56.62	89.51
	Total impervious (km^2)	71	99.75	156.38	245.89
	Total pervious area (km^2)	45.4	17	−40	−129

Integrated Urban Growth and Climate Change Scenarios

We investigated all possible combinations of our selected urbanization and climate change scenarios. Using this, the influence of the sole change of any scenario as well as the combined change of any land cover and climate scenarios can be analyzed. The developed scenarios are labeled and presented in Table 3.9.

Table 3.9 The 12 combinations of climate change and urbanization scenarios.

		Climate Change			
		Base Year	Sc 2036	Sc 2066	Sc 2096
Urbanization Scenarios	Sc00 (base land cover)	C-base-00	C-2036-00	C-2066-00	C-2096-00
	Sc01 (medium urbanized)	C-base-01	C-2036-01	C-2066-01	C-2096-01
	Sc02 (highly urbanized)	C-base-02	C-2036-02	C-2066-02	C-2096-02

3.5. RESULTS

A brief comparison of climate condition and urbanization under different scenarios is presented in Figure 3.2 and Figure 3.3. The mean rainfall intensity of the cities shows that the rainfall intensity of Toronto is slightly higher than that of Montreal and more than double the rainfall intensity of Vancouver. However, Vancouver has a maximum average annual rainfall of 1569 mm, about 90 % higher than Toronto and 50 % higher than Montreal. Overall, the trend of projected mean rainfall intensity presents an increase in the intensity of rainfall in the future for each city for each future period. However, there is an exception for Toronto in Scenario 2066, where the intensity is shown to remain almost constant compared to the previous scenario (2036). This is similar to Montreal for Scenario 2096 compared to the previous scenario (2066). Note that the variability of rainfall intensity is higher in Montreal compared to the other two cities.

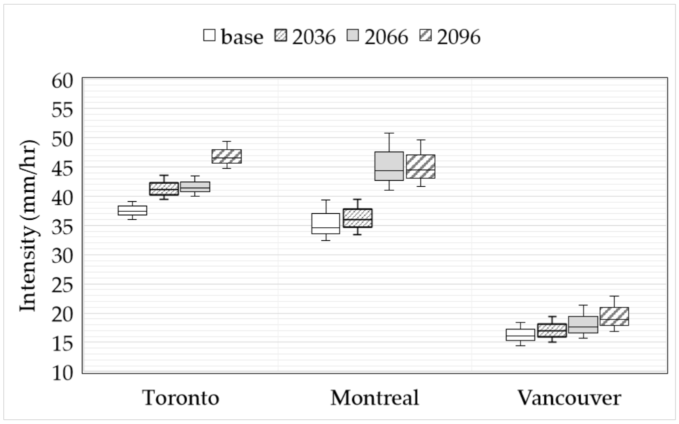


Figure 3.2 Comparison of rainfall intensity (for the 60 min duration and 10-year RP event) for the three cities in selected years.

Figure 3.3 presents an overall comparison of all urbanization scenarios for the three cities. If zero impervious surface is defined as the "green city", Figure 3.3 shows that Toronto (for the base scenario) is the closest to the "green city" and Montreal is the most urbanized city (closest to 100 % impervious cover). As expected, the two projected scenarios (Sc1 and Sc2 representing medium and high urbanization) move each city further away from the "green city".

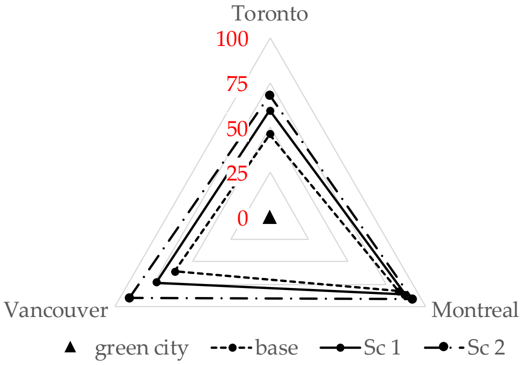


Figure 3.3 Normalized ratio of impervious area to the city area (water bodies excluded) for Toronto, Montreal, and Vancouver.

For the HHI, first, a general comparison of the three cities is presented in Figure 3.4 which shows the current state (C-base-00, i.e., the base climate and the base urbanization scenarios) as well as the worst-case scenario (C-2096-02, i.e., Scenario 2096 climate and high urbanization, Scenario 2). Note that, as identified above, the C-base-00 comparison has some limitations: the base land cover for these cities is not for the same year, while the rainfall intensity is based on available historical data (which differs for each city).

This comparison was made based on the mean and frequency of HHI in each city. Figure 3.4 shows the normalized histogram of HHI for each city for the two scenarios listed above; a low HHI value represents a lower demand for LID, and a higher value represents a higher demand. Generally, there a higher demand for LID in Montreal, with a slight difference compared to Toronto, and Vancouver has the lowest demand for LID. The mean HHI values for the C-base-00 and C-2096-02 scenarios range from 46.2 to 58.2 (a 26 % increase) for Toronto, from 44.0 to 56.4 (a 28.2 % increase) for Montreal, and from 21.3 to 25.1 (a 17.8 % increase) for Vancouver.

Toronto and Montreal present a similar pattern in response to climate change and urbanization. For example, in both cities, a significant proportion of the C-2096-02 histograms is higher than an HHI value of 50, which shows a higher demand for LID compared with the C-base-00 scenarios. In addition, there is a general change towards a higher frequency of HHI for the C-2096-02 from the C-base-00 scenario. In Vancouver, if an HHI value of 25 is used for comparison, the histogram does not show that the proportion of the C-2096-02 histogram for values greater than 25 has changed. Both the initial and final HHI values for Vancouver are much lower than both Toronto and Vancouver. The C-2096-02 demand is higher, as expected, for Vancouver, but with lower variance than the C-base-00 scenario.

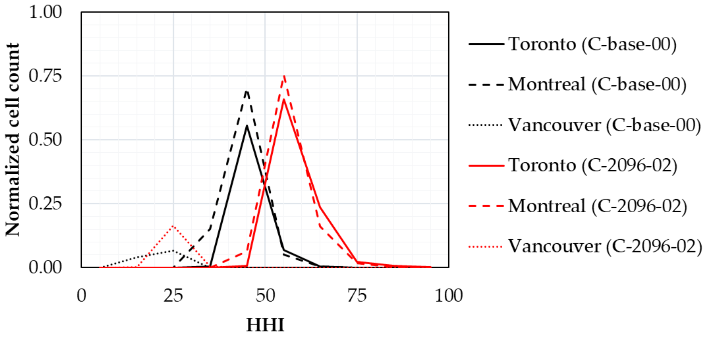


Figure 3.4 Normalized (to the maximum overall cell count of the three cities) histogram of HHI of comparing the current state (C-base-00) and the worst-case scenario (C-2096-02) among Toronto, Montreal, and Vancouver.

The HHI values for all three cities are visualized in maps presented in Figure 3.5–7. As expected, all scenario results indicate that climate change and urbanization increase the HHI and, thus, the runoff generation potential in each city, leading to a higher demand for LID for source control. Climate change also significantly impacts HHI more than urbanization in Toronto and Montreal. This can be due to two reasons: first, Montreal is already highly urbanized and, thus, the room for future change in land cover is limited; and, second, while Toronto has a high share of pervious land cover, most of the natural soil has low permeability (clayey silt till or silty clay to silt till [187]), thus increasing the HHI further. Therefore, considering the current state of the land cover of these cities, urbanization has a lower effect than the change in the magnitude of rainfall intensity. Vancouver (results are shown in Figure 3.7) responded to the integrated climate change and urbanization similarly to the other two cities (an increase of HHI), but with lower values of HHI overall. The difference between the sole effect of urbanization and climate change in this city was not as significant as the other two cities. This is because Vancouver has a lower rainfall intensity compared to the other two cities, so the HHI value is about half the values for Toronto and Montreal, which decreases the effect of climate change. Note that Vancouver is more pervious compared to the other two cities, thus it has more room for urbanization (Figure 3.3).

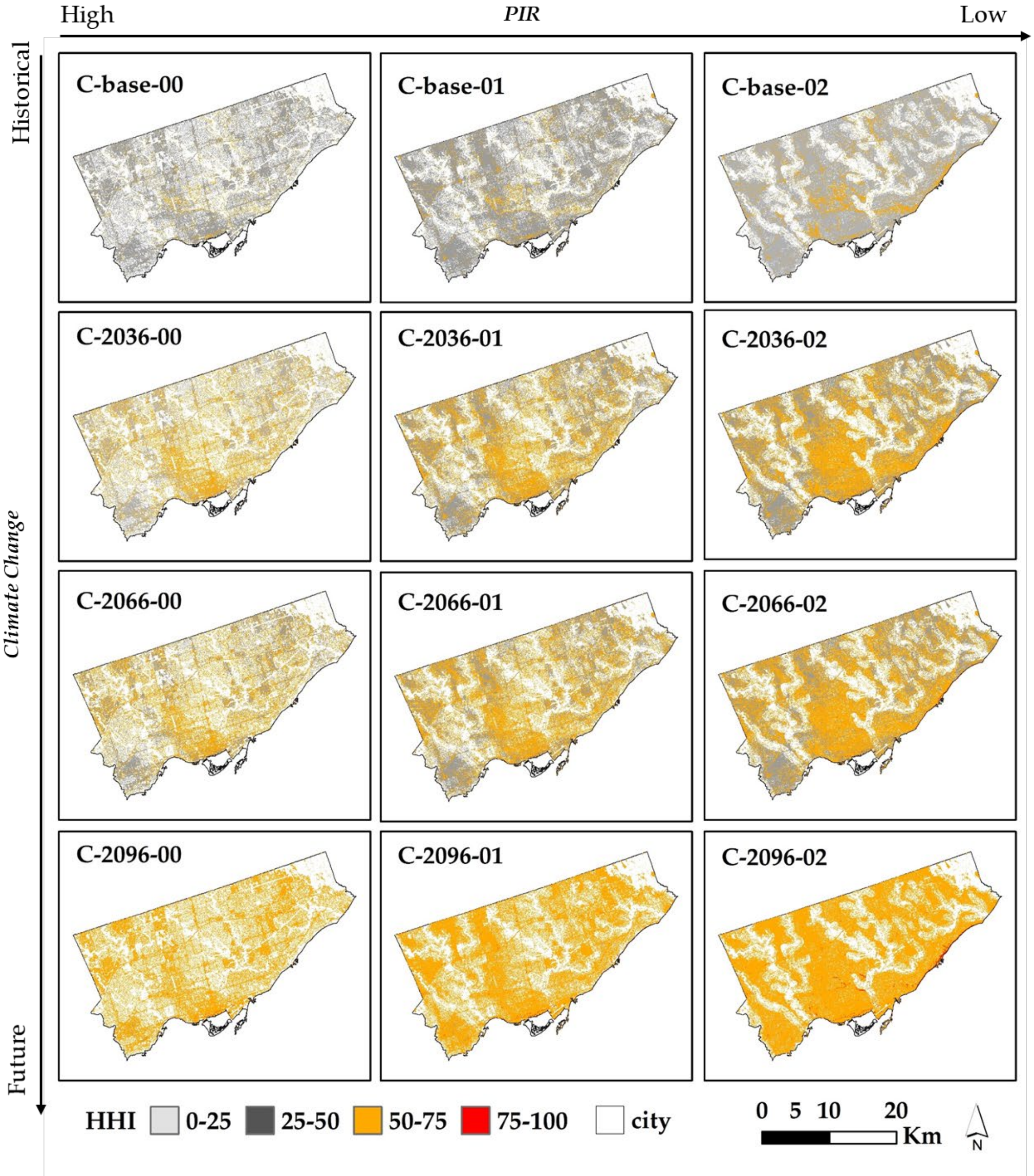


Figure 3.5 The HHI maps for Toronto under different climate (base year, 2036, 2066, and 2096) and land cover scenarios (base, Scenario 1, and Scenario 2).

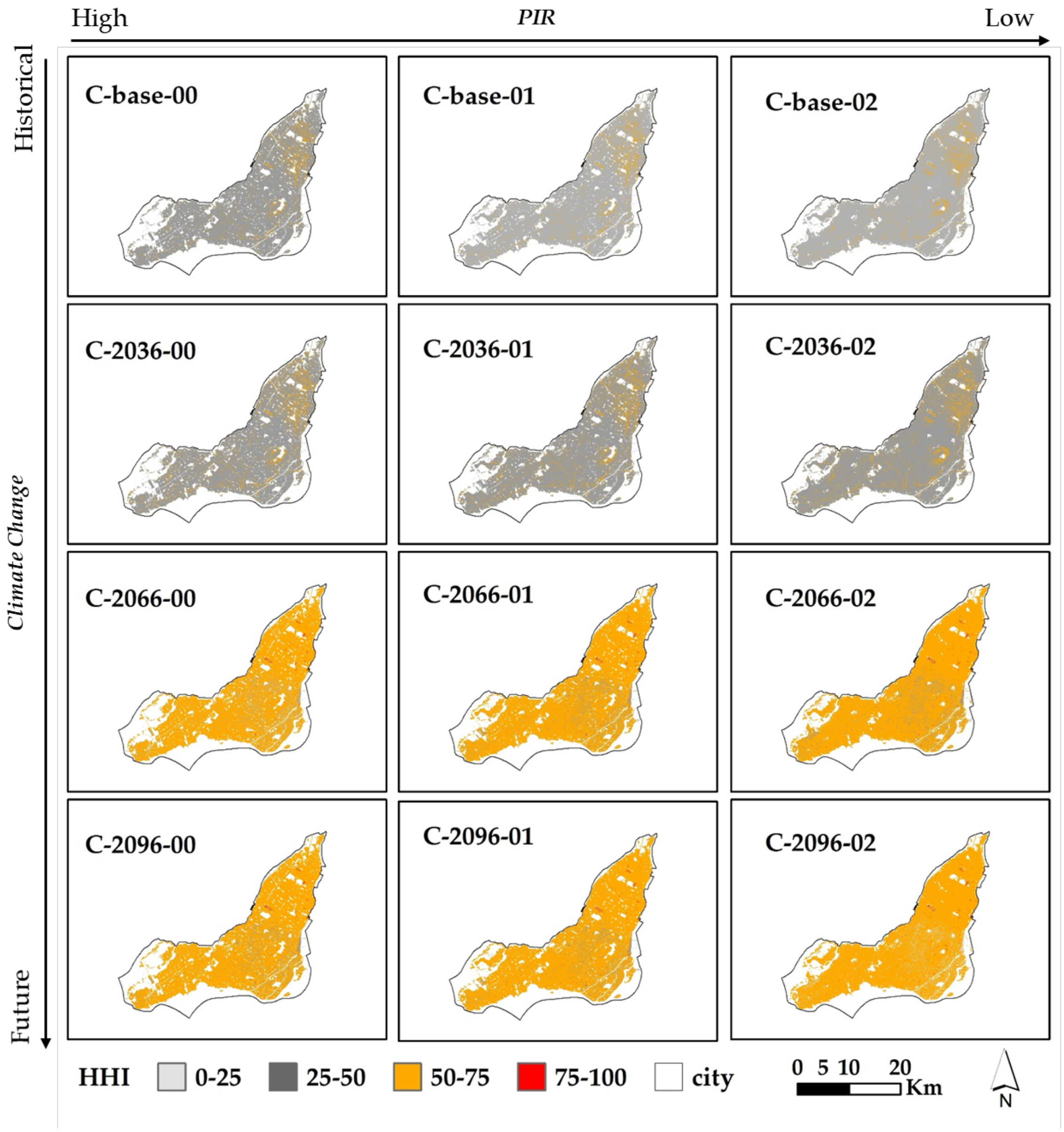


Figure 3.6 The HHI maps for Montreal under different climate (base year, 2036, 2066, and 2096) and land cover scenarios (base, Scenario 1, and Scenario 2).

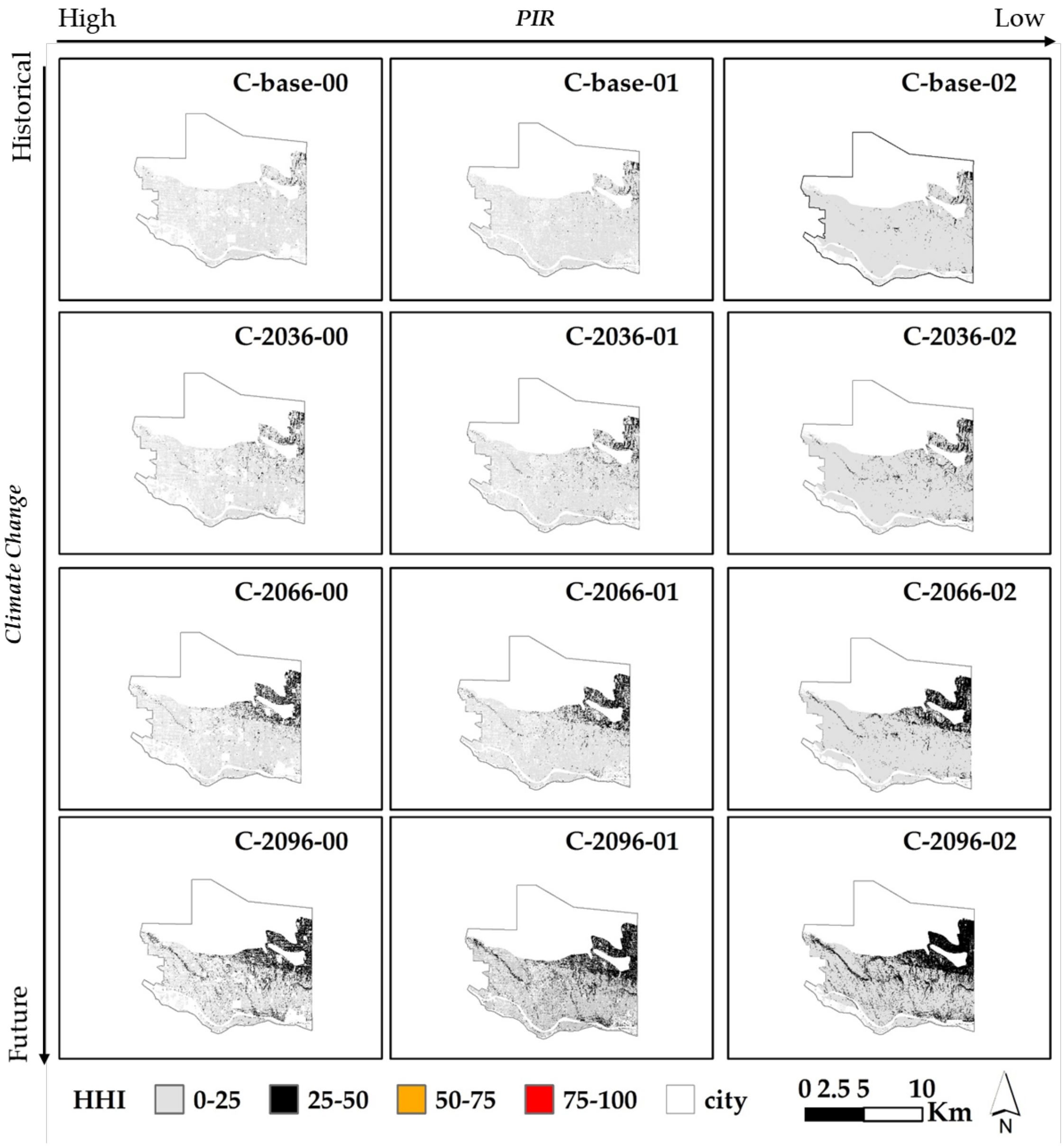
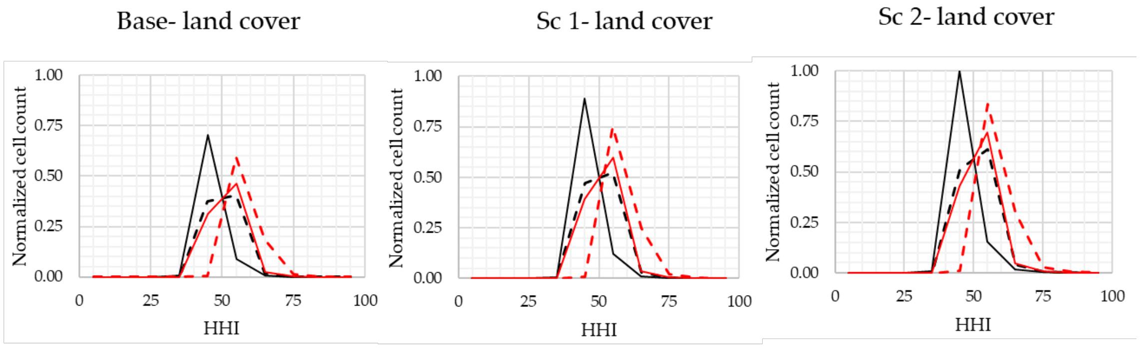
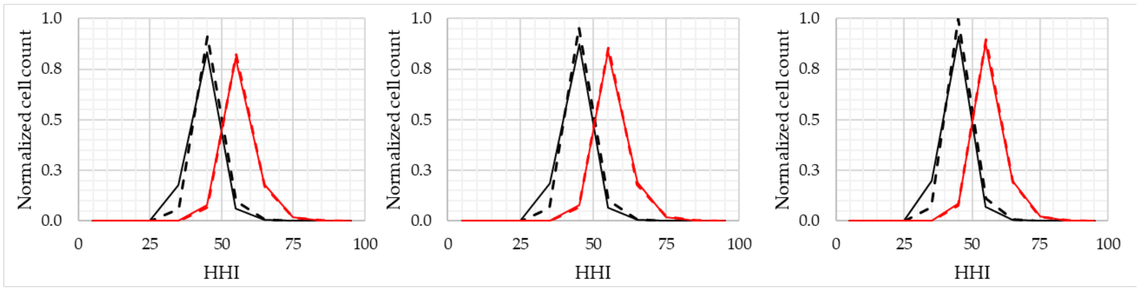


Figure 3.7 The HHI maps for Vancouver under different climate (base year, 2036, 2066, and 2096) and land cover scenarios (base, Scenario 1, and Scenario 2).

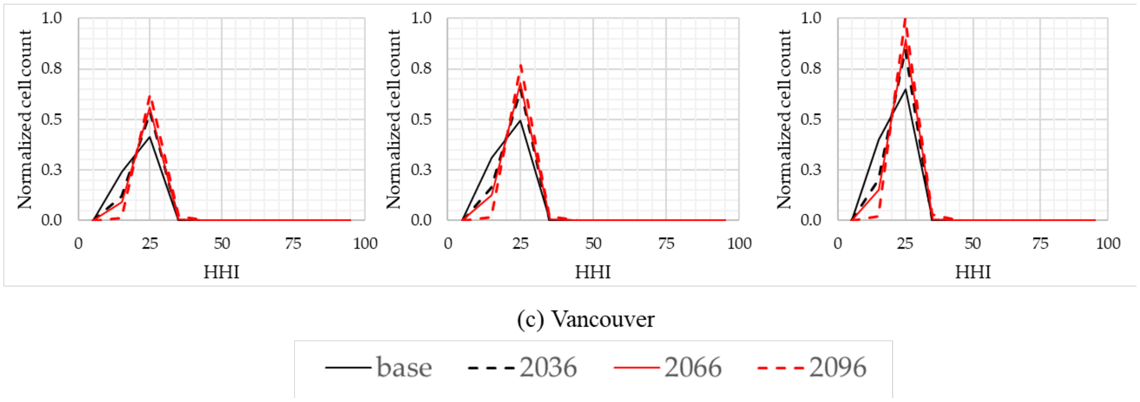
Figure 3.8 compares the histogram of HHI for each city, for each urbanization scenario, for the four climate periods. The results show that, with time (from the base time to 2096), the HHI values increase (i.e., have a higher mean), i.e., the histograms shift to the right, which indicates higher runoff generation potential and, thus, an increase in demand for LID for source control. This shift is the lowest for Vancouver compared with the other two cities. There is an exception in the observed trend in Toronto for the 2066 scenario for which the mean HHI change compared with the previous scenario (2036) is minor due to the similarity of the rainfall intensity of these scenarios. Likewise, in Montreal, Scenario 2096 has slightly followed the overall pattern because the rainfall intensity in this scenario has not increased compared with the previous scenario (2066). In addition, with urbanization, the number of cells (i.e., locations within the cities) generating runoff are increasing as well. This is because pervious areas have been converted to impervious areas—and thus, are generating runoff in areas that did not under the base urbanization scenario (resulting in higher peaks of the histograms).



(a) Toronto



(b) Montreal

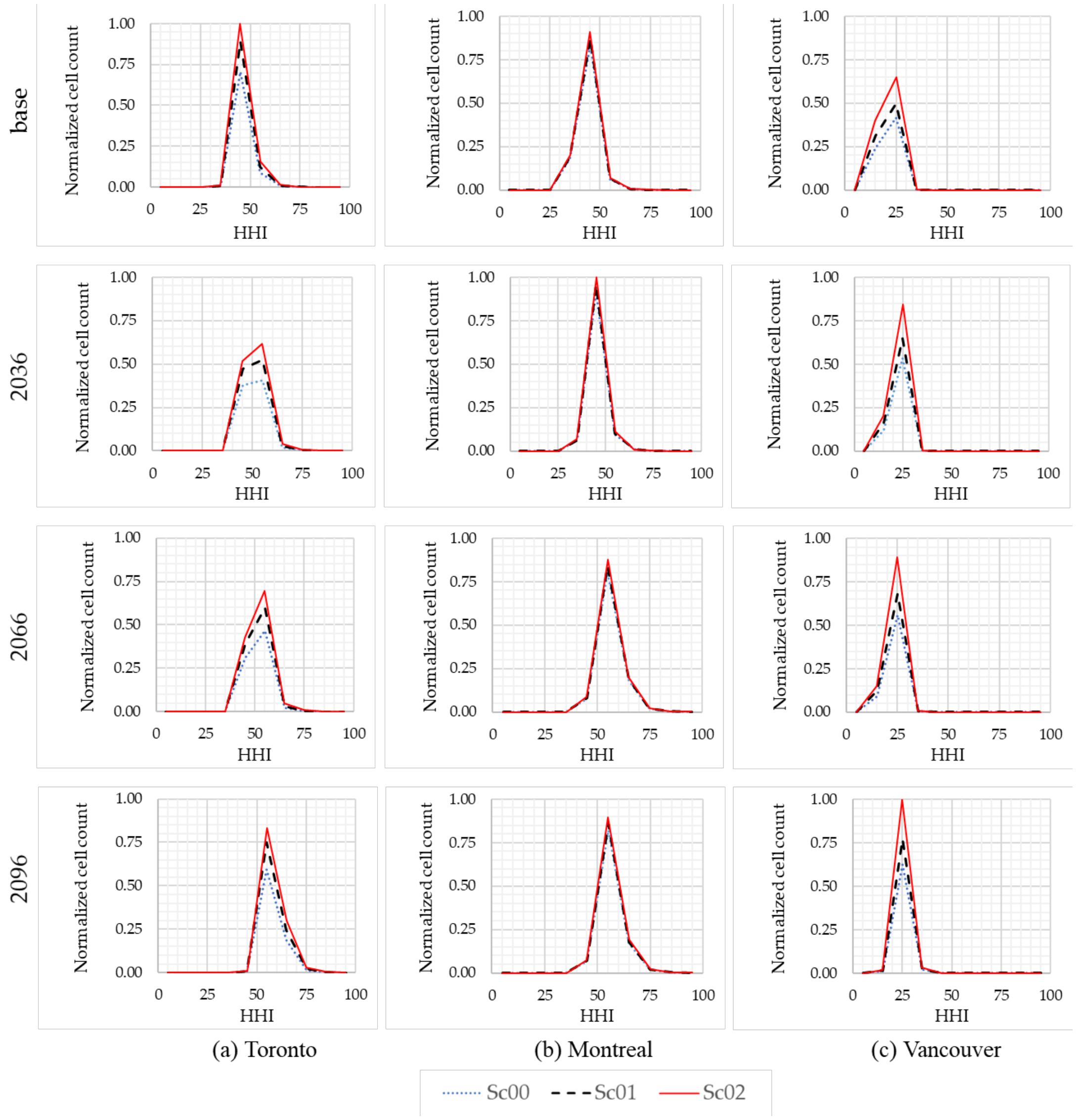


(c) Vancouver

Figure 3.8 Normalized histograms of HHI (to the maximum HHI frequency of the cities) comparing the same urbanization scenarios (base, Scenario 1, and Scenario 2) and different Climate scenarios (base, 2036, 2066, and 2096) for: (**a**) Toronto; (**b**) Montreal; and (**c**) Vancouver.

Figure 3.9 shows a comparison of the climate change scenarios (i.e., rainfall intensity) for each city versus the different urbanization scenarios. This figure demonstrates that the change in climate has a relatively minor impact on the HHI frequency, as compared to the results shown in

Figure 3.8. An increase in urbanization results in an increase in the frequency of HHI as well as an increase in the number of cells generating runoff; this is more evident in Toronto and Vancouver than in Montreal. While the increasing rainfall intensity for each city results in higher HHI values for each urbanization scenario, the change is relatively smaller than the effect illustrated in Figure 3.8.



(a) Toronto (b) Montreal (c) Vancouver

Figure 3.9 Normalized histograms of HHI (to the maximum HHI frequency of the cities) comparing the same climate scenarios (base, 2036, 2066, and 2096) and different urbanization scenarios (base, Scenario 1, and Scenario 2) for: (a) Toronto; (b) Montreal; and (c) Vancouver.

A comparison of all scenarios was conducted to determine the influence of urbanization and climate change on the magnitude of the area of sites that have a high demand for LID (referred to as high demand sites, HDS). To do this, the area of sites that have a value of HHI greater than a threshold value was calculated. The threshold was set at an HHI value of 50 for Toronto and Montreal and an HHI value of 20 for Vancouver (these values are the approximate mean HHI value for the C-base-00 scenario for each city). The area of HDS (AHDS) sites, the count of cells with an area of 25 m^2, was calculated for all scenarios and compared to AHDS of the baseline C-base-00 scenario. This comparison is shown in Figure 3.10.

Overall, in Figure 3.10, all three cities show an increasing trend of AHDS under integrated climate change and urbanization as well as the sole effect of these scenarios. The overall pattern under the climate change only scenarios is similar to the corresponding rainfall patterns in Table 3.2. For Toronto, urbanization seems to have a slight effect on AHDS, e.g., starting from 1.4 million cells for C-base-00 and reaching 2.5 million cells for C-base-02. In contrast, an increase in rainfall intensity due to climate change has a significant influence on increasing AHDS, e.g., the AHDS is 11.5 million cells for C-2096-00 and rises to 16.9 million cells for C-2096-02. Montreal presents similar behavior as Toronto; the AHDS of this city also has a notable increase with time for different climate scenarios. However, Vancouver's responses to climate change are similar to the impact of urbanization (from 1.2 million to 1.9 million cells in both cases) and are lower than in the other two cities. The reason is related to the low rainfall intensity of this city, which is a key difference between Vancouver and the other two cities.

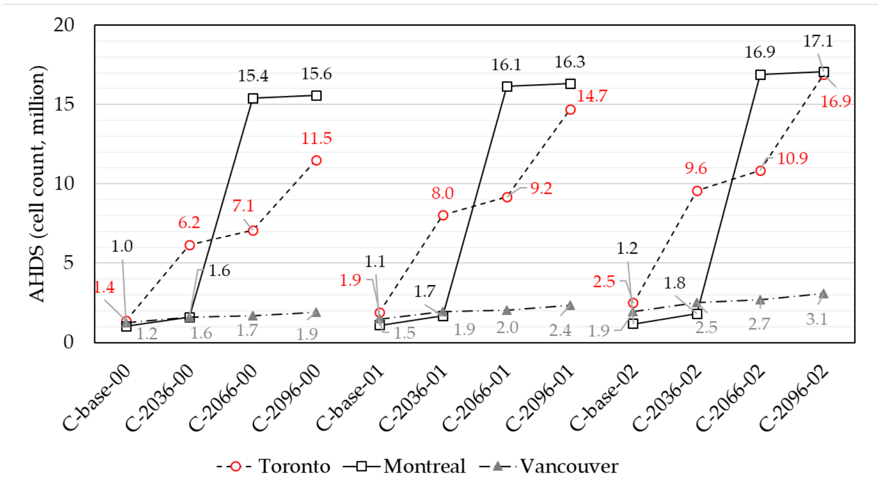


Figure 3.10 The total count of cells with HHI greater than the mean HHI for Toronto, Montreal, and Vancouver.

To further investigate the sole effect of urbanization and climate change on each city, the normalized histogram of the worst-case climate change scenario (C-2096-00) versus the worst-case urbanization scenario (C-base-02) was compared, as presented in Figure 3.11. As concluded above, in response to the effects of climate change, Toronto and Montreal present an increase of HHI value with a shift of the histograms to the right, whereas this shift is lower in Vancouver. In terms of urbanization, it is evident that in all three cities the frequency of HHI has increased (i.e., higher peaks). As mentioned above, this increase is due to the increase in the number of cells that are generating runoff (non-zero runoff cells).

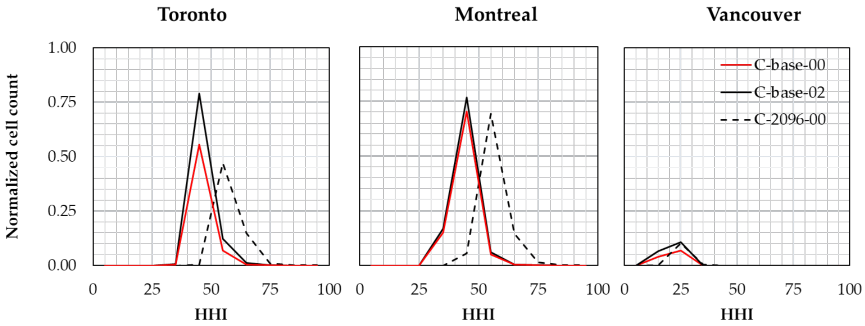


Figure 3.11 Normalized histograms of HHI (to the maximum count of three cities) of base scenario (C-base-00), the worst case of only the climate change scenario (C-2096-00) and the worst case of only urbanization (C-base-02) for the three cities (Toronto, Montreal, and Vancouver).

The trend of the mean HHI values for each city for all scenarios was also analyzed and is presented in Figure 3.12. The base scenario (C-base-00) shows that Toronto has a high HHI with a mean of 46.2. The mean HHI increases to 57.7 (a 24.9 % increase) due solely to climate change (C-2096-00) and slightly rises to 46.6 (a 0.9 % increase) solely with urbanization (C-base-02). The integrated influence of climate change and urbanization raises HHI to 58.2 (C-2096-02) (a 26.0 % increase). These results show that in Toronto the increase in mean HHI is due to climate change rather than urbanization. This is because the city has a high rainfall intensity, and the natural soil has low permeability. The consequence of increasing the HHI is that the total area of sites that need LID is increasing (since more sites are generating runoff). In this respect, the AHDS of C-base-00 for this city is 1.4 million cells (0.2 % of the city area) and reaches 11.5 million cells (8.4 times higher than the C-base-00) with the change of climate (C-2096-00). On the other hand, the AHDS growth is 78.6 % by reaching 2.5 million cells with urbanization (C-base-02). The integrated effect of climate change and urbanization increases AHDS to 16.9 million, which is 12.3 times higher than AHDS of the current state.

Montreal has a mean HHI of 44.0 in the state of the base scenario. This value rises to 56.4 with only climate change (a 28.2 % increase) and remains almost unchanged with only urbanization. The integrated effect of climate change and urbanization causes the increase of HHI value to the 56.4 (a 28.2 % increase), which reveals the significant and dominant effect of climate change on HHI in Montreal. The highly urbanized land cover of Montreal leaves limited room for more urbanization; thus, the land cover of this city has a limited change in Scenarios 1 and 2. Thus, HHI in Montreal is more sensitive to climate change scenarios rather than urbanization. Regarding AHDS, in the base scenario, Montreal has AHDS of 1.0 million cells, which increases to 15.6 million cells with only climate change and 1.2 million cells with only urbanization. The AHDS for this city rises to 17.1 million cells in the integrated climate change and urbanization scenario.

The mean HHI value for Vancouver at the base scenario is 21.3, and this increases with climate change to 25.1 (a 17.8 % increase) and remains unchanged with urbanization. The mean HHI rises to 25.1 (a 17.8 %) for the integrated climate change and urbanization scenarios. The AHDS for this city at the current state is 1.2 million cells (0.9 % of the city area), which increases to 1.9 million cells (1.6 times higher than the C-base-00) for only climate change scenarios and to 1.9 million cells (1.6 times higher than the C-base-00) for only urbanization scenario. The integrated climate change and urbanization scenario raises AHDS to 3.1 million cells, i.e., 2.5 times higher than the AHDS of the base scenario. The near-equal values of AHDS under the climate and urbanization scenarios indicate that the effect of both factors on HHI is similar. Although the mean HHI of urbanization scenarios remained the same, the increase of frequency of HHI has increased the overall AHDS.

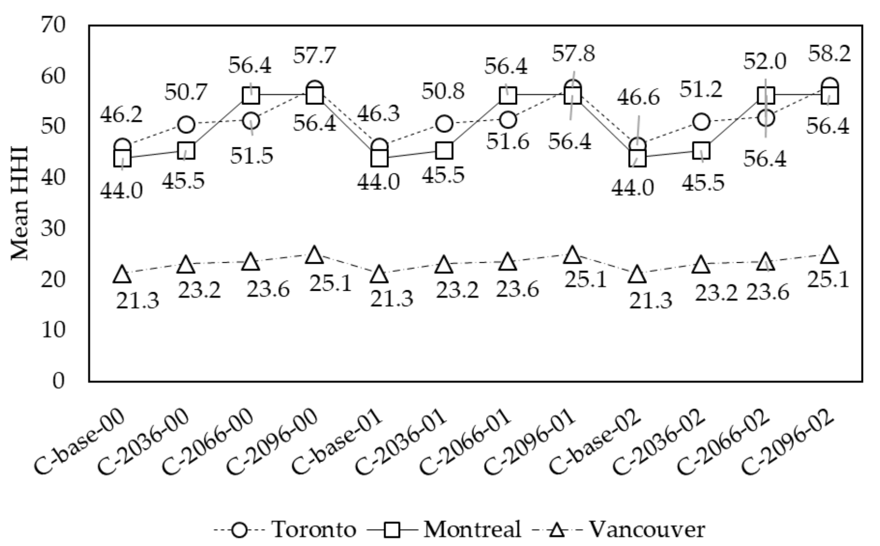


Figure 3.12 Comparing the trend of mean HHI of all twelve scenarios in Toronto, Montreal, and Vancouver.

3.6. DISCUSSIONS

An overall comparison of the cities reveals the fact that the demand for LID (which is estimated using the HHI) in Toronto and Montreal is relatively similar and is about twice the demand for LID in Vancouver. This growth in demand is represented via AHDS: the AHDS increases from 2.5 % to 16.8 %, from the base scenario (C-base-00) to the worst-case scenario (C-2096-02), respectively, for all three cities, which indicates that all cities similarly respond to the integrated climate change and urbanization scenarios. The highest growth in AHDS is for Montreal (16.8 times higher than the C-base-00), followed by Toronto (12.3 times higher than the C-base-00), and last Vancouver (2.5 times higher than the C-base-00). The growth in LID demand is also shown in the increase of the mean HHI values, which increased by 26 %, 28.2 %, and 17.8 % in Toronto, Montreal, and Vancouver, respectively. In addition, we showed that the demand for LID highly depends on the rainfall intensity rather than the overall mean annual rainfall. Vancouver, which has the highest mean annual precipitation among the selected cities, has the lowest demand for LID, which is due to its low rainfall intensity.

Generally, we showed that, if we retain the land cover as it is in these three cities, climate change will cause an increase in demand for LID since the runoff generation potential for each city will increase. With climate change only, urbanization only, and an integrated change of both, the three cities showed similar behavior: an increase in HHI, which indicates an increase in runoff generation potential, as has been reported in previous studies [188]–[194].

However, the standalone effects of climate change and urbanization were different for these cities. Toronto and Montreal were more sensitive to climate change compared with urbanization, and Vancouver was sensitive to both factors. Thus, depending on the rainfall intensity and the extent of urbanization in the study area the dominance of these two factors varies. Which factor is likely to have a greater influence on runoff generation has been reported in previous studies? Some studies found that urbanization likely exerts a greater impact on runoff than climate change [189], [195]–[197], whereas other studies confirmed that climate change impact dominates the urbanization in runoff change [191], [193], [194]. Our finding is that the key factor is the rainfall intensity. Based on this, climate change dominates urbanization levels wherein the rainfall intensity is high (e.g., Toronto and Montreal) and adversely wherein the rainfall intensity is low (e.g., Vancouver). It is notable that, if the land cover of the study area is already impermeable (such as Toronto and Montreal), the dominance of climate change increases. In this context, the room for further urbanization is limited and climate change is the only factor that can alter the runoff.

In this study, we investigated the effect of poor urbanization by converting pervious land covers to impervious. By poor urbanization, we mean urban development by increasing impervious surfaces without either decreasing imperviousness in other locations or implementing LID. Therefore, for future research, we suggest the study of more city-scale cases such as areas with both high permeability and runoff intensity (which were not included in three case studies) to further investigate the dominance of urbanization and climate change.

In addition, in contrast to the poor urbanization scenarios, a study on smart urban growth [22] is recommended. From the hydrological point of view, smart growth consists of measures such as preventing urban sprawl in future development (e.g., poor urban planning such as designing wide streets) [22] as well as using integrated stormwater management strategies such as LID [198]. Smart growth is related to the early stages of urban planning [198] and strategies that need to be considered for future development. LID techniques, a component of smart growth, can be a solution for both pre- and post-development conditions, i.e., they can be retrofitted into highly urbanized areas or be designed in the initial planning stages of new developments. Cities similar to Montreal that are already highly urbanized have limited options for new developments wherein LID can be installed; however, LID can be retrofitted into existing areas. Retrofitting LID broadly across the city will help reduce the negative impacts of poor urbanization by increasing the overall permeability of the city. Cities such as Toronto, which are not as highly urbanized and have low permeability of the natural soil, have a high demand for LID. Thus, for this city, smart growth for future development as well as retrofitting existing areas with LID are both viable options. For Vancouver, which has a low demand for LID compared to the other two cities, the actual need for LID should be investigated in more detail using detailed design studies and hydrological modelling. However, similar to the other two cities, smart growth is suggested since there is demand for LID and the impervious land cover in the city is dominant (61 % of the city area).

Overall, the future urban growth (increase in the proportion of impervious surfaces) needs to be limited in order to reduce the runoff generation potential, and, hence, the risk of urban floods. Additionally, where possible, the current impervious land cover should be converted to natural, permeable surfaces. The increase in permeability (through the use of LID techniques) will help reduce runoff generation and offset the impacts of urbanization and climate change impacts.

3.7. CONCLUSIONS

In this study, we investigated the effect of climate change and urbanization on urban runoff generation potential using a geospatial framework for three Canadian cities (Toronto, Montreal, and Vancouver). The analysis was performed using a recently developed geospatial index (called HHI) using publicly available data. Four climate change scenarios (base, 2036, 2066, and 2096) and three urbanization scenarios (base land cover, Scenario 1, and Scenario 2) were developed. The HHI was estimated for the three cities for the 12 integrated climate change and urbanization scenarios.

In our study, we showed that climate change increases the mean HHI of the study area while urbanization raises the frequency of HHI. The extent of these changes varied based on the study area. Those with high rainfall intensity (Toronto and Montreal) showed a more significant increase in mean HHI compared with the study area with low rainfall intensity (Vancouver). In addition, the current impermeableness and room for further development within a city affected the extent of increasing the frequency of HHI.

The results agree with previous findings on the influence of climate change and urbanization on increasing the runoff and hence, the demand for LID. However, the magnitude of the effect of climate change and urbanization on the HHI varied in each city, which is also in agreement with results of previous studies. For example, in cities such as Toronto and Montreal with high rainfall intensity and low permeability, climate change is a dominant factor compared with urbanization. This is different from Vancouver that has low rainfall intensity climate change and urbanization level. In this city, HHI is sensitive to both factors. We also concluded that Toronto and Montreal have a higher demand for LID, and this increases significantly with climate change and urbanization. Vancouver has a lower demand for LID and a lower rate of HHI change with the scenarios. The results of this study provide us with an insight into the contribution and the effect of climate and urbanization on the demand for LID.

These results, and the proposed methods, can be used in flood management, urban planning and for the sustainable development of cities. It is notable that, in addition to the rainfall and urbanization, HHI accounts for hydraulic conductivity, depth to the groundwater, and depth to the soil restrictive layer such as bedrock. In this study, we only investigated the effect of climate and urbanization on HHI and demand for LID, whereas modification of those parameters (hydraulic conductivity and depth to groundwater) in the future is possible and should also be studied.

CHAPTER 4: A SIMPLIFIED GEOSPATIAL MODEL TO RANK LID SOLUTIONS FOR URBAN RUNOFF MANAGEMENT

4.1. PREFACE

The focus of this chapter is the third sub-objective, developing a systematic and simplified geospatial model for ranking LID solutions (where and what type of LID to install) to maximize LID benefits. The model in this study is referred to as the LID-Solution Evaluation and Ranking ApproacH (SERAH). The LID demand index (LIDDI) developed in Chapter 2 was modified and enhanced to rank LID solutions. As a result, this chapter introduces SERAH to rank the LID solutions by incorporating the key contributing criteria (including LID benefits (hydrological, environmental-socioeconomic), cost, feasibility, and demand of the subcatchment). The applicability of SERAH is tested for a study area within the City of Toronto using a stormwater model (PCSWMM).

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Contributions:

The contributions of authors in the current chapter are as follows, **Sarah Kaykhosravi**: has conducted the literature review, performed the data collection and curation, developed the method, used the required software to perform the analysis and modelling, validated and visualized the results, and have prepared and wrote the original manuscript of this publication. **Usman Khan** has supervised the research, provided the funding, contributed to the development of the method, writing, and editing the manuscript. **Mojgan A. Jadidi** has supervised the research, provided the funding, contributed to the development of the method, writing, and editing the manuscript.

4.2. ABSTRACT

Many studies have shown the usefulness of Low Impact Development (LID) for runoff management in urban areas. However, there exists a gap for a systematic decision-making model to rank LID solution (where and what type of LID to install). In this research, a physics-based GIS-MCDM model is proposed, which we refer to as the LID-Solution Analysis and Ranking ApproacH (SERAH). SERAH integrates the key contributing criteria including LID benefits (hydrological, environmental-socioeconomic), cost, feasibility, and demand for LID within a subcatchment. The effectiveness and applicability of SERAH are demonstrated through modelling a catchment in the City of Toronto. Three types of LID (rain garden (RG), infiltration trench (IT), and porous pavement (PP)) were selected for the study. The LID solutions were ranked using SERAH. To test the effectiveness of SERAH, the hydrological performance of the ranked solutions

was estimated using a stormwater management model (PCSWMM). In PCSWMM nine scenarios including a base scenario (no LID installed in any subcatchment) and eight LID scenarios in which one type of LID (with identical design parameters and size) was implemented in individual subcatchments iteratively. The results demonstrated that the ranks of SERAH correspond to the best hydrological performance of stormwater model. The ranked subcatchments, in order, reduced the runoff volume by 9.8, 11.3, 9.0, 8.9 percent and peak runoff by 19.9, 10.4, 13.4, 1.3 percent compared with the base scenario, a catchment with no LID. In ranking the LID types, IT was ranked the highest amongst the three types for the 16 of the 19 subcatchments of the study area. The cost of LID was identified as a key factor in changing the rank of the LID type. However, in the remaining three subcatchments, the socioeconomic-environmental benefits of RG outweighed its higher cost. Thus, for these three subcatchments RG was identified as the highest-ranked LID type. The effect of different rainfall durations, frequencies, and temporal patterns on the performance of the highest-ranked LID solution suggested that LID provide higher performance in more severe events. SERAH lends itself to the scenario development for stormwater models and strategic planning for multifunctional sustainable infrastructure. It also suggests that future research is needed to better quantify the LID socioeconomic and environmental benefits to improve SERAH.

4.3. INTRODUCTION

Urban stormwater infrastructure such as LID (e.g., bioretention cells, rain gardens, green roofs, and permeable pavements), are used for detaining or retaining excessive rainfall (runoff) which in turn decreases runoff volume and peak flow rate also delays the time to peak in the drainage system downstream [21], [25], [29]. The primary benefits of most types of LID is its hydrological benefits such as runoff peak and volume reduction [21], [25], [29], [57], [93], [94], and recharging groundwater [35], [199]. Also, many lateral benefits such as environmental and socioeconomic are associated with some types of LIDs [30], [200]. Examples of environmental benefits are improved water quality, decreased air pollution, and enhanced biodiversity [56], [57], [59], improving microclimates [38], mitigating urban heat island [39], [40]. Examples of socioeconomic benefits include access to amenities and green spaces, rainwater harvesting, enhancing health, and improving educational results [33], [34].

These benefits could be increased by ranking LID solutions based on the accrued benefit. A high-ranked LID type provides the highest ratio of benefits to cost compared with other feasible types of LID in a specific subcatchemnt. A high-ranked feasible subcatchment has the highest demand for LID benefits (primary and lateral LID benefits). Conventionally, to answer the question where to install LID, the focus typically goes toward determining locations wherein implementing LID is feasible (e.g., [109], [201]). The feasibility criteria are usually set by regulatory bodies through guidelines and standards. However, the link between the demand of subcatchments for LID and the benefits provided by each type of LID is typically overlooked. The demand for LID types is different from one subcatchment to another. Thus the benefit of one type of LID varies in different subcatchments [86], [100], [152], [202]. For example, if in a specific subcatchment, a green space in any form is not in high demand, implementing a green roof would not be the preferred option compared with much less expensive LID types such as rain barrels [203], [204]. As such, the cost of each type of LID is another factor that affects identifying the optimal LID solution. To identify an optimal LID solution at the catchment scale, it is necessary to systematically consider the feasibility of implementing LID, the demand of subcatchment for

LID, and the cost and benefits associated with LID types.

Most of the previous studies have used the scenario-based approach (e.g., [205] and [206]), which is a traditional iterative (trial and error) method for ranking the LID solutions. In these types of studies, several LID solutions are generated and compared, and the most hydrologically efficient one is selected. The combinations are typically selected based on the geospatial feasibility criteria for implementing LID along with other intuitive criteria such as managerial decision or expert judgment. These scenarios are evaluated using a stormwater model and their performance is compared to rank the scenarios. For example, Simperler et al. (2020) [205] have ranked the LID solution using the results of a stormwater model (using hydrological performance as the metric) and through iterative modelling of potential locations for LID and types of LID based on expert judgment. Radinja et al. (2019) [206] also introduced a multicriteria framework to evaluate the hydrological performance of seven different scenarios. In their approach, the location and types of LID were identified by preliminary placement constraints such as flooding rate and space availability. In both studies, lateral benefit and the cost of each scenario were not considered.

Other similar studies further have focussed on the role of cost in ranking LID solutions. These studies have investigated the trade-off between the cost and benefit of LID solutions with a particular focus on runoff reduction, e.g., [76], [207]–[209]. For example, Lee et al. (2020) [76] focused on the cost-effective design of LID by coupling an optimization model with the SWM. In their method, in addition to the runoff reduction, improvement of water quality (as a lateral benefit of LID) was also considered. Jia et al. (2013) [210] ranked different LID types using their reported primary and lateral benefits (via synthesizing the information from research literature and reports). These benefits were not linked to the geographical location and demand. This linking is important since we need to assess whether there is a demand for each of the LID benefits (e.g., is there a need for a plant-based solution or not?). Considering this demand could improve the cost-effectiveness of the LID solution.

A few other studies have used Multi Criteria Decision Making models (MCDM) (e.g., [99], [210], [211]) to rank LID solutions. For example, Ariza et al. (2019) [99] used an MCDM system (not GIS-based) to integrate more significant factors such as the lateral benefit of LID and suggests LID solutions. Similarly, Jia et al. (2013) [210] introduced a multi-criteria selection index system (MCIS), which in a tabular format, quantifies and overlays multiple criteria (e.g., impact of LID types on water quantity and quality) to rank LID solutions. Likewise, Hager et al. (2015) [211] created the One Water Stormwater Planning Framework (OWSWPF) with a focus on identifying the most cost-effective LID solution. OWSWPF defines the target water balance distributed among LID, stormwater collection networks, and water reuse. Then ranks the LID solutions using a MCDM model (not GIS-based) overlaying the results of a simplified water balance model, LID benefits, and LID cost under various precipitation data. The MCDM model used in these studies is not GIS-based. Thus, these studies essentially have overseen the incorporation of the geospatial criteria into the MCDM process for ranking LID solutions. Also, the decision of where to implement LID is often considered as a strategic parameter and identified based on intuitive criteria.

There is a limited number of studies that have considered the use of GIS-based models to rank LID solutions (e.g., [212]–[214]). In a study, Tecca et al. (2021) [212] developed a GIS-based MCDM model to rank locations that demand for LID using their developed hydrological index. The focus of their method was mainly on hydrological benefits of LID, the geospatial feasibility for implementing LID, and lateral benefits of LID were overseen. Fletcher et al. (2021) [213] has used a GIS-based (raster discretization) models to identify high-demand cells for LID. Ranking types of LID and the hydrological benefit were neglected in their framework. In another similar study, Hou et al. (2020) [214] proposed a GIS-based optimization algorithm to prioritize LID scenarios. The objective of their algorithm was to maximize the hydrological performance and pollution treatment and minimize the total cost of different types of LID. Unlike many other studies for estimating the hydrological and water quality performance, the conventional stormwater modelling approach was replaced by a GIS-based model. Their GIS model uses pixel discretization and assumes that each type of LID has a ratio of performance. The optimal scenario in their study was identified using the results of the calculated GIS-based performance against the cost of different scenarios. The popularity of the development of GIS-MCDM models in recent years demonstrates their effectiveness and usefulness to address ranking LID solutions. As noted by Nguyen et al. (2020) [20] in their recent review on the topic, there is very limited research that has integrated all contributing factors through a systematic framework to identify an optimal LID solution in a catchment.

In this research, a systematic and simplified geospatial model referred to as LID Solution Evaluation and Ranking ApproacH (SERAH) is proposed. SERAH ranks the LID solutions (where and what type of LID to install). The novelty of SERAH lies in its ability to incorporate physic principles and the MCDM model to meet urban stormwater management goals. SERAH uses a geospatial system and includes key contributing criteria. These criteria include LID benefits (hydrological, environmental-socioeconomic), cost, feasibility, and demand of the subcatchment. SERAH is applicable in all catchments and has not been customized for a specific catchment. To demonstrate the practical aspect of the proposed approach, it was applied to a highly urbanized catchment within the City of Toronto. Three types of LID (rain garden (RG (essentially a bioretention cell without drainage through an underdrain pipe)), infiltration trench (IT), and porous pavement (PP)) were selected and ranked for the study. This allowed us to demonstrate the applicability of SERAH in a real-world case study. It offers a systematic objective solution as an alternative to the traditional intuitive (subjective) solutions. SERAH can further be incorporated into decision support tools for making rigorous sustainable urban planning and decisions. This paper is organized as follows: Section 4.4 presents the method and the case study. Section 4.5 includes the results and discussion, and Section 4.6 follow with a conclusion.

4.4. METHOD

4.4.1. Develop the LID-Solution Evaluation and Ranking ApproacH (SERAH)

SERAH was designed to integrate the key criteria that contribute to the decision of ranking LID solutions. As shown in Figure 4.1, it includes three components: (a) feasibility of subcatchments for implementing LID; (b) hydrological-hydraulic demand of subcatchments and the cost of each LID type; and (c) socioeconomic and environmental demand of subcatchments for each type of LID, and benefit offered by each LID type. SERAH uses publicly available data that conventionally has been used for stormwater modelling purposes.

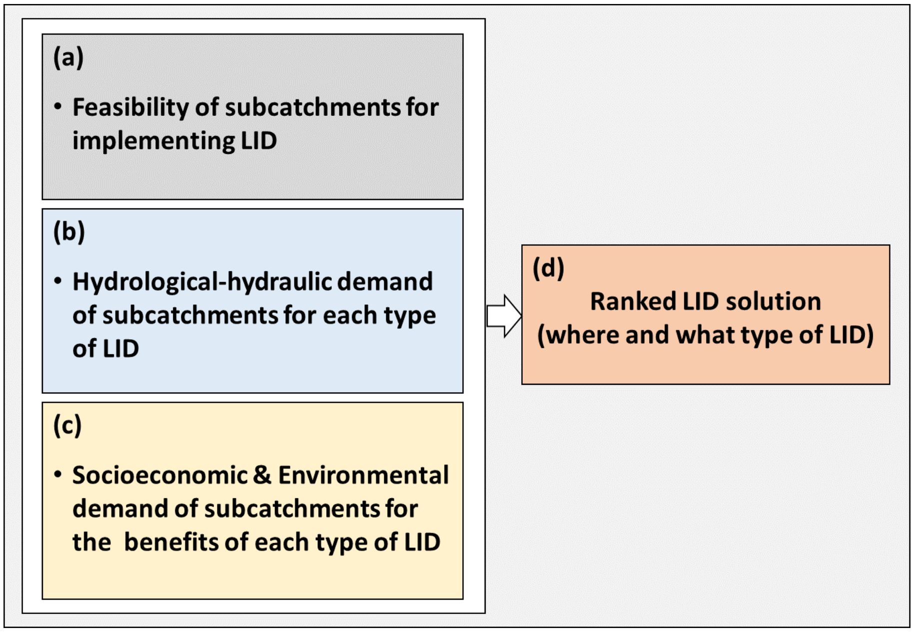


Figure 4.1 The conceptual schematic of SERAH for ranking LID solutions with its three components

Component (a) of the model identifies the feasible subcatchments for implementing LID using geospatial analysis. In this study, we have identified the feasible subcatchments in two stages. First, all data were converted to raster format where the raster consists of cells with a size of 5 m by 5 m, which is the resolution of the DEM data (in other words each subcatchment is discretized into 5 m by 5 m cells and is bounded by the subcatchment boundary which is defined by the DEM). Then the feasible cells were determined through the geospatial overlaying process, which is described in detail below. Then the subcatchments within the study area that include an adequate area of feasible cells were considered as feasible subcatchments.

Identifying feasible cells is commonly performed by geospatial overlaying methods considering the geospatial criteria (e.g., the slope of the cell, land cover, etc.) and constraints (e.g., the slope should be less than 0.5 %). These criteria and constraints are usually set by regulatory bodies through guidelines and standards (e.g., [99], [109], [175]).

Three types of LIDs were selected for this study (RG, IT, and PP) to be implemented and ranked by SERAH in each feasible subcatchments. These are the types of LID that are implementable in open spaces (rather than on buildings like green roofs). For these three types of LID, the feasibility criteria were identified based on the Toronto and Region Conservation Authority (TRCA) [175] recommendations which is the governing regulator authority of the selected case study (Section 4.4.2). We collected the required geospatial datasets, performed the data preparation and cleansing, segmented the study area as cells, performed multiple geospatial integration processes based on the criteria, and identified the feasible cells.

Based on TRCA recommendations, the locations (individual cells within a subcatchment) wherein LID is to be implemented (for RG, IT, and PP) need to meet the following criteria. The cells should have a slope of less than 5%. IT and RG need to have a minimum ratio of contributing drainage area to LID area of 5:1; this ratio can be 1:1 for PP. The maximum contributing drainage to LID area ratio should be 20:1, 10:1, and 1.2:1 for IT, RG, and PP, respectively. A setback of 4 m from buildings and be at least 1 m above the seasonal water table are recommended. The focus this study was on the conventional feasibility criteria. Thus, other TRCA recommendations, such as the hydrologic group of soil type, proximity to underground utilities, wellhead protection, pollution control based on land use, etc. are assumed to be met for simplicity. Also, subjective or practical feasibility criteria such as considering existing green spaces as a potential LID location was not considered.

The required datasets to analyze and identify feasible locations (individual feasible cells within a subcatchment) were Digital Elevation Model (DEM), land cover, and groundwater depth data. From the raster format DEM data (with a resolution of 5 m) the slope data was created and cells with a slope less than 5 % were extracted. Using the DEM data, we identified the cells that met the requirement of minimum ratio of contributing drainage area to LID area (5:1). This requirement ensures that the IT and RG receive a minimum runoff from the upstream. Although PP does not have the same requirement (according to the TRCA (2010) guideline), to attain the same feasible cells for all three types of LID (for simplicity) we considered the same limitation for the PP as well. Without such an assumption, the number of feasible cells for PP would be higher, which will suggest PP as the only option for some of the subcatchments. Our focus in this study was on ranking subcatchments that are feasible for implementing all three types of LID. Investigating more complex scenarios (subcatchments are feasible for implementing an unequal number of LID alternatives) is suggested to be conducted using SERAH in a future study.

To extract the cells which meet the minimum ratio of contributing drainage area to LID area (5:1) the following process was performed. The flow direction, which shows the direction of flow at the cell to its steepest downslope neighbour was generated using DEM data. The result was used to create the flow accumulation raster. The flow accumulation represents the accumulated weight of all cells into each downslope cell. In the flow accumulation raster, the most upstream cell is assigned a weight of 1. For example, a weight of 5, shows that 5 upstream cells drain into the cell (contributing drainage area is 5 times the cell area). On this basis, the cells with a weight of 5 and greater can at least drain 5 upstream cells. These cells were identified and extracted.

Cells with a setback of 4 m and less from buildings were screened out using a 4 m buffer around the building cells (in raster data). Similarly, cells with a water table depth of 1 m and less were eliminated from the potential feasible cells. These analyses provided us with four data sets, each representing the feasible cells according to each criterion. These data sets were geospatially overlaid using a geospatial intersection operation. As a result, the feasible cells that corresponded to all criteria were identified. The conceptual geospatial model of the process is presented in Figure

4.2.

Following this, the feasible subcatchments were determined. To do so, the maximum of the LID area to the contributing drainage area ratio was considered as the criteria. This ratio allows for excluding the subcatchments that contain a few feasible cells from being considered as a feasible subcatchment. The ratio of the area of feasible cells within each subcatchment to the area of the subcatchment was estimated. The selected ratio for this step was the maximum of the suggested ratios, 20:1 suggested for IT, equals to 5 % of subcatchment. Final checking for the maximum LID area to the contributing drainage area ratios suggested by TRCA for all three types was conducted during the detailed design in the stormwater modelling process.

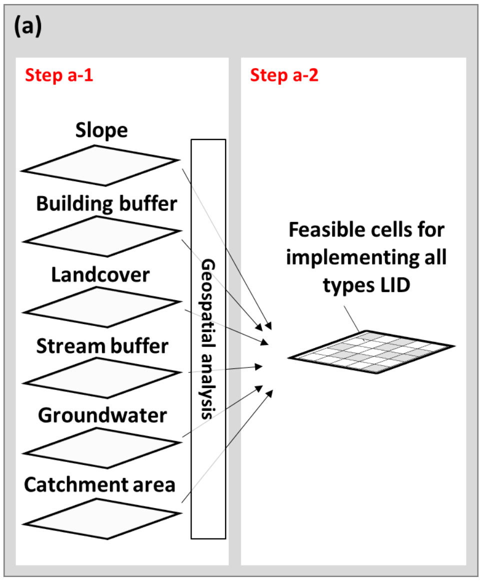


Figure 4.2 Component (a)-SERAH, the conceptual schematic for identifying feasible cells for LID, step 1: identifying the contributing data sets, step 2: generating the feasible cells data layer

The next component of SERAH, Component (b) (illustrated in Figure 4.3) was estimating and incorporating the Hydrological-Hydraulic Index (HHI) and the cost of different LID types. The HHI is a measure of the potential of a subcatchment to generate runoff [152]. Subcatchments that generate higher runoff, have a higher HHI value, and thus, have a higher demand for LID. To estimate HHI, the equation developed in [152] was used. This equation has been validated against physics-based models and is a good geospatial index for decision-making purposes. Ranking the subcatchments based on HHI values highlights the subcatchments that are the main source of runoff generation. On this basis, we can target the high HHI subcatchments for LID implementation, and thereby effectively capture the runoff at the source [152]. Since the demand for LID corresponds to the HHI values, a subcatchment with high HHI values is considered a subcatchments with high demand for LID [152]. The HHI index accounts for seven variables, as presented in Eq. 4.1. The estimation of HHI included the two following steps. First, the data were converted to raster format with the size of the DEM data, then and HHI was generated using Eq. 4.1. Second, the HHI of the subcatchments was calculated using the sum of the HHI of cells that fall within the subcatchment.

$$HHI_i = \begin{cases} \left[R_i - ((K_s)_i \cap (K_i)_i) \cap \left(n_j \times \left((D_g)_i \cap (D_r)_i\right)\right)\right] \times [1 + (tan\,S)^{0.385}] & for \quad R_i > Ks_i \\ 0 & for \quad R_i \le Ks_i \end{cases}$$

(Eq 4.1)

In Equation 4.1, i is the cell number; HHI_i is HHI at cell i; R_i is rainfall intensity (mm/h) at cell i; $(K_s)_i$ is saturated hydraulic conductivity of the surficial soil (mm/h) at cell i; $(K_i)_i$ is the hydraulic conductivity of impervious areas (e.g., roads, parking lots, and building rooftops) at cell i, which is set equal to zero for impervious cells; n_i is the soil porosity at cell i; $(D_g)_i$ and $(D_r)_i$ are, respectively, depth to groundwater (mm) and depth to the first restrictive soil layer (mm) at cell i; and S is the terrain slope (degrees) at cell i [152].

Following the generation of HHI for all subcatchments, the Hydrological-Hydraulic Cost

Indices (HHCI) for different LID types were developed. It was performed based on normalizing the HHI with the LID cost-equivalent (cost per equal volume runoff reduction, \$/m^3) as shown in Eq. 4.2 and Figure 4.3. In this study, we have used the capital cost (per equal volume runoff reduction) values derived from a study conducted by Joksimivic et al. (2014) [203] which estimated the capital cost of a single and different combination of LID types per runoff volume reduction (in \$/m^3). As noted, this cost only represents an estimate of the capital costs, and if the life-cycle costs are available, we suggest including these if possible.

$$HHCI_{i,j} = {HHI_i}/{Cost_j} \quad \text{(Eq 4.2)}$$

Where i is cell number; j is LID type number; $HHCI_{i,j}$ is the modified HHI of LID type j at cell i, HHI_i is the HHI at cell i, and $Cost_j$ is the cost of LID type j.

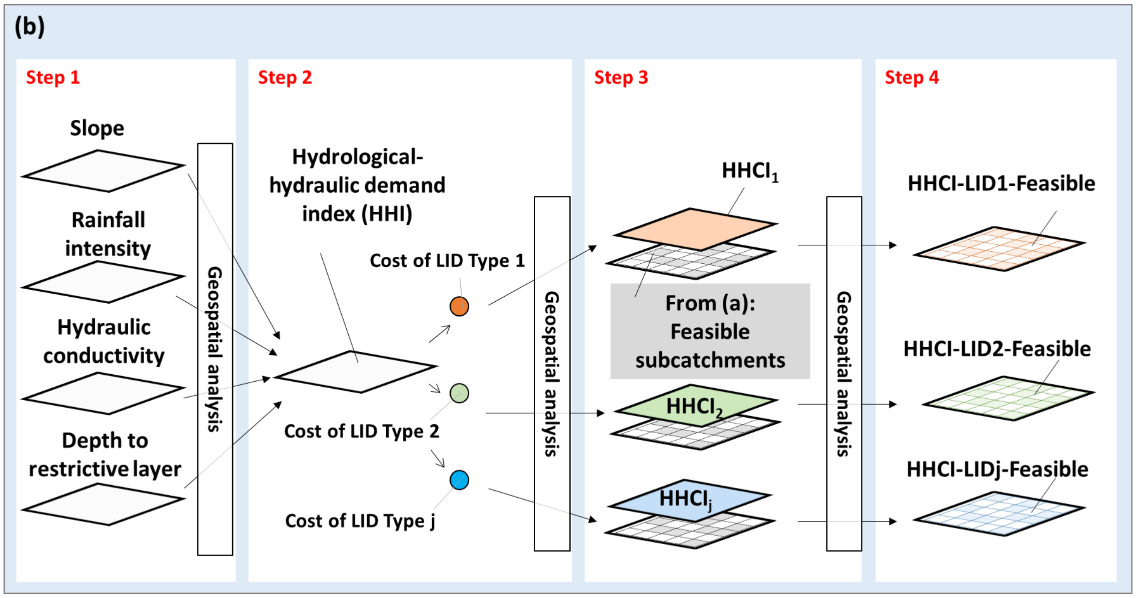


Figure 4.3 Component (b)-SERAH, the conceptual schematic for determining the hydrological-hydraulic demand for each type of LID at each feasible subcatchment

The third component of SERAH, Component (c), as shown in Figure 4.4, indexes the study area based on the demand of subcatchments for the environmental and socioeconomic benefits (i.e., the lateral benefits) of each LID type. An example of the physical meaning of the index is that if there is a high demand for treating “air pollution” at a subcatchment, the LID type that offers such a benefit should receive a higher rank compared with another LID type that is not able to treat air pollution. To what extent each LID type can treat air pollution could be a metric based on which LID types can be ranked (e.g., bioretention cell is ranked higher than a rain barrel in this regard since they have the potential to improve air quality [210]). On the flip side, where there is no air pollution, the type of LID that provides air pollution treatment should not receive a high rank. Thus, at a subcatchment with minimal demand for air pollution treatment, the rank of a bioretention cell and a rain barrel are equal in this respect. Previous research has overlooked this link between the lateral benefits of LID and the demand of subcatchment for that benefit.

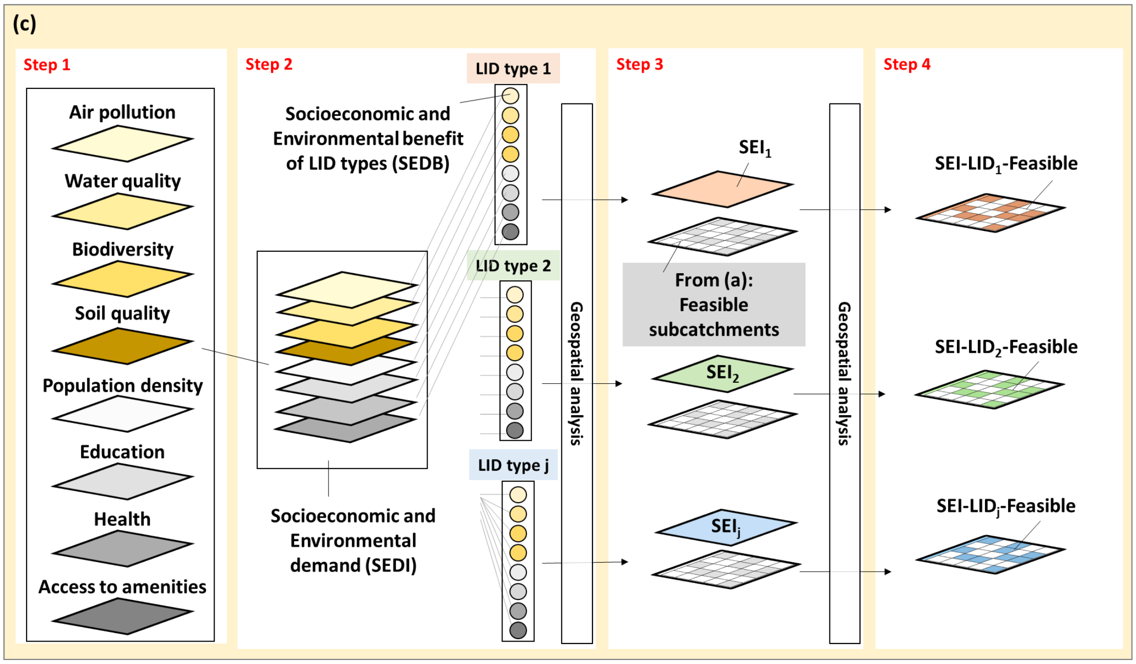


Figure 4.4 Component (c)-SERAH, the conceptual schematic for determining socioeconomic and environmental demand for each type of LID at each feasible subcatchment

All types of LID do not provide all benefits for the demands that may exist in the subcatchments. Also, the magnitude of benefits of individual LID types is different. To account for this, for each type of LID a Socioeconomic-Environmental Index (SEI) was generated. SEI represents the integrated benefit that each type of LID can provide considering the demand of the subcatchment for the same benefit. For example, if green space is not in high demand at a subcatchment, implementing PP and IT (which are not considered green spaces) are ranked equal to a rain garden (which is considered as green space). This is to change the traditional point of view of constant privileging LIDs with higher benefits (which are usually more costly) wherein that benefit is not required. For example, a study by Jia et al. (2013) [210], have used a GIS-independent MCDM system, compared the hydrological and environmental benefits of eight types of LID, and ranked bioretention cells as the first and rain barrel as the eighth. Their study gave bioretention cells a preference without identifying if there is a demand for this type of LID. Unlike this traditional point of view, SEI incorporates the extent of demand to the benefit of each LID type.

The estimation of SEI included the two following steps. First, the data were converted to raster format with the size of the DEM data (5 m by 5 m), then the SEI of cells was generated using Eq. 4.3 and Eq. 4.4. Second, the SEI of subcatchments was created by estimating the mean of the SEI of cells that fall within the subcatchment.

The mathematical model for applying this concept was performed through a GIS-based heuristic relationship (Eq. 4.4). First, three Socioeconomic-Environmental Demand Indices (SEDI) were generated [152], based on the three selected criteria for this study. These criteria included: i) decreasing Total Suspended Solid (TSS) concentration (denoted as $SEDI_1$) [70]; ii) even distribution of green spaces, for its ecological benefits (denoted as $SEDI_2$) [210]; iii) aesthetic benefit for buildings ($SEDI_3$) [210]. Note that out of many possible criteria (e.g., [30], [70], [208], [215]), we selected these three to focus on to demonstrate the application of SERAH. Thus, the criteria may change according to the case study and its associated needs.

All three demand indices representing TSS, even green spaces, and aesthetic benefits were generated by calculating the Euclidean distance from the source [216]. The sources have a distance equal to zero and cells farther from the source have a higher Euclidean distance. The source for $SEDI_1$ was pavement cells (streets, roads, parking lots, etc. where TSS is typically washed off from). The objective was to capture the TSS at the source and the distance from the pavement lowers the priority of the subcatchment. TSS from pavements is one of the main contributors of the TSS sources in our urban study area (other possible contributors are erosion, landfills, construction sites, etc. which does not apply to our case study) [217]. The source for $SEDI_2$ was green spaces. The reason is to increase the even distribution of green spaces to enhance the LID ecological benefits. To achieve an even distribution, cells in the vicinity of green spaces were ranked lower. The source for $SEDI_3$ (aesthetic benefit) was building cells. EPA (1995) has reported that the value of buildings next to well-designed types of LID has increased about 28 % based on a study conducted by the National Association of Home Builders [208], [215].

All three indices were standardized by applying the linear standardization between 0 and 1. The linear standardization assumes that the demand is a linear function of distance, which is a simplification of reality. This standardization is a well-known procedure [218] in the design of decision-making systems that allows for bringing a wide range of criteria with various magnitudes into a similar unit to be comparable and integrable. For $SEDI_1$ and $SEDI_3$, the maximum value, one (1), was given to minimum distance (representing a high demand for LID close to the pavement surfaces and building blocks) and inversely the minimum value was assigned to the maximum distance from the pavements. In contrast, for $SEDI_2$ the maximum value, one (1), was assigned to the maximum distance to the green spaces (representing a high demand for LID wherein the distance from green spaces is far). The process is presented in Table 4.1.

Table 4.1 The process of generating the socioeconomic-environmental demand index (SED) for each of the selected criteria

Criteria	**Data set generated by calculating**	**Comment**	**Priority**	**Standardization**
SED1: decreasing TSS concentration	Euclidean distance to the pavement	1- buildings were considered as a barrier 2- distance calculated before clipping the data to the extent of the catchment to account for the neighbourhood	closer distance higher priority	inversely rescaled by linear function between 0 and 1
SED2: even distribution of green spaces	Euclidean distance to green spaces		closer distance lower priority	rescaled by linear function between 0 and 1
SED3: aesthetic benefit for buildings	Euclidean distance to the building			

$$SEDI_i = \frac{ASEDI_i}{(ASEDI_i)_{\max}} \quad \text{(Eq. 4.3)}$$

Where i is the cell number, $ASEDI_i$ is the actual value of SEDI at cell i, $(ASEDI)_{max}$ is the maximum value of ASEDI within the study area, and $SEDI_i$ is the standardized ASEDI at cell i. The mathematical model for SEI which incorporates the demand index (relates to the cell) into the benefit that the type of LID provides for the same demand is presented in Eq. 4.4.

$$SEI_{i,j} = \sum_{k=1}^{n} w_k \times SEDI_{i,k} \times SEB_{j,k} \qquad \text{(Eq. 4.4)}$$

Where SEI_{ij} is Socioeconomic-Environmental Index at cell i (*i=1 to l*, *l* is the number of cells covering the study area), for LID types j (j=1 to m, m is the number of selected LIDs), $SEDI_{i,k}$ is SEDI at cell i for benefit k (k=1 to n; where n is equal to three in this study), $SEB_{j,k}$ is the

Standardized Socioeconomic-Environmental Benefit k (0 to 1) of LID type j, and w_k is the weight of criteria k and the sum of weights for all criteria should be 1. The SEB of the selected LID types in this study and their associated SEDI are presented in Table 4.2.

Table 4.2 Standardized benefits of the selected LID types in this study and their associated SED

	Decreasing TSS concentration benefit			Even distribution of green space benefit		Aesthetic benefit for buildings	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LID Type	Percent decreased TSS concentration [70] *	Mean column (2)	Normalized: column (2)/ max(column(2))	Percent benefit (compared to other LID types) [210]	Normalized: column (5)/ max(column(5))	Percent aesthetic benefit (compared to other LID types) [210]	Normalized: column (7)/ max(column (7))
RG	-6-99	46.5	0.63	80	1.00	1.0	1.00
IT	46-100	73.0	0.95	20	0.25	0.2	0.20
PP	47-100	73.5	1.00	20	0.25	0.4	0.40

*change in concentration [220]

An example of how SEI is calculated for two assumed subcatchments (*x* and *y*) are presented in Table 4.3. Subcatchment *x* has a demand of 1 for TSS removal ($\text{SEDI}_{x,1}=1$), no demand for green space ($\text{SEDI}_{x,2}=0.0$), and 0.25 for aesthetic benefit ($\text{SEDI}_{x,3}=0.25$). Subcatchment *y* has an equally high demand for all benefits ($\text{SEDI}_{y,1}= \text{SEDI}_{y,2}= \text{SEDI}_{y,3}=1$). Also, it was assumed that all three benefits are equally important, so have equal weights of one-third (0.33). The ranking results in Table 4.3 suggest that at subcatchment *x*, PP is the most suitable LID whereas at subcatchment *y,* RG is the priority option offering more benefits. This is because SERAH accounts for the demand of the subcatchment and justifies the benefit of each type based on the demand. Therefore, even though the rain garden for subcatchment *x* is the most beneficial LID (Table 4.2), the subcatchment demand can change this perception. Note that this ranking was only based on the lateral demand and benefits. SEI needs to be incorporated into the primary demand and benefit (HHCI) to rank the subcatchments and rank the types of LID comprehensively.

Table 4.3 Estimation of SEI for two sample subcatchments (*x* and *y*) for prioritizing LID alternatives (LID1 to 3)

subcatchment ID	LID	$\mathrm{SEI}_{x,1} = (w_1 * \mathrm{SEDI}_{x,1} * \mathrm{SEB}_{1,1}) + (w_1 * \mathrm{SEDI}_{x,2} * \mathrm{SEB}_{1,2}) + (w_1 * \mathrm{SEDI}_{x,3} * \mathrm{SEB}_{1,3})$	Rank of LID Type
x	RG	$\mathrm{SEI}_{x,1} = (0.33*1*\mathbf{0.63}) + (0.33*0.0*\mathbf{0.95}) + (0.33*0.25*\mathbf{1}) = 0.29$	3
	IT	$\mathrm{SEI}_{x,2} = (0.33*1*\mathbf{1}) + (0.33*0.0*\mathbf{0.25}) + (0.33*0.25*\mathbf{0.25}) = 0.35$	2
	PP	$\mathrm{SEI}_{x,3} = (0.33*1*\mathbf{1}) + (0.33*0.0*\mathbf{0.20}) + (0.33*0.25*\mathbf{0.40}) = 0.36$	**1**
y	RG	$\mathrm{SEI}_{y,1} = (0.33*1*\mathbf{0.63}) + (0.33*1*\mathbf{0.95}) + (0.33*1*\mathbf{1}) = 0.85$	**1**
	IT	$\mathrm{SEI}_{y,2} = (0.33*1*\mathbf{1}) + (0.33*1*\mathbf{0.25}) + (0.33*1*\mathbf{0.25}) = 0.50$	3
	PP	$\mathrm{SEI}_{y,3} = (0.33*1*\mathbf{1}) + (0.33*1*\mathbf{0.20}) + (0.33*1*\mathbf{0.40}) = 0.53$	2

Since implementing LID in all cells are not feasible, the subcatchments infeasible cells' demand for LID should also be accounted for. To do this, we modified the HHCI and SEI indices by incorporating the demand of infeasible into the feasible cells through modifying the SEI and HHCI.

The SEI was modified using a cell-based calculation based, then, the mean SEI (of cells within the subcatchment) was calculated for the feasible subcatchments. The concept for modifying SEI was that the benefit of LID in a specific cell can be gained from implementing LID in the same cell or with a different magnitude of benefit in a neighbourhood cell. For example, if the need for green space (e.g., for ecological benefit) is high in an infeasible cell, the closest feasible cell can address that need. To mathematically model this concept, we used the focal weighted mean principle (the feasible cell as the focal cell) and assumed higher weights for the closer cells and lower weights for the farther cells. The weighted mean of the SEI was calculated for all feasible cells. For the weights, we assumed a linear decreasing weight that is 1 at the focal cell and 0 at the farthest cell (the boundary of the study area).

The HHCI was modified on the subcatchment discretization level (not cell-based) for the simplicity and through the hydrological concepts. Implementing LID in feasible subcatchments can capture the runoff from upstream infeasible ones. Thus, by adding the HHCI of infeasible to the downstream feasible subcatchment the hydrological demand of those subcatchments (represented by HHCI) is reflected in the HHCI of feasible subcatchments.

We overlaid the two modified indices (HHCI and SEI) generated for the feasible subcatchments using the weighted sum method. The weight of both indices was selected identical and equal to 0.5 (Eq. 4.5). It is noticeable that the overlaying method and weights are selected to demonstrate the application of SERAH. The selection of optimal weights for the two indices is out of the scope of the research (e.g., pairwise comparison) since the focus of this study is on the development of SERAH. The selection of weights depends on a variety of parameters such as the demands of the study area, the nature of the criteria considered, the strategic decisions, and the responsibilities and objectives of stakeholders who want to implement LID.

$$@\ cell\ i, for\ LID\ types\ 1\ to\ j: \begin{bmatrix} HSE_{i,1} = 0.5\ \times\ HHCI_{i,1} + 0.5\ \times SEI_{i,1} \\ \vdots \\ HSE_{i,j} = 0.5\ \times HHCI_{i,j} \times 0.5\ \times SEI_{i,j} \end{bmatrix} \qquad \text{(Eq 4.5)}$$

where $HSE_{i,1}$ is HSE at cell i for LID type 1; $HSE_{i,j}$ is HSE at cell i for LID type j, SEI_{i1} is the SEI at cell i for LID type 1; $SEI_{i,j}$ is the SEI at cell i for LID type j; $HHCI_{i,1}$ is the HHCI at cell i for LID type 1, and $HHCI_{i,j}$ is the HHCI at cell i for LID type j.

Figure 4.5 presents the fourth component of SERAH, Component (d), a conceptual schematic for the HSE layers (step 1); an example of the HSE value in one of the catchments that each are associated with a feasible subcatchment (step 2); and how it leads to ranking the type of LID (step 3). The ranking of subcatchments is conducted based on the values of HSE. Subcatchments with the highest HSE value have the highest rank for implementing LID.

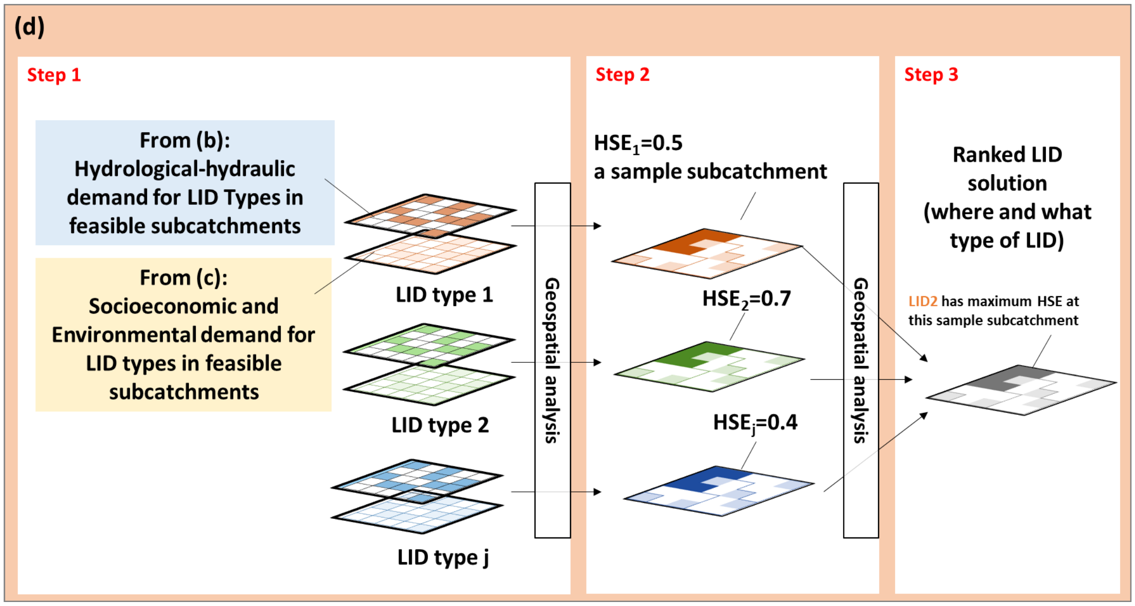


Figure 4.5 Component (d)-SERAH, The conceptual schematic for ranking LID solution, step 1) geospatial analysis of components (b) and (c), step 2) geospatial ranking of the HSE datasets, step3) identifying the rank of LID subcatchments and types

Types of LID are ranked through the geospatial ranking of HSE datasets (HSE_1 to HSE_3). For each feasible subcatchment, a comparison is made among the value of all three HSE indices of the subcatchment. The LID type with the highest HSE value is introduced as the highest priority LID for the same subcatchment. Thus, for all feasible subcatchments, the high-ranked type of LID may be identified.

4.4.2. Develop the stormwater model

To investigate the applicability of SERAH, we applied it to a case study for a location within the City of Toronto. First, the LID types and subcatchments were ranked for the case study using SERAH and geospatial analysis (using Arc-GIS Pro_15). Then the results of ranking by SERAH were hydrologically modelled using PCSWMM version 7.3. The objective of the hydrological modelling is to validate the hydrological-hydraulic component of the method and simulating the effects of the ranked LID solutions using a hydrological model. It is notable, that the focus of the validation is on the hydrological component. The validation of the MCDM model related to the lateral benefit is not feasible since it is a decision-making component and can not be compared against a stormwater model [86].

Case study

The case study was an area of 7.3 ha located in the City of Toronto, within the East Don River watershed. This area is located upstream of one of the flood-vulnerable clusters reported by TRCA [219]. It also provides a good variety of land cover types which provides us with a variation of HHI and SEDI, which are indices that depend on the land cover of the study area. The land cover in this catchment includes high-density residential (0.18 ha, 2%), general commercial (1.1 ha, 15%), green spaces (0.78 ha, 11%), and the remaining are parking lots and streets (5.24 ha, 72%). Except for the green space (11%) which is pervious, the remaining 89% of the land cover is impervious. The location of the area and its land cover are presented in Figure 4.6. The study area overall has 8 inlet junctions, about 715 m of circular pipe conduits, with diameters ranged from 0.6 to 1.2 m [220]. The outfall of the network is located at the central south side of the study area. It is notable that, SERAH is not limited by the size of the study area of interest, as long as the necessary data (as listed in Section 4.4.1) are available.

The data used for the urban drainage network was acquired from the City of Toronto [220]. A list of data that were used in this study, their format and source are presented in Table 4.4. The drainage network and its delineated subcatchments are presented in Figure 4.7. The subcatchments were delineated using the “watershed delineation” tool in PCSWMM. The tool uses DEM data and burns in manhole data as points. However, some judgment and justification were conducted to account for the inadequacy of DEM data precision in representing urban features such as the elevation of curbs. Some of the subcatchments were routed into the downstream subcatchments (e.g., S06 and S07 to S08) and some were directly routed to the downstream hydraulic system (e.g., S04). The maximum subcatchment size is about 1.25 ha and the minimum subcatchment area is about 0.06 ha.

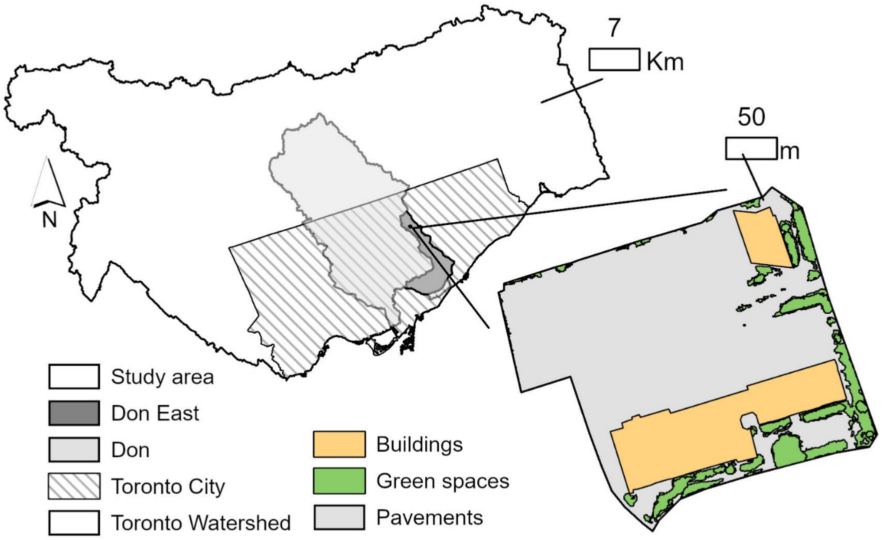


Figure 4.6 The location of the selected study area in the Toronto watershed and administrative border of the City of Toronto, Don sub-catchment and its Eastern River branch

Table 4.4 The name, format, and source of the input data in alphabetical order

Data	Format	Data Source
Bedrock layer	Vector/polygon	Ministry of Northern Development and Mines
Digital elevation model (DEM)	Raster (5 m)	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit
Groundwater table	Vector/point	Groundwater Information Network (GIN)
Land cover	Raster (0.6 m)	City of Toronto
Surficial geology and saturated hydraulic conductivity (K_s)	Vector/polygon	Government of Canada open data website
Toronto precipitation data	Vector/point	Institute for Catastrophic Loss Reduction and Western University [176]
Toronto rivers	Vector/polyline	Toronto and Region Conservation Authority (TRCA)
Urban drainage network	DWG file	City of Toronto

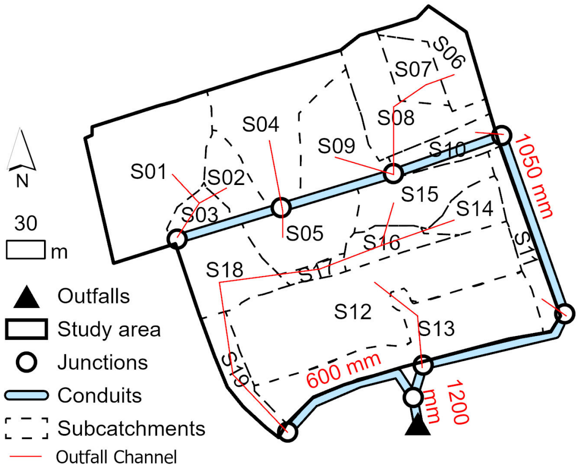


Figure 4.7 The layout of the study area, including subcatchments (S01 to S19), inlet junctions and conduit

Developing the PCSWMM model

To evaluate the effectiveness of SERAH in ranking the subcatchments, the study area was modelled in PCSWMM software. The modelling included two parts.

First, the effectiveness of SERAH in ranking subcatchments and representing their potential in runoff generation was studied. To do this, nine scenarios were developed and modelled. Scenarios included a base scenario with no LID implemented in the subcatchments and eight LID scenarios in which one type of LID (with identical design parameters and size) was implemented in individual subcatchments iteratively. The selected type of LID was IT which was sized using the design parameters suggested in Song et al (2017) [105] and TRCA (2013) [204] (the details of the parameter values are available in Appendix F). Using this identical design, area and one type of LID for all scenarios allowed for comparing the impact of the subcatchment on the runoff reduction in the catchment. Scenarios were denoted as S01, S02, S04, S05, S08 (which receives runon from the S06, and S07 which are infeasible subcatchments, therefore no scenarios are needed for them), S09, S13 (receives runon from S12 which is infeasible catchment), S19 (receives runon from feasible subcatchments (S14 to S18) with and without LID. For example, scenario S01 had IT assigned to the subcatchment S01. The assigned LID was an arbitrary area of 400 m^2 of LID (selected within the recommended range of LID to subcatchment area ratio) which was added to the eight subcatchments iteratively. In this part, since the selected study area (Section 4.4.1) had a time of concentration (t_c) of less than one hour the duration of 1-hr (the smallest recommended duration [221]) was used for design rainfall. Different frequencies for LID design is suggested by guidelines including 2-year [172]–[174], 5-year [173], 10-year [172], [175], or 100-year [222]. However, we have selected the most recommended frequency (10-year) and the common rainfall pattern of the study area (AES Southern Ontario).

Second, the influence of patterns on the selected LID solution was investigated using four different rainfall patterns that are commonly used in the Toronto area and are suggested by conservation authorities. It was done through simulating two scenarios: i) with LID (using the top-ranked LID solution derived from SERAH results), and ii) without LID (no LID installed) under different rainfall patterns. All results were compared and discussed based on three hydrological metrics: i) volume runoff reduction; ii) peak runoff reduction, and iii) delaying the peak flow time. The four rainfall patterns included AES Southern Ontario, Chicago, SCS Type II, and Hurricane Hazel [222], with standard durations of 6, 12, and 24 hours were also modelled for which was available. Testing the performance of LID for the extreme events has been recommended by the TRCA. To do so, we have selected the most extreme duration and frequency for the four selected rainfall patterns. The longest duration of the AES_SO rainfall pattern is 12-hours which were generated for a 100-year frequency. Hurricane Hazel is a historical extreme event with an about 12-hours duration which has an average of about 230 mm rainfall. Chicago and SCS type II patterns also were simulated with a 24-hours duration and 100-year return period.

4.5. RESULTS AND DISCUSSIONS

4.5.1. Identifying feasible subcatchments (component a)

As mentioned in Section 4.4.1, the determination of feasible subcatchment was conducted in two stages. First, the feasible cells, which met all feasibility criteria were extracted. The feasibility criteria were based on the TRCA recommendations for the selected types of LID (Figure 4.8). Second, feasible subcatchments were determined based on the percentage of the area of feasible cells within them. The subcatchments that had an area of 5% and greater feasible cells were identified as feasible subcatchments. This was to provide an adequate area of LID in each subcatchment, also this ratio is recommended by TRCA for IT and RG (the minimum ratio of subcatchment area: LID area is 20:1). Figure 4.9 presents the location of feasible subcatchments in the study area.

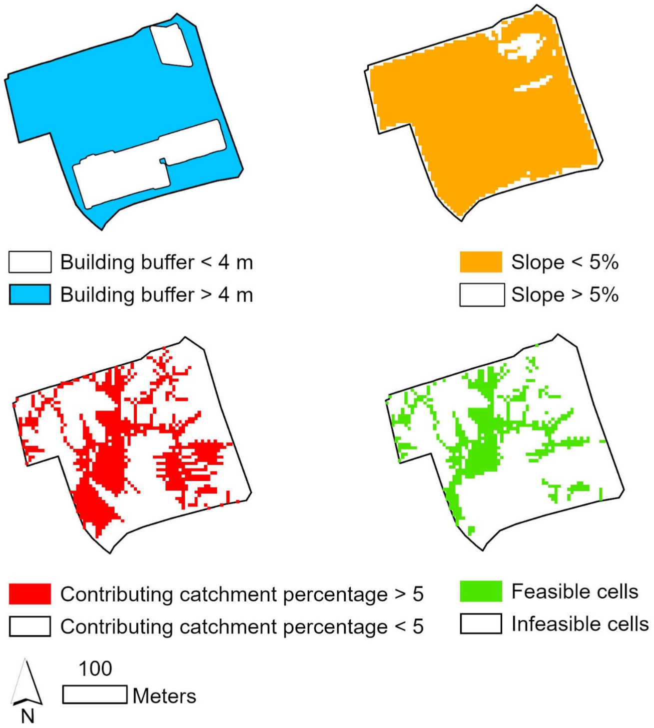


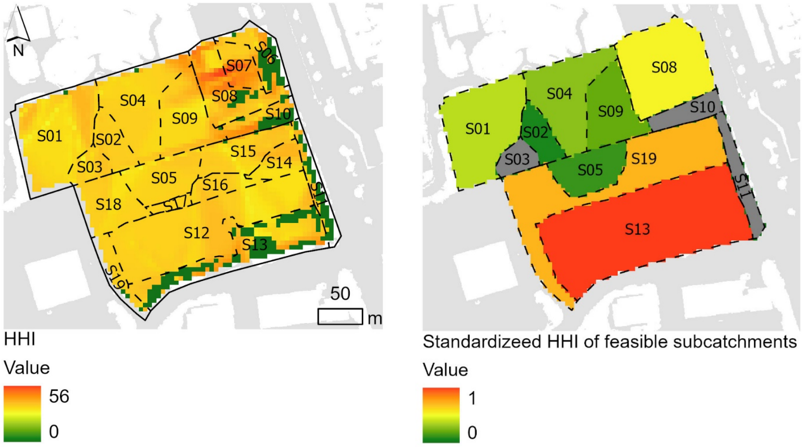
Figure 4.8 Feasibility criteria: top-left: cells farther than 4 meters from buildings; top-right: cells with slopes less than 5 %; bottom-left: cells with a contributing drainage area of 5 times and greater, bottom right: identified feasible cells (coloured green)

Figure 4.9 The location of feasible subcatchments (the area of feasible cells within the catchment is greater than 5 % of the area of catchment)

4.5.2. HHI and HHCI generation (component b)

HHI was generated using the geospatial integration of the input data in Eq. 4.1. R_i (mm/hr) was the distribution of the rainfall data (mm) for 1-hour rainfall intensity and 10 years return period [223]. It is notable that due to the size of the study area, the spatial variation of the rainfall was negligible (about 0.02 mm/hr), yet the variation of other parameters (e.g., slope and hydraulic conductivity) was considerable. K_s and K_i (mm/hr) were respectively derived from the surficial geology and land cover data of the study area and converted to the raster format. D_g and $n*D_r$ were respectively derived from the data representing the depth to the groundwater and bedrock in the study area. These two parameters $((\mathrm{D_g})_i \cap (\mathrm{D_r})_i)$ were significantly greater than $(\mathrm{K_s})_i \cap (\mathrm{K_i})_i$. Thus, the intersection of the parameters was dominated by the intersection of hydraulic conductivity. The slope (in degrees) was derived from the DEM data. For generating HHI the actual value of the input data was used, and no standardization was conducted. The generated HHI for each cell is presented in Figure 4.10 (a).

The layout of the catchment (the connection between subcatchments and inlet junctions) was found to be an important factor in the estimation of the HHI of each subcatchment. The HHI of subcatchments that were the outlet of upstream subcatchments needed to account for the HHI of upstream (all cells that contribute to the runoff in the subcatchment) as well. In our case study among feasible subcatchments, S08 and S19 accepted runon from upstream. The HHI of S08 was calculated by adding the HHI of S07 and S06 to the HHI of S08. Likewise, for S19, HHI of S19 was the sum of HHI within S14 to S19 (all cells that contribute to the runoff in S19) An example is subcatchment S19 (Figure 4.10). Other feasible subcatchments did not receive runon from upstream and the HHI was the sum of HHI of cells within the subcatchment.



(a) (b)

Figure 4.10 Generated (a) HHI of each cell (b) HHI of each subcatchments (normalized between 0 and 1)

The results of the stormwater modelling of LID scenarios (eight scenarios, under AES_SO rainfall pattern with 1-hour duration and 10-year frequency) are presented in Table 4.5. The results suggest that the total inflow into the LID from the S13 is the highest whereas the S02 is the lowest. It also, revealed that LID has an infiltration loss from 182 mm to 585 mm, which contributes to 46 to 100% runoff reduction. The remaining runoff is discharged to the hydraulic system from the LID as outflow. The maximum outflow is from the LID located in S13 with a value of 677 mm and the minimum is zero for S02, S05, and S09. This shows that implementing LID at these three subcatchments has reduced the runoff to zero, while other subcatchments need LID with a higher capacity. The performance of LID with equal design when is iteratively installed in different subcatchments allows for ranking the subcatchments based on their demand for LID. Thus, with an overall comparison, one can decide with a limited resource implementing LID in which subcatchment will provide the most runoff reduction result.

Table 4.5 The inflow, infiltration, and outflow of LID individually implemented in subcatchments (volume runoff per area of LID) as well as the percentage runoff reduction (the eight scenarios, under AES_SO rainfall pattern with 1-hour duration and 10-year frequency)

Subcatchment	Total inflow per area of IT mm	Infiltration loss per area of IT mm	Percentage runoff reduction	Surface outflow per area of IT mm
S13	1245	568	46	677
S19	1203	585	49	530
S08	709	540	76	169
S01	808	551	68	257
S04	632	543	86	89
S09	458	458	100	0
S05	367	367	100	0
S02	182	182	100	0

The normalized inflow and infiltration loss (normalized to the maximum value) are compared against the normalized HHI of subcatchment (normalized to the maximum value) in Figure 4.11. Overall, the figure suggests that there is a better agreement between the ranking by HHI and inflow compared with the infiltration loss (except S08). S08 has a slightly lower rank than S01 according to the “inflow” into the LID and has a marginally higher rank than S01 based on HHI. S08 is a high slope subcatchment (about 4 %) compared with S01 whose slope is 1%. In addition to runoff volume generation, HHI accounts for peak flow by considering the slope of the subcatchment, and it can cause a marginal outranking of high slope subcatchments.

The infiltration loss graph (solid blue line) and Table 4.5 showed that, once the runoff of the catchment exceeds the capacity of the LID (which starts at S04), the infiltration loss becomes almost constant. This explains the similarity of the infiltration loss of S13, S19, S08, S01, and S04. However, the potential of these subcatchments in runoff generation is high as is shown by the inflow graph (solid black line). Thus, an increase in the capacity of LID in these subcatchments helps with the increase of infiltration and presenting their actual rank by infiltration loss. Since

HHI represents the potential for runoff generation it is corresponding to the inflow into the LID.

In this highly urbanized case study, the contributing drainage area of the subcatchment was found to be a key variable in ranking the subcatchments by HHI. On this basis, the highly ranked subcatchments were found to be subcatchments that have a high contributing area (Figure 4.11 and Figure 4.12). An example of this is S19, which receives runon from S14 to S18. The area of S19 is 0.19 ha but it receives runoff from about 1.8 ha area upstream. Despite that S19 does not generate a high volume of runoff (compared with S13 which has a high rank), implementing LID in this subcatchment has a significant contribution to the runoff reduction of the catchment. This result suggests that the topographically lowest subcatchment that has the most contributing area is the best efficient location for implementing LID. However, implementing multiple LID upstream with a capacity equal to their corresponding subcatchment will give a different result. In such a case, the subcatchment that generates the highest runoff will be the best subcatchment for implementing LID. This is along with the findings that suggest the location of LID at the end-of-pipe or the most downstream location presents better performance [98] [224].

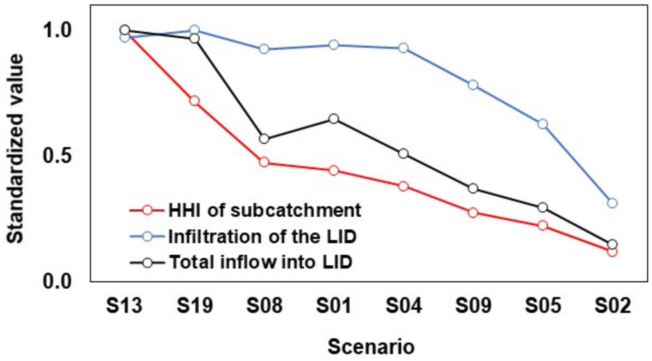


Figure 4.11 The normalized (values divided by the maximum value) HHI of subcatchments, inflow entered the LID controls (scenarios S01, S02, S04, S05, S08, S09, S13, S19), and the infiltrated runoff in each LID of individual subcatchments

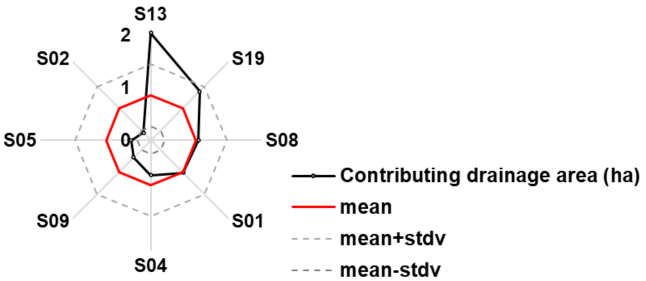


Figure 4.12 The comparison of the area of feasible and runon receiving subcatchments (ha) with its statistics (mean, standard deviation) for the scenarios S01, S02, S04, S05, S08, S09, S13, S19

The impact of implementing LID (the eight previous scenarios) on the outflow of the case study is presented in Figure 4.13. by comparing the hydrograph of the catchment at the outlet for all scenarios (the base and LID scenarios). The result shows the stark effect of LID in attenuating the peak of the hydrograph at the outlet of the system. It also reveals that the impact of implementing LID at the first four subcatchments which were ranked higher by HHI (S13, S19, S01, S08) has a higher impact on runoff reduction, compared with the other scenarios.

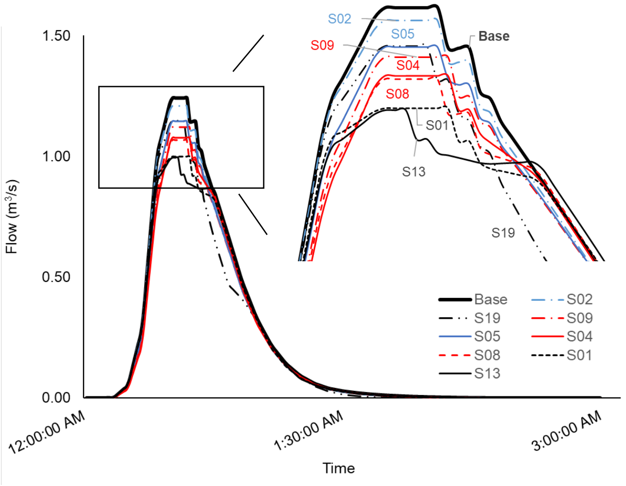
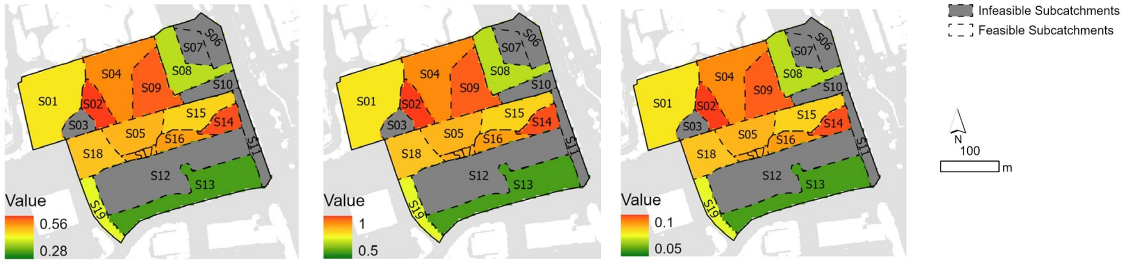


Figure 4.13 Hydrograph of the outfall of the catchment, for all scenarios (the base scenario and, scenarios S01, S02, S04, S05, S08, S09, S13, S19)

The HHCI was calculated based on dividing the HHI-subcatchment by the normalized cost of the LID. Then the results were normalized against the maximum HHI-subcatchment of all LIDs (Figure 4.14). For this study, we used the results of research conducted by TRCA (2013) and Joksimovic & Alam (2014) [203], [204], which has calculated the cost of each LID type per unit volume runoff reduction. According to this study, IT have the lowest cost, thus have the highest HHCI among the three LID types (with a maximum value of 1.0). PP, however, is the most expensive option and has a maximum value of HHCI which is one-tenth the IT and RG are in between two options (Figure 4.14). Thus, conducting a maximum operation among all three HHCI data sets suggests that IT is the most suitable option among the LID types, which was expected due to its low cost. Thus, if only the primary benefit of LID is the only concern (the lateral benefits are overlooked), the LID type that is the least expensive (cost compared based on the identical hydrological-hydraulic performance) is the most suitable option for the study area. Integrating lateral benefits could increase the priority of the more expensive types of LID.

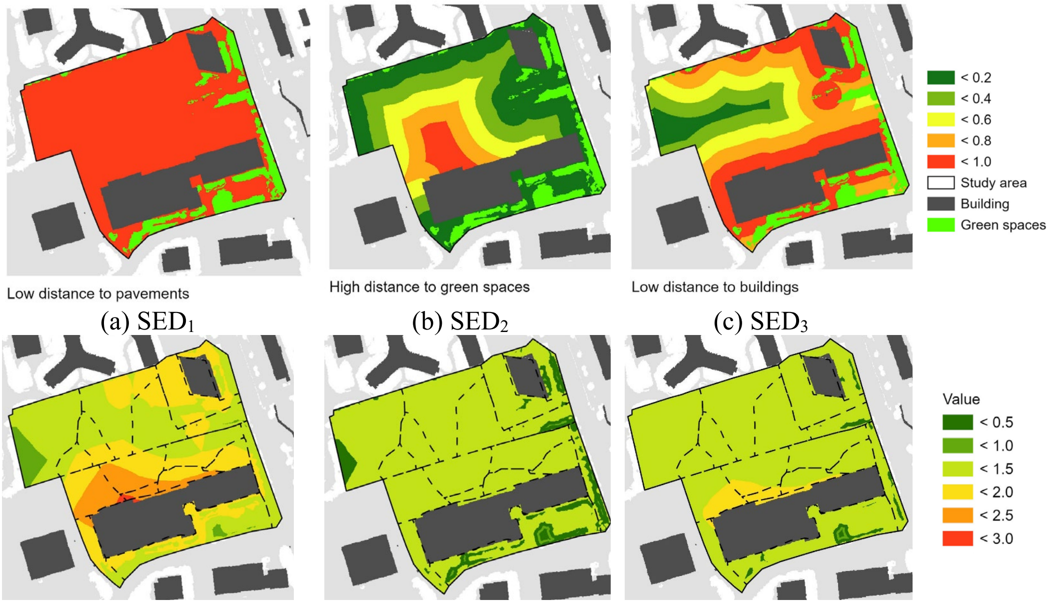


HHCI-RG-Feasible	HHCI-IT-Feasible	HHCI-PP-Feasible
(Normalized by max (HHCI) = 428.2)		
Range of HHCI: HHI-Subcatchment/ Normalized cost		
118.4 – 237.9	213.1 – 428.2	21.3 – 42.8
Normalized cost		
0.18	0.10	1.00
Cost ($) per volume runoff reduction [203]		
28.69 ($/m3)	15.91 ($/m3)	157.24 ($/m3)

Figure 4.14 The HHCI of the three selected LIDs (RG, IT, and PP) normalized by the maximum HHCI value (428.2), the range of the generated HHCI before standardization, and the cost of each LID in $ per volume runoff reduction in m^3 (before and after standardization)

4.5.3. SEI generation (component c)

SEI was generated by following the steps presented in Table 4.1. All three layers (SED_1: decreasing TSS concentration; SED_2: the even distribution of green spaces; SED_3: aesthetic benefit for buildings) were generated by calculating the distance from the source. Comparing the results (Figure 4.15 a, b, and c) shows that there is a high demand for TSS removal across all subcatchments, whereas the demand for green spaces is only high at the west of the catchment. The eastern part of the catchment where the density of buildings is higher, has a higher demand for the aesthetic benefit of LID. The result of the integration of the demand indices (SED_1 to SED_3) into the benefit of each type of LID (SEB_1 to SEB_3) is presented in Figure 4.15 (d, e, f). Overall, the demand for RG (Figure 4.15d) is the highest among all LID types and the demand for IT is the lowest. Figure 4.15 (d) and (f) suggests that the demand for RG and PP around the north of the southern building is higher than in other parts of the catchment. The location of the demand for all LIDs is the lowest wherein green space exists. One of the remarkable results of this approach is that where the demand for the LID benefit is low the index value is low. For example, RG is a high benefit LID but the demand for RG is low wherein green space exists. This helps us with the systematic allocation of the resources where it is required.



(a) SED_1 (b) SED_2 (c) SED_3

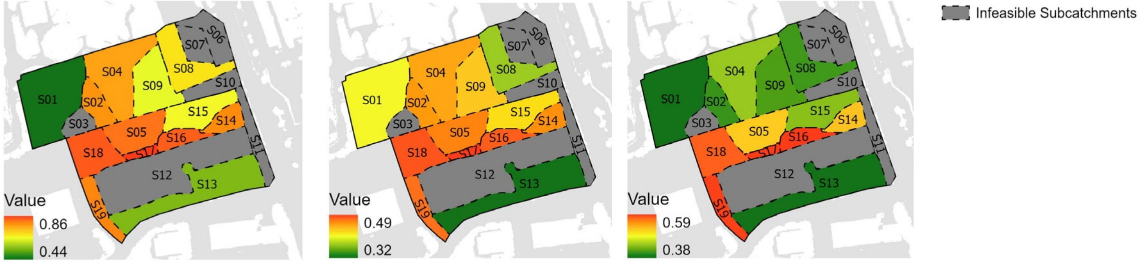
(d) SEI-RG (SEI_1) (e) SEI-IT (SEI_2) (f) SEI-PP (SEI_3)

$SEI_1 = 0.63 * SED_1 + 1.00 * SED_2 + 1.00 * SED_3$			RG
$SEB_{1,1} = 0.63$	$SEB_{1,2} = 1.00$	$SEB_{1,3} = 1.00$	
$SEI_2 = 0.95 * SED_1 + 0.25 * SED_2 + 0.2 * SED_3$			IT
$SEB_{2,1} = 0.95$	$SEB_{2,2} = 0.25$	$SEB_{2,3} = 0.20$	
$SEI_3 = 1.00 * SED_1 + 0.25 * SED_2 + 0.40 * SED_3$			PP
$SEB_{3,1} = 1.00$	$SEB_{3,2} = 0.25$	$SEB_{3,3} = 0.40$	

Figure 4.15 socioeconomic-environmental indices (a) low distance to pavements (representing SED_1) (b) high distance to green spaces (representing SED_2) (c) low distance to building s (representing SED_3) (d) socioeconomic-environmental demand index for rain garden (e) socioeconomic-environmental demand index for IT (f) socioeconomic-environmental demand index for porous pavement

To account for the effect of the neighbourhood the focal weighted mean of SEI-RG, SEI-IT, and SEI-PP was generated. The results are presented in Figure 4.16 (a, b, c). Overall, the effect of the neighbourhood decreased the SEI of cells with high SEI (e.g., north of the southern building), and increased the SEI of some areas with low SEI and are located close to the high SEI areas (e.g., SEI-RG of south of the southern building). Following this, the SEI of the feasible subcatchments was created and integrated into the HHCI of each feasible subcatchment (Figure 4.16 d, e, and f). The range of the values suggest that the socioeconomic-environmental demand for RG is higher than the other two type of LIDs (Figure 4.16 d, e, and f). Comparing the SEI of subcatchments demonstrates that the SEI of S16, S17, and S18 are the highest for all three LID types. There is also a high demand for only RG and IT at subcatchments S02, S04, S05, S14, S19. Whereas S01 and S13 have the lowest demand for RG and PP. Likewise, S13 has the lowest SEI for IT, yet the second lowest SEI-IT is not S01 and is S08.

(a) SEI-RG-Neighbour (b) SEI-IT-Neighbour (c) SEI-PP -Neighbour



(d) SEI-RG-Feasible (e) SEI-IT-Feasible (f) SEI-PP -Feasible

Figure 4.16 Focal weighted mean of (a) SEI for RG (b) SEI for IT (c) SEI for PP, also, the mean of SEI in each subcatchment for the three LID types at feasible subcatchments (d) RG (e) IT (f) PP

4.5.4. HSE generation (component d)

The HHCI and SEI of the feasible subcatchments are integrated using the weighted sum method considering equal weights for both indices. HHCI, SEI and HSE are colour rendered between 0 and 1, with equal intervals of 0.1 (Figure 4.17 (a) to (i)). Overall, HHCI for IT is the highest among all three types of LID whereas PP is the lowest. SEI of RG is the highest, whereas

IT and PP are about identical. The HSE for IT and RG are higher than PP. The geospatial ranking of the three HSE data sets ranks the LID types (RG, IT, PP) at each subcatchment.

(a) HHCI-RG-Feasible (b) HHCI-IT-Feasible (c) HHCI-PP-Feasible

(d) SEI-RG-Feasible (e) SEI-IT-Feasible (f) SEI-PP -Feasible

(g) HSE-RG*
Weighted Sum

(h) HSE-IT
Weighted Sum

(i) HSE-PP
Weighted Sum

e.g., HSE-RG = 0.5 "HHCI-RG-Feasible"+ 0.5*"SEI-RG-Feasible

Figure 4.17 The HHCI, SEI, and HSE of all three LID types (RG, IT, PP)

The result of the geospatial ranking of HSE-RG, HSE-IT, and HSE-PP is presented in Figure 4.18. The figure shows that for subcatchments S02, S05, and S17 the value of HSE-RG is the highest among all, so RG was introduced as the most suitable LID for these subcatchments. For the remainder of the subcatchments, IT was identified as the highest-ranked LID. The priority of IT over the other types of LID is a result of its low cost compared with the other two LIDs. PP acquired the lowest rank since it is costly (10 times the cost of IT) and offers low lateral benefits. The cost of RG is 1.8 times the cost of IT, yet its high lateral benefits outweighed the cost and introduced the RG as the best alternative in three subcatchment (S02, S05, and S17).

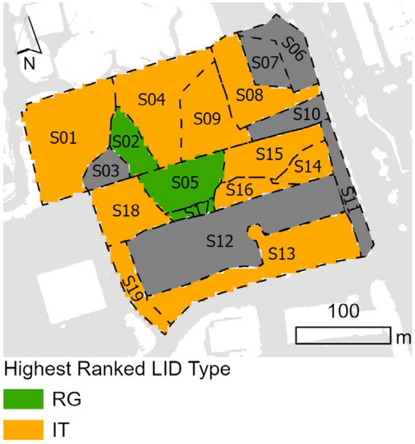


Figure 4.18 The priority of LID types to be implemented in each subcatchment

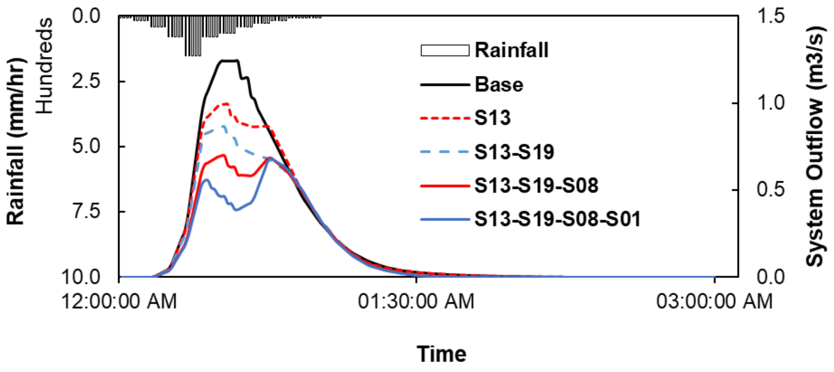
4.5.5. Hydrological Modelling

Using SERAH the feasible subcatchments and the LID types were ranked. Using the results of SERAH, we selected the first four high-ranked subcatchments (S13, S19, S01, and S08) to model after the implementation of the highest ranked LID type in each subcatchment (which was IT for each of the four). These models were developed and run to demonstrate the application and effectiveness of the ranked LID solutions provided by SERAH. In the model we assigned an area of 400 m^2 of IT to the four high-ranked subcatchments iteratively (Figure 4.19). The scenarios were analyzed under AES_SO rainfall pattern, 1-hour duration, and 10-year. The hydrological performance of the results (compared with the base scenario (without LID) and the scenario parameters are presented in Table 4.6.

Table 4.6 The scenario development and results of the performance of the selected solutions (a) and (b)

Scenario ID	Subcatchment with IT added to the previous scenario	The contributing drainage area (ha) of the subcatchment added	The cumulative area of IT (m^2)	Incremental area of IT (m^2)	The cumulative runoff volume reduction %	The incremental runoff volume reduction %	The cumulative peak runoff reduction %	Scenario incremental peak runoff reduction %
S13	S13	2.04	400	400	9.8	9.8	19.9	19.9
S13-S19	S19	1.14	800	400	21.1	11.3	30.3	10.4
S13-S19-S08	S08	0.90	1200	400	30.2	9.0	43.7	13.4
S13-S19-S08-S01	S01	0.87	**1600**	400	**39.1**	8.9	**45.0**	1.3

Table 4.6 shows that the scenarios respectively reduce the runoff volume by 9.8, 21.1, 30.2, and 39.1% and peak runoff by 19.9, 30.3, 43.7, and 45.0% (Figure 4.19) compared with the base scenario. These results showed the overall impact of IT when is implemented in the top-ranked subcatchments. Also, the scenarios respectively reduce the runoff volume by 9.8, 11.3, 9.0, 8.9% and peak runoff by 19.9, 10.4, 13.4, 1.3% (Figure 4.19) compared with the prior scenario (e.g., S13 is the prior scenario of S13-S19). These results revealed the importance of subcatchment selection for implementing IT by comparing the performance and its impact on runoff reduction (volume and peak). Overall, these results suggest that with the addition of IT to the lower rank subcatchment the subsequent effect to the total runoff reduction decreases. The exception is subcatchments S13 and S19, S13 shows the highest impact on the peak runoff reduction and S19 has the highest effect on runoff volume. S13 has a higher slope (2.52 %) than S19 (1.17 %) thus the IT has attenuated the peak runoff in this catchment significantly.



(a)

Figure 4.19 The change in the system outflow hydrograph when iteratively implementing the high-ranked LID, equal area of IT (400 m^2 per subcatchment) in each subcatchment (respectively S13, S19, S08, and S01)

Another comparison was made to investigate the effect of the different design rainfalls on the performance of IT in the four top-ranked subcatchments. For comparing the impact of rainfall frequency, we used the combination of AES_SO pattern with different frequencies of 2, 5, 10, 25, 50, and 100 years and 1-hour duration for the design rainfall. Using these rainfall patterns, six different pairs of scenarios: one with and one without IT were generated (twelve scenarios in all). Area of 400 m^2 of IT was considered in subcatchment S13, S19, S08, and S01, 1600 m^2 of IT overall. The results of the comparison are shown in Figure 4.20. The results showed that the total percentage of runoff reduction varies between 35.0 to 61.1% with an average of 42.6% for all six pairs of scenarios. Also, the peak runoff attenuated between 42.8 and 54.3% with an average of 47.3%.

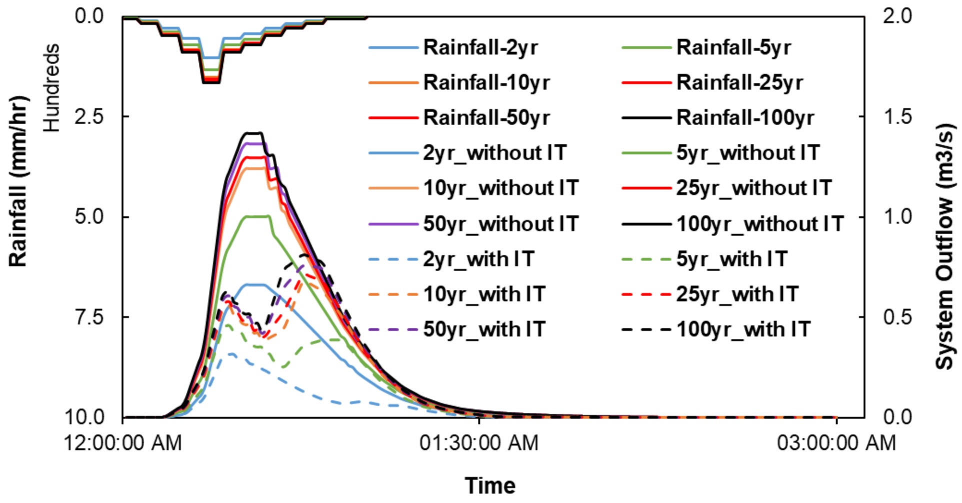


Figure 4.20 A comparison of the LID performance (implementing IT in the four top-ranked subcatchments) for AES Southern Ontario 1-hour rainfalls and 2, 5, 10, 25, 50, and 100 return periods

The influence of patterns and of extreme events on the performance of the selected LID solution were modelled based on Section 4.4.2 using the same implementation of IT in the top-four ranked subcatchments. Results of these simulations are shown in Figure 4.21 and the performance of IT under different rainfalls are presented in Figure 4.22. Overall, the results suggested that under extreme rainfall events the selected LID solution performs at a higher capacity (m^3) compared to the low frequency and duration events. The percent runoff reduction has remained between 31.6% and 61.2% for all events. But it did not exhibit a strong correlation with the frequency and duration events. In low-intensity rainfall patterns such as Hurricane Hazel, IT exhibited high performance in runoff volume reduction (maximum of all scenarios). The high-intensity rainfall patterns such as Chicago presented the lowest performance in percentage runoff reduction (the minimum of all scenarios). This result reveals the impact of the rainfall intensity on the performance of LID (IT) which agrees with other findings which reported the sensitivity of the performance of the selected LID solution to the rainfall intensity and hydraulic conductivity [70]. Meaning that in areas with higher rainfall intensity the performance of LID (IT) is lower.

A comparison among all scenarios has suggested that implementing IT in the four high-ranked subcatchments has delayed the peak of runoff hydrograph of the catchment somewhere between 10 to 65 minutes. In this case, the impact of IT on delaying the peak of runoff was higher on rainfall patterns with lower intensities (e.g., Hurricane Hazel was delayed the most). However, there was an exception for three of the patterns which had two peaks, and the higher peak occurs earlier. Even in these cases, the overall delay of hydrograph and shift toward the later time is evident through the comparison of their hydrographs in Figure 4.21.

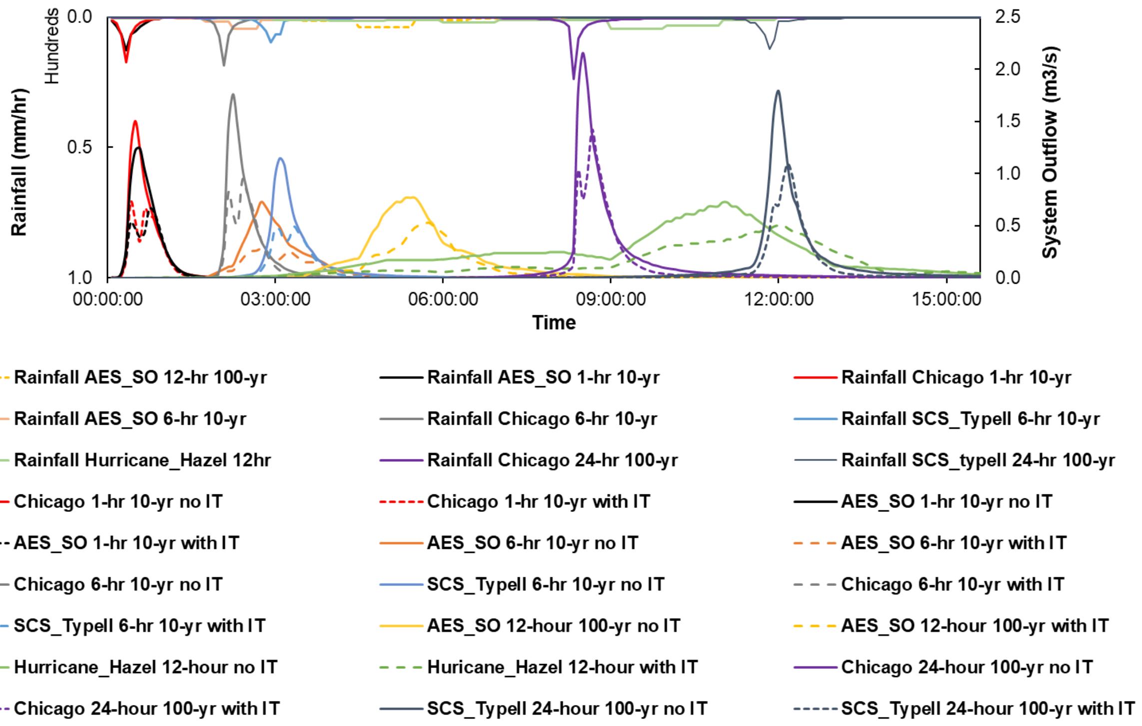


Figure 4.21 A comparison of hydrographs of the catchment outflow without and with LID (IT implemented in the four top-ranked subcatchments) under different rainfall patterns and durations

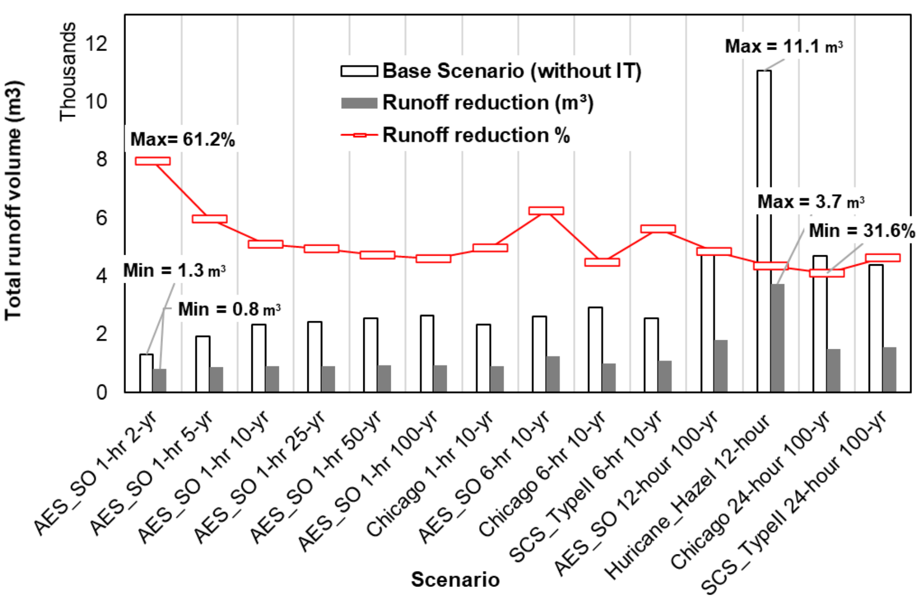


Figure 4.22 A comparison of the performance (volume and percentage runoff reduction) of LID (IT implemented in the four top-ranked subcatchments) under different rainfall patterns (AES_SO, Chicago, Hurricane Hazel, and SCS Type II), durations (1, 6, 12, and 24-hour), and return periods (2, 5, 10, 25, and 100 years)

Overall, in this section two parts of stormwater modelling were presented. First, the stormwater modeling of LID solution ranking by SERAH was conducted to examine its ability on ranking subcatchments. The results suggest that SERAH captures the potential of runoff generation of subcatchments and their demand for LID since implementing LID in the high-ranked subcatchments showed a higher performance (e.g., S13 and S19, S08, and S01). Second, the effect of different rainfall temporal patterns, duration and return periods on the LID solution suggested by SERAH (IT implemented in the first four high-ranked LID subcatchments) investigated. The results suggested that the selected LID solution exhibits a higher performance under severe rainfalls, however a high rainfall intensity can decrease the performance.

4.6. CONCLUSION

In this study, we addressed the gap of the lack of a systematic model for ranking LID solutions. To do so we developed a systematic and simplified geospatial model (referred to as SERAH), which can be used as input of stormwater models. This was conducted through the establishment of a geospatial relationship between the key contributing factors including LID benefits (hydrological, environmental-socioeconomic), cost, feasibility, and demand of the subcatchment. To examine the applicability of SERAH was applied to a catchment within the City of Toronto, located at eastern Don River.

The results showed that the hydrological-hydraulic index (HHI) effectively ranked the LID subcatchments and represented their potential in runoff generation. In our case study, which is a highly urbanized area, the contributing drainage area of the subcatchment was found to be an important variable in their ranks. The HHI ranking results were validated against a stormwater model. The stormwater modelling showed that implementing an equal area of IT (400 m^2) in the individual subcatchments reduces the runoff from 46 to 100%. In prioritizing the types of LID, the cost of the LID type was identified as a key factor. However, the lateral benefits of LID can outweigh the cost if the demand for those benefits is high. For example, RG was more expensive than IT but was ranked the highest at three subcatchments due to its high lateral benefits. The geospatial methods for quantifying the lateral benefits of LID types effectively reflected the demand of subcatchments, yet there is a vast need for research in this area for quantifying the selected lateral benefits. Incorporating the lateral benefits of LID into the demand of subcatchments for these benefits allowed for the subcatchment-specific ranking of LID types. An example of the identified LID solution (IT considered for the first four top-ranked subcatchments) was applied to the case study. The result showed that implementing an infiltration trench with a total area of 1600 m^2 (2.2 % of the study area) in the first four high-ranked subcatchments reduces the runoff volume by 39.1% and peak by 45%. The study of the influence of different rainfall patterns, frequency, and duration suggested that in response to higher runoff volumes LID exhibits a higher performance. However, the pattern of the rainfall (rainfall intensity) was shown to be an important factor in affecting the performance. LID was found to have a more effective performance in response to lower rainfall intensities (such as Hurricane Hazel).

SERAH efficiently prioritizes the subcatchment and types of LID and is applicable in all catchments (was not customized for a specific catchment). It is suitable for the strategic planning and detailed design phases of LID projects. SERAH integrates benefits of LID to the demand of subcatchments for LID. It provides us with information about the distribution of demands for LID across the catchment. SERAH identified future areas of research, particularly the incorporation of the non-hydrological aspects of LID into LID planning.

CHAPTER 5: INPUT DATA SOURCES AND SENSITIVITY ANALYSIS

5.1. PREFACE

This chapter includes two sections. The first section presents the data used in this research, the sources of data and discussion about the data gathering challenges. The second section investigates the effect of input data (parameters and weights) on the indices (HHI, LIDDI, HSE) suggested in this dissertation (chapters 2, 3 and 4).

5.2. INPUT DATA SOURCES AND SUMMARY INFORMATION

One of the main stages in this research was the geospatial data preparation and cleansing. The multiple resources of data, various reference coordinate systems and projections, and conflicting data classifications were challenging. A standard data repository platform (spatial data infrastructure) linking all these data will assist the end users with a more efficient data preparation and cleansing, access to the most suitable dataset, and reduces the duplication and redundancy of data. Because of the diversity of the reference coordinate systems used for the different sets of data at the same location, the coordinate transformation was applied to tackle this issue. Also, there was a considerable inconsistency on the data interpretation and classification for the same set of data prepared by different organizations. For example, the land cover map of the three cities, Toronto, Montreal, and Vancouver has followed a significantly different ways of classification of land covers. Having an ontology for data classes (a unified terminology for data interpretation) will help the users with a more efficient understanding and synthesizing of the data.

The last and most important challenge was the inadequacy of the available data. This included inadequacy in the precision of the available data in representing the reality (e.g., data was too simplified to address the need of this research) as well as the amount of information that could be derived from a set of data. Out of all other reasons, this could be impacted by the common acceptable lack of precision which has various known sources (the discussion is out of the scope of this research); the extent of simplification of data (data represents rough information about the location (e.g., biodiversity data set for the City of Toronto provided us with a minimum required information); the age of data (data were old and have not been updated and revised), etc. In some cases of detailed data sets (less simplified), the amount of information that could be derived from was not adequate. For example, determining the saturated hydraulic conductivity of the surficial soil of the cities was a major challenge since it was not provided in many of the available geological data sets. One of the reasons causing this could be the need for data from multiple disciplines (hydrological- hydraulic, environmental, and socioeconomic), for stormwater management purposes.

A summary of datasets, their sources, and their characteristics are presented in Table 5.1 to 5.3. for City of Toronto, Montreal, and Vancouver, respectively. All these data were collected from the publicly available data sources.

Table 5.1 The geospatial data used for Toronto, including a summary of the metadata and access links

Official name	**Owner**	**Purpose for Collecting**	**Time Coverage**	**Spatial Coverage**	**Data source**	**Format**	**Resolution**
Toronto							
Air pollution (TPM2.5)	Government of Ontario , Ministry of Environment, Conservation and Parks	Monitoring air quality	2000-2021	Province of Ontario	Recording stations	CSV/HTML/XML	Temporal (hourly) Spatial (point data (stations)
Access link: http://www.airqualityontario.com/history/index.php							
Bedrock topography and overburden thickness mapping, southern Ontario	Ministry of Northern Development and Mines	This digital mapping initiative for southern Ontario was undertaken to determine the true nature of the bedrock surface both in thin-drift areas and in areas where overburden is thick in order to better understand both exposed and buried bedrock topographic features in relation to the known and/or inferred regional bedrock geology	2006	West Bounding Coordinate: -83° 29' East Bounding Coordinate: -74° 21' North Bounding Coordinate: 46° 01' South Bounding Coordinate: 41° 41'	Aerial Survey	SHP/Vector	0.005 decimal degree
Access link: http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth							
Census Tracts Boundary File	Government of Canada; Statistics Canada; Statistical Registers and Geography Division	Census tracts (CTs) are small, relatively stable geographic areas that usually have a population of less than 10,000, based on data from the previous Census of Population Program. They are located in census metropolitan areas and in census agglomerations that had a core population of 50,000 or more in the previous census	2004	West bound longitude: -180° East bound longitude: 180° North bound latitude: 89.999531° South bound latitude: 36.265059°	Census records	Vector/polygon	NA
Access link: http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-eng.cfm							

Official name	Owner	Purpose for Collecting	Time Coverage	Spatial Coverage	Data source	Format	Resolution
Digital elevation model (DEM)	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit	The Ontario Digital Elevation Model (Imagery-Derived) is a raster elevation product that provides a generalized representation of both surface and ground features	2017, data is continually being updated	West longitude: -93.0983° East longitude: -78.871° North latitude: 50.568° South latitude: 41.3011°	Aerial photography	Raster	5 m (in 2017) (2 m in 2021)
Access link: https://geohub.lio.gov.on.ca/datasets/mnrf::ontario-digital-elevation-model-imagery-derived							
Ecozones of Ontario	Scholars Geoportal	Work is proceeding on many fronts to protect Canada's ecosystems. Activities include establishing protected areas to help conserve ecosystems and implementing species and habitat recovery programs. The federal government now provides tax incentives to individuals for donations of lands for conservation purposes. Industries such as forestry and agricultural are incorporating ecosystem management practices into their working practice.	2002	West Bounding Coordinate: -141° East Bounding Coordinate: -52° North Bounding Coordinate: 84° South Bounding Coordinate: 42°	Source Scale Denominator: 250000	Vector/polygon	0.000001 decimal degree
Access link: http://geo2.scholarsportal.info/proxy.html?http:__giseditor.scholarsportal.info/details/view.html?uri=/NAP/Geogratis_1991_1998_Ecoatlas.xml&show_as_standalone=true							

Official name	Owner	Purpose for Collecting	Time Coverage	Spatial Coverage	Data source	Format	Resolution
Groundwater Level Time Series of the Oak Ridges Moraine	Groundwater Information Network (GIN)	This dataset exhibits the surficial geology of the Oak Ridges Moraine area, southern Ontario. The study area includes most of the Greater Toronto Area. This dataset presents groundwater level time series of monitoring sites from the Oak Ridges Moraine.	Dec-2011 to Dec-2012	West bound: 80.007888000° East bound: NA North bound: 44.108799000° 43.862067° South bound : 43.495759000°	The dataset comes from the Provincial Groundwater Monitoring Network (PGMN) from the Ministry of the Environment and Climate Change Ontario	Vector/point	1: 75000
Access link: https://gin.gw-info.net/service/api_ngwds:gin2/en/data/standard.download.html?THEME=5&BBOX=-79.829254,43.637329,-78.266449,44.186646							
Land cover for the City of Toronto, ONT	City of Toronto	This dataset was developed as part of the Urban Tree Canopy (UTC) Assessment for Toronto. As such, it represents a "top down" mapping perspective in which tree canopy over hanging other features is assigned to the tree canopy class. At the time of its creation this dataset represents the most detailed and accurate land cover dataset for the area	2007	West bound: 79.643724° East bound: 79.113286° North bound: 43.862067° South bound : 43.574826°	The primary sources used to derive this land cover layer were QuickBird satellite imagery (0.6 m) acquired in 2007.	Raster	0.6 m
Access link: https://open.toronto.ca/dataset/forest-and-land-cover/							

Official name	**Owner**	**Purpose for Collecting**	**Time Coverage**	**Spatial Coverage**	**Data source**	**Format**	**Resolution**
Water course centerline in TRCA jurisdiction	Toronto and Region Conservation Authority (TRCA)	The data set is a line feature layer representing the approximate centerline of the river channel.	2017 (was used) 2021 (latest updated)	Top: 4,875,905.071300 m Bottom: 4,826,760.423200 m Left: 578,555.410900 m Right: 661,998.401100 m	Current orthophotography as the base source, The update was using 2015 Lidar DEM and 2018 ortho photo	Vector/polyline	0.0001 m
Access link: https://data.trca.ca/dataset/watercourses-trca							
Surficial Geology of Southern Ontario	Government of Canada	This data provide a detailed overview of the surficial geology of provinces including southern Ontario and associated attributes available to the land-use planning, consulting, aggregate/industrial mineral industry and development community as well as government geoscientists, resource scientists, conservation authorities, land-use planners and academic researchers.	2010	North bound: 46° 00' South bound: 42° 00' West bound: -83° 00' East bound: -74° 00'	OGS Hard copy Quaternary geology maps by Ontario Geological Survey, Ministry of Northern Development and Mines	Vector/polygon	1:50 000
Access link: http://open.canada.ca/data/en/dataset/a75c3d6c-354d-436d-999d-431fb3a9de79							

Official name	Owner	Purpose for Collecting	Time Coverage	Spatial Coverage	Data source	Format	Resolution
Precipitation data	The Institute for Catastrophic Loss Reduction	This data is prepared to generate local IDF curve information that accounts for the possible impacts of climate change. It applies a user-friendly GIS interface and provides precipitation accumulation depths for a variety of return periods (2, 5, 10, 25, 50 and 100 years) and durations (5, 10, 15 and 30 minutes and 1, 2, 6, 12 and 24 hours), and allows users to generate IDF curve information based on historical data, as well as future climate conditions that can inform infrastructure decisions.	Temporal data up to 2017(about 10 years)	800 Environment and Climate Change Canada operated rain stations from across Canada	Gridded dataset produced for the IDF_CC tool [225]	Vector/point	NA
Access link: https://www.idf-cc-uwo.ca/home							
Educational institute	City of Toronto	NA	NA	NA	NA	KML	NA
Access link: https://www.google.com/maps/search/toronto+ Educational institute							
Toronto Hospitals	City of Toronto	NA	NA	NA	NA	KML	NA
Access link: https://www.google.com/maps/search/toronto+hospitals							
Flood vulnerable areas	Toronto and Region Conservation Authority (TRCA)	NA	NA	NA	TRCA	PDF	NA
Access link: https://data.trca.ca/dataset/flood-vulnerable-cluster							

Table 5.2 The geospatial data used for Montreal, including the type of data, the format, and the source of data

Official name	Owner	Purpose for Collecting	Time Coverage	Spatial Coverage	Data source	Format	Resolution
Montreal							
Digital elevation model (DEM)	City of Montreal	This data set is the Montreal Digital Elevation Model is a raster elevation product that provides a generalized representation of both surface and ground features.	2015-11-24 to 2015-12-08	West bound: -73.995838° East bound: -73.458903° North bound: 45.706882° South bound: 45.391025°	LiDAR data (Point Cloud) acquired in partnership with the city of Montreal.	Raster	1 m
Access link: https://ftp.maps.canada.ca/pub/elevation/dem_mne/highresolution_hauteresolution/dtm_mnt/1m/VILLE_MONTREAL/VILLE_MONTREAL/thumbnail/							
Groundwater	Government of Quebec	This data set is prepared to include the drilling reports transmitted by drilling companies, drilling teams from the Ministry of Natural Resources, and nknown well diggers, or geotechnical drilling carried out by the Ministry of Transport	1978 to 2019	North bound: 2,728,943.753180 m South bound: 2,666,255.978993 m West bound: 1,709,015.306867 m East bound: -1,767,673.263497 m	European Petroleum Survey Group (EPSG)	Vector/point	1: 10 000
Access link: http://www.sih.environnement.gouv.qc.ca/inforesultats.php#lithologie							
Land Cover	Metro Montreal	The data is to present land use of the Montreal, as compiled by the CMM for all of its territory on the land use mapping, version 2016, using a methodology, a classification and segmentation rules of its own.	2016	West bound: 265,961.230900 m East bound: 306,814.230900 m North bound: 5,063,078.067800 m South bound: 5,027,324.067800 m	The data land use numbers are those used for the production of the 97 fact sheets. the land use mapping	Vector/polygon	1: 1000
Surficial geology and saturated hydraulic conductivity (K_s)	The same data source used for Toronto						
Precipitation data	Same data source used for Toronto						

Table 5.3 The geospatial data used for Vancouver, including the type of data, the format, and the source of data

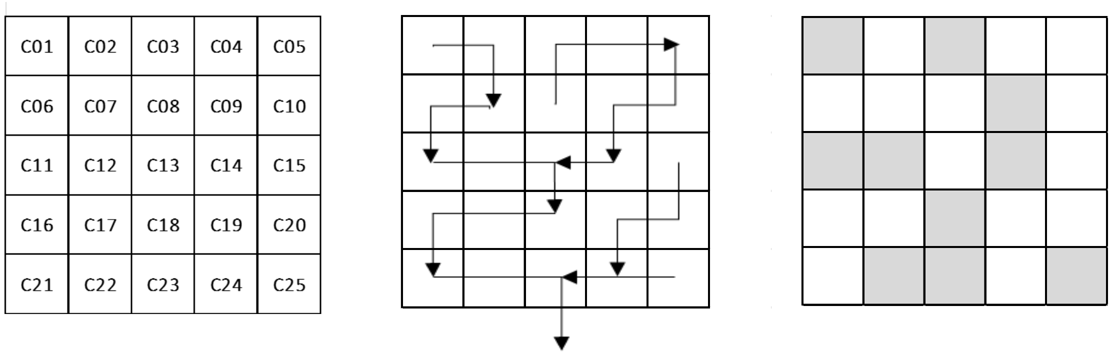
Official name	Owner	Purpose for Collecting	Time Coverage	Spatial Coverage	Data source	Format	Resolution
Vancouver							
Digital elevation model (DEM)	City of Vancouver	The data include the Digital Elevation Model (DEM) data coverage up to extents of City of Vancouver’s legal jurisdiction	2013	West bound: 483,639.100000 m East bound: 498,326.600000 m North bound: 5,463,000.430000 m South bound: 5,449,435.930000 m	LiDAR data	Raster	1 m
Access link: https://opendata.vancouver.ca/explore/embed/dataset/open-data-change-log/log/?disjunctive.datasets&sort=logdate&refine.datasetids=digital-elevation-model&refine.datasets=Digital%20elevation%20model							
Groundwater	Province of British Columbia	The data presents the well data including the active with real -time, active without real-time, and inactive	2017 to 2019	West bound: 487,075.983400 m East bound: 496,523.967700 m North bound: 5,458,148.955300 m South bound: 5,449,778.012900 m	European Petroleum Survey Group (EPSG)	Vector/point	1: 1000
Access link: https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=b53cb0bf3f6848e79d66ffd09b74f00d							
Land Cover	City of Vancouver	The data is to create a Canada wide topographic dataset which can be used for cartographic display, facilities management, and location-based services	2014	West bound: 479,351.596508 m East bound: 500,227.798140 m North bound: 5,463,416.209166 m South bound: 5,445,137.327789 m	DMTI Spatial Inc.	Vector/polygon	
Access link: http://www.metrovancouver.org/metro2040/land-use-designation/Pages/default.aspx							
Surficial geology and saturated hydraulic conductivity (K_s)	The same data source used for Toronto						
Precipitation data	The same data source used for Toronto						

5.3. THE SENSITIVITY ANALYSIS FOR INPUT DATA (PARAMETERS AND WEIGHTS)

This section includes the sensitivity analysis of the input data (parameters and weights) of the models and indices developed in this dissertation (HHI, LIDDI, HSE). Sensitivity analysis methods investigate the effect of possible errors in input data on the model outputs. Meaning that sensitivity analysis methods are used to exhibit the impact of alternative assumptions of the modelling process through visualization and numerical analysis [226]. There are a variety of methods for sensitivity analysis. The most conventional method tests the model based on changing one parameter at a time and assuming other inputs are constant. Also, there exist other different methods that test the combined effect of the input data which are not considered in this study [226].

To investigate the sensitivity analysis, we applied it to an artificial catchment. This catchment was discretized into 25 square-shaped subcatchments represented in Figure 5.1 (a), with an assumed flow direction (Figure 5.1 (b)). Among all 25 subcatchments, 10 feasible subcatchments were randomly selected as the subcatchments which layouts are present in Figure 5.1 (c).

The geospatial characteristic of the catchment including slope (S), rainfall (R), hydraulic conductivity (Ks), depth to groundwater table (Dg), depth to restrictive soil layer (Dr), environmental demand indices (assumed to be four indices), socioeconomic demand indices (assumed to be four indices) were randomly generated through random functions for all 25 subcatchments (C01 to C25). The minimum and maximum values for S, R, Ks, n, Dg, and Dr were generated based on the actual data from the city of Toronto [152]. However, the range of environmental and socioeconomic indices was considered to fall between 0 and 1, which overall led to eight different random layers (four for environmental and four for socioeconomic). Also, in our conceptual model, we compare three arbitrary LID types. These LID types are assumed to have three different costs (normalized between 0 and 1), and eight benefits. Each benefit was assumed to be a corresponding benefit to a demand of the artificial catchment. These benefits also were randomly generated which resulted in assigning eight values to each LID type.



(a) (b) (c)

Figure 5.1 the characteristics of the conceptual model including (a) The layout of the catchment and assigned name of the subcatchments (b) The direction of flow (black arrows) to the outlet (c) feasible subcatchments (grey)

The base scenario was randomly generated in the range of actual data of the City of Toronto. The sensitivity analysis was performed considering a -30 %, -20 %, -10 %, +10 %, +20 %, and +30 % change in the input data (the deviation from the input data of the base scenario) [227] [228]. The sensitivity analysis was conducted in four stages: First, generating 875 subcatchments' data for exploring the impact of Rainfall (R), hydraulic conductivity

(Ks), Depth to restrictive layer (Dr), porosity (n), and Slope (S) on HHI. Second, the impact of changes in HHI in combined with constant environmental (ENI) and socioeconomic benefit (SEI) on LIDDI has been studied as well as the correlation of these data with LIDDI. Third, three types of LID and their benefits and cost were generated randomly. Then the impact of change of the input data on the HSE was examined. Fourth, the weights used for combining HHCI and SEI were changed from 10 to 100 percent by 10 percent intervals. Then, the effect of the change of these weights on the HSE was explored.

5.3.1. HHI sensitivity to input parameters

The sensitivity of HHI to the five input parameters (rainfall, slope, porosity (n), depth to restrictive layer (Dr), and hydraulic conductivity (Ks)) was explored. To do so, 6 scenarios for each input parameter were generated including -30 %, -20 %, -10 %, +10 %, +20 %, and +30 % change in the input parameter. Table 5.4 and Table 5.5 present the summary of the results. Including the scenario ID, the average value of each parameter per catchment for each scenario, percent change of the average and standard deviation of the output (HHI and LIDDI). The results suggest that the sensitivity of HHI to the rainfall (R) and the hydraulic conductivity (Ks) is the most, with Ks slightly lower than the R. It showed that HHI is marginally sensitive to the slope (for -30 % change in slope the HHI decreased approximately 4 percent). Also, the sensitivity of HHI to Dr and n was the least since the Ks outweighed these values in the relationship and was always the minimum value. Since these parameters represent the infiltration rate similar to Ks the sensitivity of HHI to Dr is identical to the Ks if they outweigh the Ks. Figure 5.2 presents the relationship between HHI and each of the input parameters to investigate the correlation between these data. The plots presented in Figure 5.2 agree with the findings of Table 5.4 and Table 5.5. They exhibit a strong correlation between HHI and R as well as HHI and Ks. This correlation confirms the high sensitivity of HHI to R and Ks parameters.

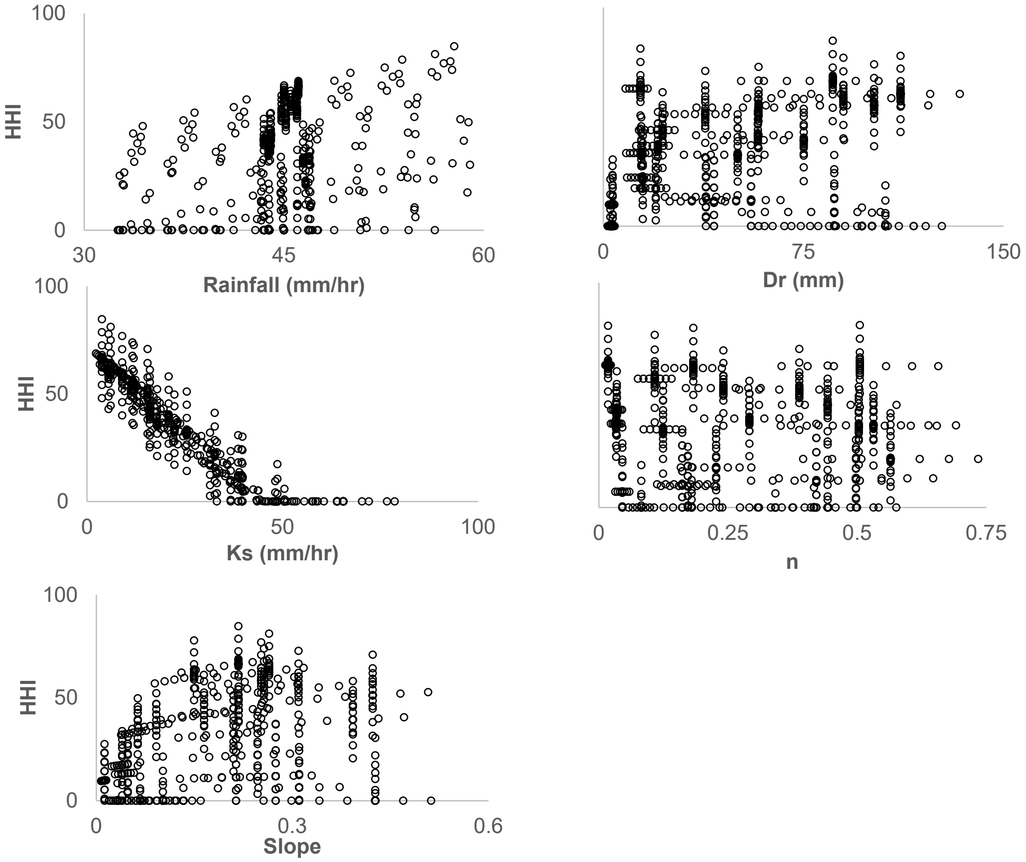


Figure 5.2 HHI versus the input data (Rainfall, Hydraulic conductivity (Ks), Slope, Depth to restrictive layer (Dr,), and porosity n)

Table 5.4 The impact of -30, -20, -10, 10, 20, 30 percentage changes in input data on the average of HHI compared to the base scenario

Scenario	Average of rainfall	Average of slope	Average of Dr	Average of n	Average of Ks	Average of HHI
R -30%	33.70	0.20	52.35	0.28	28.48	-43.75%
R -20%	37.48	0.20	52.35	0.28	28.48	-30.96%
R -10%	41.26	0.20	52.35	0.28	28.48	-15.99%
Base	45.05	0.20	52.35	0.28	28.48	
R +10%	48.83	0.20	52.35	0.28	28.48	16.49%
R +20%	52.61	0.20	52.35	0.28	28.48	34.13%
R +30%	56.40	0.20	52.35	0.28	28.48	52.47%
S -30%	45.05	0.14	52.35	0.28	28.48	-4.39%
S -20%	45.05	0.16	52.35	0.28	28.48	-2.82%
S -10%	45.05	0.18	52.35	0.28	28.48	-1.36%
S +10%	45.05	0.22	52.35	0.28	28.48	1.27%
S +20%	45.05	0.24	52.35	0.28	28.48	2.48%
S +30%	45.05	0.26	52.35	0.28	28.48	3.62%
Dr -30%	45.05	0.20	36.65	0.28	28.48	0.00%
Dr -20%	45.05	0.20	41.88	0.28	28.48	0.00%
Dr -10%	45.05	0.20	47.12	0.28	28.48	0.00%
Dr +10%	45.05	0.20	57.59	0.28	28.48	0.00%
Dr +20%	45.05	0.20	62.82	0.28	28.48	0.00%
Dr +30%	45.05	0.20	68.06	0.28	28.48	0.00%
n -30%	45.05	0.20	52.35	0.20	28.48	0.00%
n -20%	45.05	0.20	52.35	0.22	28.48	0.00%
n -10%	45.05	0.20	52.35	0.25	28.48	0.00%
n +10%	45.05	0.20	52.35	0.31	28.48	0.00%
n +20%	45.05	0.20	52.35	0.33	28.48	0.00%
n +30%	45.05	0.20	52.35	0.36	28.48	0.00%
Ks -30%	45.05	0.20	52.35	0.28	19.94	33.73%
Ks -20%	45.05	0.20	52.35	0.28	22.79	21.61%
Ks -10%	45.05	0.20	52.35	0.28	25.63	9.82%
Ks +10%	45.05	0.20	52.35	0.28	31.33	-9.01%
Ks +20%	45.05	0.20	52.35	0.28	34.18	-16.89%
Ks +30%	45.05	0.20	52.35	0.28	37.03	-22.82%

Table 5.5 The impact of -30, -20, -10, 10, 20, 30 percentage changes in input data on the standard deviation of HHI compared to the base scenario

Scenario	**StdDev of rainfall**	**StdDev of slope**	**StdDev of n**	**StdDev of Dr**	**StdDev of Ks**	**StdDev of HHI**
R -30%	0.81	0.12	0.18	36.78	17.86	-24.62%
R -20%	0.95	0.12	0.18	36.78	17.86	-14.69%
R -10%	1.08	0.12	0.18	36.78	17.86	-6.96%
Base	1.22	0.12	0.18	36.78	17.86	
R +10%	1.35	0.12	0.18	36.78	17.86	6.70%
R +20%	1.49	0.12	0.18	36.78	17.86	11.85%
R +30%	1.62	0.12	0.18	36.78	17.86	16.02%
S -30%	1.22	0.09	0.18	36.78	17.86	-4.64%
S -20%	1.22	0.10	0.18	36.78	17.86	-2.97%
S -10%	1.22	0.11	0.18	36.78	17.86	-1.43%
S +10%	1.22	0.13	0.18	36.78	17.86	1.35%
S +20%	1.22	0.15	0.18	36.78	17.86	2.62%
S +30%	1.22	0.16	0.18	36.78	17.86	3.83%
Dr -30%	1.22	0.12	0.18	25.74	17.86	0.00%
Dr -20%	1.22	0.12	0.18	29.42	17.86	0.00%
Dr -10%	1.22	0.12	0.18	33.10	17.86	0.00%
Dr +10%	1.22	0.12	0.18	40.46	17.86	0.00%
Dr +20%	1.22	0.12	0.18	44.13	17.86	0.00%
Dr +30%	1.22	0.12	0.18	47.81	17.86	0.00%
n -30%	1.22	0.12	0.13	36.78	17.86	0.00%
n -20%	1.22	0.12	0.14	36.78	17.86	0.00%
n -10%	1.22	0.12	0.16	36.78	17.86	0.00%
n +10%	1.22	0.12	0.20	36.78	17.86	0.00%
n +20%	1.22	0.12	0.22	36.78	17.86	0.00%
n +30%	1.22	0.12	0.24	36.78	17.86	0.00%
Ks -30%	1.22	0.12	0.18	36.78	12.50	-12.15%
Ks -20%	1.22	0.12	0.18	36.78	14.29	-7.33%
Ks -10%	1.22	0.12	0.18	36.78	16.08	-2.31%
Ks +10%	1.22	0.12	0.18	36.78	19.65	1.74%
Ks +20%	1.22	0.12	0.18	36.78	21.44	2.60%
Ks +30%	1.22	0.12	0.18	36.78	23.22	1.45%

5.3.2. LIDDI sensitivity to input parameters

LIDDI is generated from the HHI, SEI and ENI as presented in Chapter 2. The change in input parameters led to a change in HHI and consequently change in LIDDI. To investigate this change, SEI and ENI were remained unchanged for all scenarios and LIDDI was generated in Table 5.6 presents the summary of the analysis. The results revealed that change in HHI causes an identical change in LIDDI. It was deducted from both average and standard deviation values of HHI and LIDDI. Thus, any change in the input parameters R, S, Ks, Dr, and n will have a direct impact on LIDDI as HHI. Correlation between LIDDI versus HHI, SEI1 to SEI 4, and ENI1 to ENI 4 was explored by plotting these data. Figure 5.3 shows the results, which suggest a strong correlation between LIDDI and HHI. This confirms the findings of the earlier sensitivity analysis (Table 5.6).

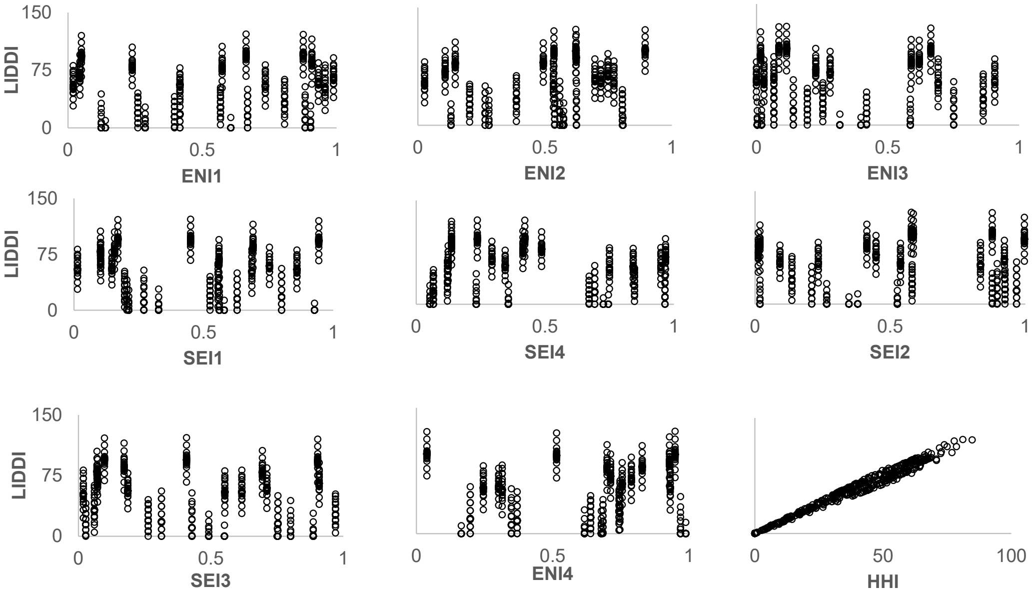


Figure 5.3 LIDDI versus the input data HHI, ENI1-4 and SEI1-4

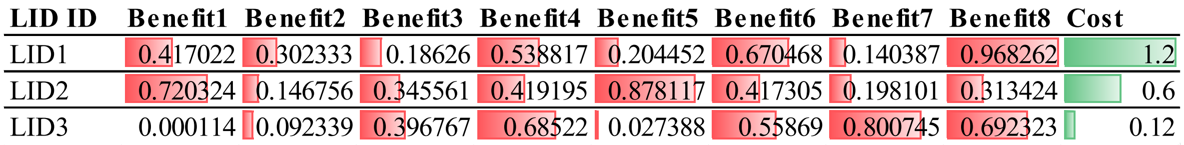
Table 5.6 The impact of HHI changes on LIDDI compared to the base scenario

Scenario	ENI1	ENI2	ENI3	ENI4	SEI1	SEI2	SEI3	SEI4	Average of HHI	% change of average of HHI	Average of LIDDI	% change of average of LIDDI	StdDev of LIDDI	% change of StdDev of LIDDI
R -30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-43.75%	-43.75%	24.12	-43.91%	25.62	-24.59%
R -20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-30.96%	-30.96%	29.64	-31.08%	29.00	-14.66%
R -10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-15.99%	-15.99%	36.08	-16.09%	31.64	-6.89%
Base	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47			43.00		33.98	
R +10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	16.49%	16.49%	50.13	16.57%	36.25	6.68%
R +20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	34.13%	34.13%	57.72	34.22%	38.04	11.94%
R +30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	52.47%	52.47%	65.61	52.56%	39.50	16.23%
S -30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-4.39%	-4.39%	41.12	-4.37%	32.43	-4.58%
S -20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-2.82%	-2.82%	41.80	-2.80%	32.98	-2.93%
S -10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-1.36%	-1.36%	42.42	-1.35%	33.50	-1.42%
S +10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	1.27%	1.27%	43.55	1.27%	34.43	1.33%
S +20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	2.48%	2.48%	44.06	2.47%	34.86	2.58%
S +30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	3.62%	3.62%	44.55	3.60%	35.26	3.77%
Dr -30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
Dr -20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
Dr -10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
Dr +10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
Dr +20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
Dr +30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
n -30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
n -20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
n -10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
n +10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
n +20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
n +30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	0.00%	0.00%	43.00	0.00%	33.98	0.00%
Ks -30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	33.73%	33.73%	57.53	33.79%	29.95	-11.85%
Ks -20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	21.61%	21.61%	52.33	21.68%	31.54	-7.18%
Ks -10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	9.82%	9.82%	47.27	9.91%	33.19	-2.32%
Ks +10%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-9.01%	-9.01%	39.08	-9.12%	34.60	1.83%
Ks +20%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-16.89%	-16.89%	35.68	-17.02%	34.88	2.65%
Ks +30%	0.54	0.51	0.33	0.61	0.46	0.51	0.47	0.47	-22.82%	-22.82%	33.11	-23.01%	34.49	1.49%

5.3.3. HSE sensitivity to input parameters

HSE sensitivity analysis was conducted using the same catchment as the previous steps. To calculate HSE three random LID types were generated with eight benefits. These benefits are corresponding to the eight LID demands (SEI1 to SEI4 and ENI1 to ENI4). All benefits and demands are assumed to be normalized between 0 and 1. Table 5.7 presents a comparison between the three random LID types. It shows that the maximum of benefits is 2/8 for LID1 2/8 for LID2 and 5/8 for LID3. LID1 is the most expensive and LID3 is the least expensive type. In this step, the impact of change in input data (R, S, Ks, Dr, n) on the HSE1 to HSE3 was investigated and the weight of HHCI and SEI were considered equal. Following this, in the next step, the impact of weights of HHCI and SEI on HSE was explored. Table 5.7 shows the summary of the analysis by presenting the change in average and standard deviation of HSE1 to HSE3 against the change in HHI. The results suggest that change in HHI has the maximum impact on the average of HSE3 and the minimum impact on the average of HSE1. It also shows that the standard deviation had not significantly changed and is similarly the highest for HSE3 and the lowest for HSE1. The extent of the impact of HHI seems to be related to the cost of LID type. The lowest the cost the highest the sensitivity to change in the input data

Table 5.7 The cost and benefit comparison among the three selected LID types (LID1 to LID3)



LID ID	Benefit1	Benefit2	Benefit3	Benefit4	Benefit5	Benefit6	Benefit7	Benefit8	Cost
LID1	0.417022	0.302333	0.18626	0.538817	0.204452	0.670468	0.140387	0.968262	1.2
LID2	0.720324	0.146756	0.345561	0.419195	0.878117	0.417305	0.198101	0.313424	0.6
LID3	0.000114	0.092339	0.396767	0.68522	0.027388	0.55869	0.800745	0.692323	0.12

Table 5.8 The impact of HHI changes on a mean and standard deviation of HSE of the three selected types of LID

Scenario	Scenario	Average of HHI	StdDev of HHI	Average of hse_lid1	Average of hse_lid2	Average of hse_lid3	StdDev of hse_lid1	StdDev of hse_lid2	StdDev of hse_lid3
Sc01	R -30%	-43.75%	-24.62%	-0.63%	-1.22%	-4.79%	-0.19%	-4.63%	-8.38%
Sc02	R -20%	-30.96%	-14.69%	-0.46%	-0.89%	-3.48%	-0.69%	-3.69%	-6.68%
Sc03	R -10%	-15.99%	-6.96%	-0.22%	-0.43%	-1.70%	-0.65%	-1.98%	-3.50%
Sc04	Base								
Sc05	R +10%	16.49%	6.70%	0.20%	0.38%	1.50%	1.00%	2.20%	3.64%
Sc06	R +20%	34.13%	11.85%	0.40%	0.77%	3.03%	2.51%	4.72%	7.52%
Sc07	R +30%	52.47%	16.02%	0.59%	1.14%	4.47%	3.80%	7.04%	10.97%
Sc08	S -30%	-4.39%	-4.64%	0.00%	-0.01%	-0.03%	-0.03%	-0.06%	-0.05%
Sc09	S -20%	-2.82%	-2.97%	0.00%	0.00%	-0.02%	-0.02%	-0.04%	-0.03%
Sc10	S -10%	-1.36%	-1.43%	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.02%
Sc12	S +10%	1.27%	1.35%	0.00%	0.00%	0.01%	0.01%	0.02%	0.01%
Sc13	S +20%	2.48%	2.62%	0.00%	0.00%	0.01%	0.02%	0.03%	0.03%
Sc14	S +30%	3.62%	3.83%	0.00%	0.01%	0.02%	0.02%	0.05%	0.04%
Sc15	Dr -30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc16	Dr -20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc17	Dr -10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc19	Dr +10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc20	Dr +20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc21	Dr +30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc22	n -30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc23	n -20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc24	n -10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc26	n +10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc27	n +20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc28	n +30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sc29	Ks -30%	33.73%	-12.15%	0.53%	1.02%	4.00%	3.61%	5.85%	8.82%
Sc30	Ks -20%	21.61%	-7.33%	0.59%	1.15%	4.50%	3.82%	7.08%	11.06%
Sc31	Ks -10%	9.82%	-2.31%	0.27%	0.51%	2.02%	1.49%	3.05%	4.97%
Sc33	Ks +10%	-9.01%	1.74%	-0.25%	-0.48%	-1.89%	-0.72%	-2.18%	-3.86%
Sc34	Ks +20%	-16.89%	2.60%	-0.46%	-0.90%	-3.51%	-0.71%	-3.74%	-6.80%
Sc35	Ks +30%	-22.82%	1.45%	-0.60%	-1.16%	-4.56%	-0.35%	-4.55%	-8.29%

5.3.4. Sensitivity of the result of SERAH to weights of HHCI and SEI

The impact of the selected weights on the rank of the LID types was investigated by changing the weight of HHCI and SEI. The weight of HHCI was started with 0.1 to 1.0 by 0.1 intervals. The sum of the weights was 1.0, so the weight of SEI was decreased from 0.9 to 0.0 by 0.1 intervals. As a result, 10 scenarios were generated and compared to the base scenario (equal weights for HHCI and SEI, weights = 0.5). The summary of the results is presented in Table 5.9 and Figure 5.4 The impact of HHCI and SEI weights on the HSE values. Table 5.9 presents how the rank of each LID type has change (e.g., -1 means that LID has down-ranked by 1, and 1 means that LID is up-ranked by 1 compared to the base scenario). Overall, the change in weights about ±20 % (HHCI weights = 0.3 to 0.7) has not changed the ranks significantly. The changes ±30 % had a mild effect on the ranks. However, ±40 % of the change in the weights had a significant impact on the ranks of LID3, where the variation of the rank in this type of LID is the highest among all. Thus, the rank of LID3 is the most sensitive compared to the other two types. The reason is related to the cost of this type of LID. Wherein the HHCI weight is the maximum, the rank of LID3 increases significantly. The results suggest that with increasing the weight of HHCI, the rank of the unexpensive LID (LID3) increases whereas decreasing the weight of HHCI, outweighs the lateral benefit of LID1 to its cost and gives this type of LID a higher rank.

The variation of SEI of the three LID types is presented in Figure 5.4, which agrees with these results. This figure shows that the value of HSE increases for LID3 (grey colour solid lines) dramatically with higher weights. It also suggests that LID3 is the most sensitive to the weights compared to the other two types.

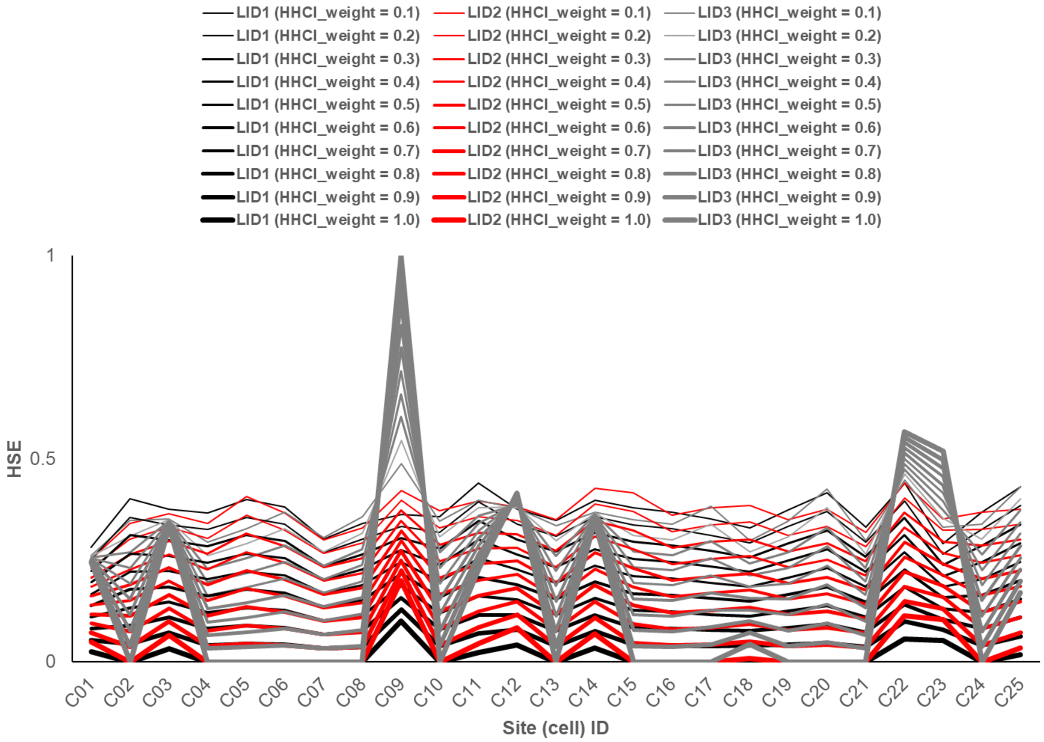


Figure 5.4 The impact of HHCI and SEI weights on the HSE values

Table 5.9 The impact of weight of HHCI and SEI on the rank of LID types in different subcatchments (cells) compared with the base scenario (equal weights for HHCI and SEI = 0.5)

	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3	LID1	LID2	LID3
	HHCI Weights																													
Cell ID	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.4**	**0.4**	**0.4**	**0.5**	**0.5**	**0.5**	**0.6**	**0.6**	**0.6**	**0.7**	**0.7**	**0.7**	**0.8**	**0.8**	**0.8**	**0.9**	**0.9**	**0.9**	**1.0**	**1.0**	**1.0**
C01	-1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0
C02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1
C03	-2	0	2	-1	1	0	-1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	0
C06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1
C07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	2
C08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	2
C09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	0
C11	-1	0	1	-1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0
C12	0	-1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	0
C14	-1	-1	2	0	-1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	0
C16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	0	2
C18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	-1	1	0	-1	1	1	-2	1	1	-2	1	1	-2
C19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	2
C21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	0	-1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	0	1	-1	0	1	-1	0

5.4. CONCLUSION

This chapter presents, first, the challenges related to the input data, the sources, and the summary of the metadata used for this research. Second, the sensitivity of the input data (parameters and weights) on the output of the suggested models and corresponding indices (HHI, LIDDI, and HSE) are investigated. Generally, the data gathering and cleansing still are challenging processes due to some drawbacks such as the multiple resources of data, reference coordinate systems and projections, and conflicting data classification. The concern about the accuracy of the input data led our research to investigate the sensitivity of the output on the input data. This investigation was performed through a synthetic catchment and random dataset.

The sensitivity analysis for -30 %, -20 %, -10 %, +10 %, +20% , +30% change in input data (rainfall, slope, Dr, n, K_s) showed that the HHI is the most sensitive to rainfall and least sensitive to the slope. LIDDI has a linear relationship to HHI, therefore the impact of rainfall on LIDDI is identical to HHI. The effect of change in HHI on the rank of LID types suggested that the magnitude of the impact is related to the cost of LID type. The lowest the cost the highest the sensitivity to change in the input data. The sensitivity of the HSE to the weights by changing the weight of HHCI from 0.1 to 1.0 by 0.1 intervals was compared with the base scenario of equal weights for HHCI and SEI. Thus, the results showed that the rank of LID3 is the most sensitive compared to the other two due to the cost of LID3. Wherein the HHCI weight is the maximum the rank of LID3 increases and vice versa. This result is aligned with the results of Chapter 4 which suggested the cost of LID is an important parameter in the determination of the rank.

CHAPTER 6: CONCLUSION

This chapter in three sections provides the summary on the major conclusions from each chapter, presents the novel contributions of this dissertation, and recommendations for future research.

6.1. GENERAL CONCLUSIONS

The overall objective of this dissertation was to develop a novel GIS-based LID framework for sustainable urban runoff management and using LID techniques. This objective was reached by dividing it into three sub-objectives: i) developing a simplified geospatial index for ranking LID subcatchments, ii) applying the proposed index under climate change and urbanization, iii) developing a simplified geospatial model for ranking LID solutions, which also included a comprehensive review on LID models. The major conclusions of each objective are provided below.

6.1.1. Developing a simplified geospatial index for ranking LID subcatchments

In Chapter 2 a simplified geospatial index was developed to rank the subcatchments within a study area. The index was generated through an innovative framework and determines the rank of subcatchments using the physics of the runoff generation phenomenon and a GIS-based MCDM model. In this Chapter, the contributing criteria to the decision were comprehensively identified, quantified, and integrated through geospatial analysis. The data preparation and cleansing were performed using an automated process through developed scriptsd in Python.

The framework ranked the study area by generating the LID Demand Index (LIDDI). LIDDI ranks the subcatchments of the study area based on the three proposed indices: Hydrological-Hydraulic Index (HHI), Environmental Index (ENI), and Socioeconomic Index (SEI). Subcatchments with high LIDDI have a high rank for implementing LID. HHI indexes the study area based on the potential of subcatchments in runoff generation using a novel and heuristic physical-based geospatial relationship that was proposed in this chapter. HHI was validated by comparing the GIS-generated results against the results of a hydrological model (HEC-HMS) and historical flood-vulnerable locations within the study area. High ENI and SEI in a subcatchment represent a high environmental and socioeconomic demand for LID. HHI, ENI, and SEI were integrated through a second heuristic equation which considered the lateral benefit (SEI and ENI) as an additive value to the primary benefit (HHI). Also, a sensitivity analysis (as presented in Section 5.3) was performed to investigate the impact of the change in input data (parameters and weights) on the HHI and LIDDI.

LIDDI was generated for the City of Toronto. The results showed that the developed indices offer multiple advantages. LIDDI resolved the lack of a knowledge-based decision-making system for identifying high-rank subcatchments for implementing LID. LIDDI creates a novel index for the runoff reduction benefit of LID, HHI, and integrates it into the indices generated for lateral benefits of LID (environmental and socioeconomic). The integration of an HHI into lateral benefits through MCDM and heuristic relationships suggests an innovative approach. The data required to generate LIDDI are publicly available, which facilitates the wider use of the framework. The framework is not limited to the scale of the study area and modelling multiple scales (micro-, meso-, and mega-scale) is feasible. This is a significant advantage for modelling city-scale study areas for narrowing down the decision of which subcatchments need to have LID implemented. It accepts the actual values of data and does not require modification or customization of data to generate the indices. Lastly, the developed model is universal and is not limited to a certain study area. Thus, it can be used in any study area or region of interest.

6.1.2. Applying the proposed index under climate change and urbanization

In Chapter 3 using the application of the novel hydrological-hydraulic index (HHI) developed in Chapter 2 was investigated. This investigation also lends itself to studying the impact of climate change and urbanization on the potential of runoff generation (demand for LID) for three Canadian cities (Toronto, Montreal, and Vancouver). The study considered twelve combinations of climate change and urbanization scenarios to cover a wide range of possible future conditions. The combinations were created from four climate change scenarios (considering historical precipitation data as the “base” scenario and three projected precipitation data for the years 2006 to 2036, 2066, and 2096). Also, three urbanization scenarios, “base” scenario (based on the current land cover status), Scenario 1 (medium urbanization), and Scenario 2 (high urbanization). The variety of case studies (three Canadian cities) having different climate and urbanization statuses increased the breadth of these variables under the investigation.

Overall, the results of this Chapter agreed with previous findings of the impact of urbanization and climate change on runoff generation. This result represented the overall demand for LID. A comparison among all three cities showed that for a status of urbanization and climate, Toronto and Montreal have a higher demand for LID compared with Vancouver. Also with time, the magnitude of increase in demand for LID was higher for these cities and lower for Vancouver. The extent of the impact of future scenarios was a function of the current permeability of the city and the rainfall intensity. These parameters (rainfall intensity and current permeability) determine the change in which future factor (urbanization/climate change) has a higher effect on runoff generation. Unlike Vancouver with low rainfall intensity, in Toronto and Montreal climate change is the key factor compared with the urbanization. Unlike these cities, in Vancouver, it was found that HHI is sensitive to both urbanization and climate change. In this Chapter, it was revealed that climate change increases the mean HHI of all three cities in contrast to urbanization which causes an increase in HHI frequency. Meaning that with time demand for LID will increase but the magnitude of this change varies depending on the case study. The mean HHI in Toronto and Montreal more dramatically raised compared with Vancouver. Because these cities have high-intensity rainfall compared with Vancouver with lower rainfall intensity. The change in frequency of HHI (representing the increase in the number of subcatchments that demand LID) was affected by the current permeability status of the cities. The high current impermeability leaves lower room for a raise in HHI.

Modelling city-scale study areas through traditional stormwater models is associated with complexity due to numerous input data including LID subcatchments, constant urban change (and growth), global climate change, and the non-uniform spatial distribution of land cover and rainfall. This chapter overcame this complexity through an innovative index (HHI) and facilitated modelling three cities for future scenarios. This modelling allowed us to reach knowledge about how changes in climate and urban land cover impacts the demand for LID. Such information lends itself to urban planning, designing multifunctional urban infrastructure, policymaking regarding urban growth, and the optimal assignment of financial resources for runoff and flood risk management.

6.1.3. Developing a simplified geospatial model for ranking LID solutions

In Chapter 4, the objective was attained utilizing the indices developed in Chapter 2 and investigated in Chapter 3. In this chapter a simplified geospatial model for ranking LID solutions was developed. The model is referred to as LID-Solution Evaluation and Ranking ApproacH (SERAH). SERAH considers the key criteria contributing to ranking LID solutions including LID benefits (hydrological-hydraulic, environmental, and socioeconomic), costs, demand for LID, and feasibility for implementing LID. It develops a systematic and knowledge-based decision-making model for ranking the LID solutions to address the gap for such a model in the field. The effectiveness and applicability of SERAH were tested and demonstrated for an actual case study within the City of Toronto using a stormwater model (PCSWMM). Also, a sensitivity analysis (as presented in Section 5.3) was conducted to exhibit the impact of the change in input data (parameters and weights) on the results of SERAH and its related indices (HHI and HSE). As the result, SERAH were able to rank LID solutions and the sensitivity of the results on the parameters were demonstrated to enhance the reliability of the results of SERAH in practice.

Overall, the results of the case study modelling showed that the hydrological-hydraulic index (HHI) is representing the potential of subcatchments in runoff generation and ranks the subcatchments effectively on this basis. In our case study (located in Toronto), which is a highly urbanized area, the contributing drainage area of the subcatchment was found to be an important variable in their ranks. The stormwater modelling showed that implementing an equal area of IT (400 m^2) in the individual subcatchments reduces the runoff from 46 to 100 percent. In prioritizing the types of LID, the cost of the LID type was identified as a key factor. However, the lateral benefits of LID outweighed the cost wherein the demand for lateral benefits was high. The geospatial methods for quantifying the lateral benefits of LID types effectively reflected the demand of subcatchments, however, there is an area for research in this field for quantifying all key lateral benefits. Incorporating the lateral benefits of LID into the demand of subcatchments for these benefits allowed for subcatchment-specific ranking of LID types.

SERAH effectively ranked the need for LID at subcatchments and coressponding LID types. The developed method is universally applicable. SERAH lends itself to the strategic planning for multifunctional sustainable infrastructures (LID) involving multiple stakeholders and decision-makers. Also, SERAH helps with attaining a comprehensive insight into the demands for LID across the catchment. It also suggests areas for future research through multidisciplinary approaches (water resources, geography, socioeconomic, and environment) for runoff-reduction management.

6.2. LIMITATIONS

The limitations and shortcomings of developed method in this research are presented in this section. To apply SERAH for ranking LID solutions these limitations need to be considered.

1. *Hydrological-hydraulic component*
    - *1.1.* The focus of the research is on the runoff reduction in urban areas using LID and pluvial flood management,
    - *1.2.* Each ranked LID subcatchment is considered hydrologically homogenous,
    - *1.3.* Cost of LID needs equivalent hydraulic performance and is limited to capital cost, the life cycle cost can be added in future studies,
    - *1.4.* The discussions on the effect of urbanization and climate change on the demand for LID is limited to the case studies,
2. *Socioeconomic-Environmental components*
    - *2.1.* The weights of the indices in the weighted sum methods are considered equal,
    - 2.2. Linear standardization has been used,
3. *GIS component*
    - *3.1.* The subcatchments were discretized as regular grid cells in the Chapter 2 and 3 and then this was improved as regular grid cells and vector polygons in Chapter 4, which should be considered while using SERAH,
    - *3.2.* Using SERAH requires a resolution that is suitable for detailed design

stormwater projects. The HHI component assumes that the cell is hydrologically homogenous to rank the subcatchments. Thus, the resolution should reflect this assumption. However, like other stormwater projects using excessively fine cells (e.g., 0.1 m) can increase the redundancy of data and computational cost. In contrast, using very coarse cells (e.g., 50 m) needs to be used by considering the assumption. The judgment and the extent of acceptance of the accuracy of the result is the engineer's decision.

6.3. NOVEL CONTRIBUTIONS

This research investigated the solutions for a GIS-based LID framework for sustainable urban runoff management. The innovation and novel contributions of this research include:

1- An innovative physics-based GIS-MCDM index (LIDDI) was developed to systematically rank the LID subcatchments. LIDDI integrates the primary (hydrological-hydraulic) and lateral (environmental and socioeconomic) benefits of LID by suggesting three innovative indices (respectively HHI, ENI, and SEI),

2- A heuristic geospatial relationship was established between variables contributing to runoff generation, called hydrological-hydraulic index (HHI), and validated against a physical model. The HHI is a novel stand-alone index that provides us with a comprehensive insight into the spatiotemporal hydrological status of the catchment,

3- The complexity of city-scale modelling for attaining an insight about future scenarios (a wide range of climate and urbanization) overcame through proposing a physics-GIS-based index (HHI). Three Canadian cities were modelled to explore the applicability of the index. Also, for all cities, the impact of these scenarios on the runoff generation (represented by HHI) and demand for LID in the future is extensively portrayed,

4- A physics-based GIS-MCDM model (SERAH) was proposed to rank LID solutions (LID subcatchments and types). The innovation of SERAH lies in overcoming the complexity of the integration of multiple key contributing factors (feasibility/demand, LID cost/benefit, and variety of LID types). HSE establishes a mathematical and geospatial relationship between these key contributing factors and suggests effective LID solutions,

5- The application of SERAH was tested for a real-world set of data using a SWM. The novelty of these types of modelling lies in testing the effectiveness of the proposed theory with new sets of data, analyzing, portraying the results, and reporting the limitations and areas for improvement.

6.4. FUTURE RESEARCH DIRECTIONS

Using LID in stormwater collection networks still has a wide range of unexplored areas and aspects. During this research many of these areas were highlighted and are suggested for future research:

6.4.1. Identifying and quantifying the key lateral benefit of LID

In Chapters 2 and 4, several lateral benefits (environmental and socioeconomic) of LID were identified, quantified, and integrated into the primary benefit of LID (hydrological-hydraulic). The selected lateral benefits demonstrated the application and effectiveness of the proposed SERAH and its indices. However, there is a need to extensively identify and quantify the most common lateral benefits that are considered in different study areas. The approach for quantification of these benefits varies depending on the nature of that benefit. For example, for air treatment, a distance from the center of pollution was considered as a metric. This was different for the population concentration or biodiversity which had concentration within a polygon as the metric. A comprehensive literature review and data gathering from the decision-makers are required to conduct the suggested research. Such research will enhance the use of SERAH by incorporating the most common and important lateral benefits of LID into ranking the LID types and subcatchments in a catchment and identifying the optimal LID solution. There is limited research in this area some examples of such studies are conducted by Yu et al. (2020) and Bai et al. (2019) [229], [230].

6.4.2. Exploring further geospatial relationships for the integration of the lateral benefits into the primary benefit

In Chapter 2, to generate LIDDI, the lateral benefits (SEI and ENI) were integrated into the primary benefit (HHI) using the weighted sum method and considering equal weights for considered criteria (eight criteria). This was the first step to demonstrate the framework and its effectiveness. However, the use of other MCDM models in geospatial concept, contrasting the different method and their impact on the results can lead to developing improved approaches or increasing the confidence toward the results of the existing framework. There are limited investigations in this area some examples of such studies are by Kuller et al. (2019) and Gallet (2011) [86], [214].

6.4.3. Developing a model which allows for DEM-based outlet detection and routing for LID-scale subcatchments in urban areas

One of the drawbacks in this research was the lack of a model that can automatically delineate and route the pixel-size "urban" subcatchments downstream subcatchments and lastly to the downstream hydraulic unit (inlet or manhole). In conventional models, the discretization of the catchment is through delineating subcatchments using DEM data overlooking "urban" features (such as land cover and land use). Developing an automatic urban catchment delineation method that allows for a more accurate delineation and routing between the subcatchments considering urban features will allow for wide use and further development of frameworks that require finer resolution subcatchments. The research around the subcatchment delineation as a general hydrologic concept has been conducted in previous studies. However, yet there is a need for different approaches, particularly for finer resolution subcatchments. Some examples of recent research are conducted by Islam et al. (2020) and Liu et al. (2020) [231], [232].

6.4.4. Investigation further spatial discretization formats

In Chapter 2 and part of Chapter 4, the regular grid cells and polygon-based discretization formats were used as a representative of a LID subcatchment (one unit of a geographical entity). Future research that uses other spatial discretization methods (e.g., Triangular irregular networks (TIN), Voronoi Diagram, Hexagonal, etc.) for representing geographical entities for the LIDDI and HSE frameworks is suggested. Investigating the impact of shapes (e.g., irregular shapes), resolution, and distribution (e.g., nonhomogeneous size) of the discretized units across the study area could introduce on the results the potential advantage of using other discretization methods. The potential advantages can be improving the computational cost or suggesting innovative methods for overlaying the contributing criteria. An example of similar recent research is by Liao et al. (2020) [233].

6.4.5. Developing physics-based indices for lateral benefits of LID

The hydrological-hydraulic index (HHI), the primary demand index, was developed based on the physics principles governing the runoff generation phenomenon. Lateral benefits of LID were quantified using MCDM concepts. As discussed in Chapter 2, physics-based decision-making models can be validated against an actual physics-based model (as done for HHI in this research). However, validating the fact that MCDM models are accurately representing reality is not practical. Thus, through multidisciplinary research developing physics-based indices for lateral benefits of LID like HHI is recommended for further studies. Integration of such indices will allow for developing a fully physics-based comprehensive LIDDI (LID demand index). An example of similar research is Hou et al. (2020) [214] which models water quality and She et al. (2021) [52] which models carbon emission using GIS and integrates it into the runoff reduction.

6.4.6. Further investigation of the LID demand under future scenarios

In this research, the impact of climate (by projecting rainfall) and urbanization (by projecting imperviousness ratio) on hydrologic-hydraulic demand for LID were investigated. The projection of other variables such as hydraulic conductivity or depth to groundwater in the future is also possible and could be studied using HHI. Also, the demand for lateral benefits of LID (environmental and socioeconomic) under future scenarios such as urbanization and climate change are suggested to be investigated.

6.4.7. Investigation the adequacy of available geospatial data and methods for their improvement for use in LID projects

As discussed in Chapter 5, the inadequacy of data from many aspects such as diversity of projection system, format, resolution, et. were one of the challenges of this research. Thus, an investigation on the quality and adequacy of the existing data, a comprehensive comparison and suggestions for improvement can help the future similar studies in the data processing phase.

6.4.8. Correlating HHI with the basement floods in Toronto

We have corelated the results of HHI with the flood vulnerable areas in the city of Toronto. A future study on a method that corelates this index to the basement floods which has causes further than upstream flood generation is suggested. Such a study will assist the decision-makers of the City of Toronto in planning for future basement flood reduction.

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APPENDICES

APPENDIX A: PYTHON CODE FOR CHAPTER 2

Preparing the data to be used in HHI generation and LIDDI generation code

```
# This script prepares data for LIDDI generation
# Import system modules
************************************************************************************************
import arcpy
arcpy.CheckOutExtension("Spatial") # Check out the ArcGIS Spatial Analyst extension license
****************************
from arcpy import env
from arcpy.sa import *
from arcpy.geoprocessing import env
import time
import os

start_time = time.time()

# Create list of variables of HHI
****************************************************************************************************
work_space = "C:/Users/Sarah/O1/Montreal"
cell_size = 5
study_area = "city.shp"
study_area_t = "city.shp" # This is the study area that euclidean distance is calculated within it
dem = "dem"  # The name of the DEM raster file
rainfall = "idf_h"  # the rainfall intensity raster (mm/hr)
ks = "ks"  # the hydraulic conductivity raster (mm/hr)
groundwater = "gw"
bedrock = "bdrck"  # the depth to impermeable layer raster (m)
parking_lot = ""
open_space = ""  # all land covers except buildings and pavements
building = ""
pavement = ""
land_cover = "lc"
air = ""
biodiversity = ""
stream = "strm.shp"  # feature class data
population = ""
green_space = ""
school = "" # feature class data
hospital = "" # feature class data

# Enter the name of variables that needs Euclidean distance calculations
****************************************************************************************************
dist_list = [stream, pavement, green_space, school, hospital]

# A list of data that need to be convert from feature to raster.
*******************************************************
# This is a 2D list (first col is data name, second is the "field" that is going to be the "value"
of the raster) that
# need conversion from shp to raster. e.g., conversion[["strm", "watershed"], ["hospital", "FID"]]
conversion_list = []
# This a list of all variables
****************************************************************************************************
```

```
toclip_list = [rainfall, ks, groundwater, dem]

#print("Create new folder for the results
****************************************************************************************************

#try:
#    my_path = work_space + "/" + my_folder
#    print(my_path)
#    os.mkdir(my_path)
#except OSError:
#    print("my_py already exists")
#else:
#    print("Successfully created the directory my_py")

# Set environment settings
****************************************************************************************************
env.workspace = work_space  # Input the path of the folder that includes all inout files
env.cellSize = cell_size  # cell size of the results
env.overwriteOutput = True  # Allow to overwrite new files on the old files
env.mask = study_area  # Input the extent of the study area (raster or feature file)
env.snapRaster = land_cover
env.extent = study_area

****************************************************************************************************
if len(conversion_list) != 0:
    for i in range(len(conversion_list):
        map = conversion_list [0, i]
    shp_type = arcpy.Describe(map).shapeType
    inFeatures = map
    outRaster = map[0:-4]
    assignmentType = "MAXIMUM_COMBINED_LENGTH"
    priorityField = ""
    if shp_type == "Polygon":
        valField = col
    map_raster = arcpy.PolygonToRaster_conversion(inFeatures, valField, outRaster, assignmentType,
priorityField, cell_size)
    elif shp_type == "Polyline":
    valField = conversion_list[1, i]
    map_raster = arcpy.PolylineToRaster_conversion(inFeatures, valField, outRaster, assignmentType,
priorityField, cell_size)
    elif shp_type == "Point":
    valField = conversion_list[1, i]
    map_raster = arcpy.PointToRaster_conversion(inFeatures, valField, outRaster, assignmentType,
priorityField, cell_size)
    else:
****************************************************************************************************
# Data is read from work_space and the saved into work_space too
import os.path
# Clip land cover data
****************************************************************************************************
out_raster = land_cover + "_c"

print(os.path.exists(out_raster))

if os.path.exists(work_space + "/" + out_raster) is False:  # check if land_cover is already
clipped.
    lc_extent = arcpy.Describe(land_cover).Extent
    print(lc_extent)
    print(arcpy.Describe(study_area).ShapeType)
    print(arcpy.Describe(study_area).spatialReference)
    sa_geo = arcpy.Geometry(arcpy.Describe(study_area).ShapeType,
arcpy.Describe(study_area).spatialReference)
    print(sa_geo)
    print(lc_extent.contains(sa_geo))
    if lc_extent.contains(sa_geo) is True:
        arcpy.Clip_management(land_cover, "", out_raster, study_area, "", "ClippingGeometry",
```

```
"MAINTAIN_EXTENT")
        print(out_raster + " clipped")

# Reclassify types of land uses
****************************************************************************************************
inRaster = "lc_c"
out_raster1 = "lc_sc01"
out_raster2 = "lc_sc02"
imp = 10  # impervious lands
perv = 20  # pervious lands
water = 30  # water bodies

if os.path.exists(work_space + "/" + out_raster1) is False:
    if os.path.exists(out_raster1) is False: # check if the file is already generated
        temp1 = Reclassify(inRaster, "VALUE", RemapValue([[0, "NoDATA"], [1, imp], [2, perv], [3, 
imp], [4, imp], [5, imp], [6, imp], [7, water], [8, imp]]), "NoDATA")
        temp1.save(out_raster1)
        print(out_raster1 + " layer created")
    else:
        print(out_raster1 + " exists")

if os.path.exists(work_space + "/" + out_raster2) is False:
    if os.path.exists(out_raster2) is False:  # check if the file is already generated
        temp2 = Reclassify(inRaster, "VALUE", RemapValue([[0, "NoDATA"], [1, imp], [2, imp], [3, 
imp], [4, imp], [5, imp], [6, imp], [7, water], [8, imp]]), "NoDATA")
        temp2.save(out_raster2)
        print(out_raster2 + " layer created")
    else:
        print(out_raster2 + " exists")


****************************************************************************************************
# Data is read from work_space and the saved into work_space too
# The toclip_list is updated here to replace new file names
print(dist_list)
if len(dist_list) != 0:
    print("Euclidean distance is calculated within: " + study_area_t)
    env.mask = study_area_t
    for i in range(len(dist_list)):  # Iterate through dist_list
        in_data = dist_list[i]
        out_data = in_data.replace(".shp", "") + "_d"
        toclip_list.remove(in_data)
        toclip_list.insert(i+5, out_data)
        if os.path.exists(work_space + "/" + out_data) is False:  #  Check if file already exists
            temp = EucDistance(in_data)
            temp.save(out_data)
            print(out_data)
        else:
            print(out_data + " exists")

****************************************************************************************************
# Data is read from work_space and the clipped data is saved into my_path,
# The name of the clipped data is as original data (but saved in the my_path folder)
print(toclip_list)
if len(toclip_list) != 0:
    for k in range(len(toclip_list)):
        in_data = toclip_list[k]
        print(in_data)
        out_data = in_data + "_c"
        x_extent = arcpy.Describe(in_data).Extent
        print(x_extent)
        sa_geo = arcpy.Geometry(arcpy.Describe(study_area).ShapeType, 
arcpy.Describe(study_area).spatialReference)
        print(x_extent.contains(sa_geo))
        if x_extent.contains(sa_geo) is True:  # check if the data layer needs clip (the extent of 
the data contains the study area extent)
```

```
            if os.path.exists(work_space + out_data) is False:  # check if the data is already
clipped due to previous runs
                arcpy.Clip_management(in_data, "", out_data, study_area, "", "ClippingGeometry",
"MAINTAIN_EXTENT")
                print(out_data + " created!")
            else:
                print(out_data + " exist!")

****************************************************************************************************
# The resolution of all data in my_path is checked and if need justification they will be justified
print(toclip_list)
for i in range(len(toclip_list)):
    in_data = toclip_list[i]
    data_resolution = arcpy.Describe(in_data).children[0].meanCellHeight
    print(in_data + " resolution is: " + str(data_resolution))
    out_data = in_data + "_r"
    if data_resolution > cell_size:
        print(os.path.exists(my_path + "/" + out_data))
        if os.path.exists(my_path + "/" + out_data) is False:  # Check if resolution already changed
            arcpy.Resample_management(in_data, out_data, cell_size, "NEAREST")
            print(out_data + " created: resolution changed from " + str(data_resolution) + " to " +
str(cell_size))
            toclip_list.remove(in_data)
            toclip_list.insert(i, out_data)
        else:
            print(out_data + " with resolution of " + str(cell_size) + " exists")
            toclip_list.remove(in_data)
            toclip_list.insert(i, out_data)
    else:
        print(out_data + " with resolution of " + str(cell_size) + " cell size is fine")

print(toclip_list)

****************************************************************************************************
print(os.path.exists(work_space + "/" + "slope"))
if os.path.exists(work_space + "/" + "slope") is False:
    slope = Slope(dem, "DEGREE", 1)
    slope.save("slope")
    print("slope layer created")
else:
    print("slope exists")


end_time = time.time() - start_time
print(time.time())
print("run time =" + str(end_time) + " seconds")
```

This code is to remap a list of raster data located in a workplace and write the results in the same folder

```
****************************************************************************************************
from arcpy import env
from arcpy.sa import *
env.overwriteOutput = True  # Allow to overwrite new files on the old files
#work_spaces = ["E:/Sarah/O1/Toronto/", "E:/Sarah/O1/Montreal/", "E:/Sarah/O1/Vancouver/"]
work_spaces = ["E:/Sarah/O1/Vancouver/"]

in_rasters = ["hhi_00_sc0", "hhi_00_sc1", "hhi_00_sc2", "hhi_36_sc0", "hhi_36_sc1", "hhi_36_sc2",
"hhi_66_sc0",
              "hhi_66_sc1", "hhi_66_sc2", "hhi_96_sc0", "hhi_96_sc1", "hhi_96_sc2"]

#in_rasters= ["idf_00", "idf_36", "idf_66", "idf_96"]
#myRemapRange = RemapRange([[0, 10, 5], [10, 20, 15], [20, 30, 25],[30, 40, 35], [40, 50, 45], [50,
60, 55],
#                                  [60, 70, 65], [70, 80, 75], [80, 90, 85], [90, 100, 95]])
#myRemapRange = RemapRange([[0, 25, 1], [25, 50, 2], [50, 75, 3], [75, 100, 4]])
myRemapRange = RemapRange([[0, 15, 10], [15, 25, 20], [25, 35, 30],[35, 45, 40], [45, 55, 50],
                           [55, 65, 60]])
for work_space in work_spaces:
    for in_raster in in_rasters:
        env.workspace = work_space
        temp = Reclassify(in_raster, "VALUE", myRemapRange)
        temp.save(str(in_raster) + "_rn")
        print(str(in_raster) + "_rm is created")

 This script calculates HHI
# IMPORTANT!!!!!!! Items to check:  1- Work_space 2- Name of each single variable 3- Unit_factor of
Variables
# Import system modules
****************************************************************************************************
import arcpy
from arcpy import env
from arcpy.sa import *
import time
import os

#os.system("C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py")
#open(r"C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py").read()
#from HGML.HGML_DataPreparation import *
start_time = time.time()

# Set the variables
****************************************************************************************************
# Select the variables from the my_path of HGML_DataPreparation
****************************************************************************************************
# If there is a file with "_r" suffix, it is prefered to the original name of the file
****************************************************************************************************
work_space = "C:/Users/Sarah/O1/Toronto/my_py_Toronto"
env.workspace = work_space
env.overwriteOutput = True  # Allow to overwrite new files on the old files
rainfall = "int"  # the rainfall intensity raster (mm/hr):::: if unit is not correct set the unit
factor in the code
ks = "ks"  # the hydraulic conductivity raster (mm/hr):::: if unit is not correct set the unit
factor in the code
groundwater = "gw"  # in mm :::: if unit is not correct set the unit factor in the code
bedrock = ""  # the depth to impermeable layer raster (mm) :::: if unit is not correct set the unit
factor in the code
dem = "gta_dem5m"
# if change if unit is needed enter the unit change factor below in each section
hhi_list = [rainfall, ks, bedrock, groundwater, dem]
#  Rainfall
```

```
****************************************************************************************************
print("rainfall is: " + rainfall)
unit_factor = 1
r_mm_hr = Times(rainfall, unit_factor)  # change the unit to mm/hr is required
r_mm_hr.save("r_mm_hr")
# return ks (cm/hr)
****************************************************************************************************
if ks != "":  # Check if ks data exist
    print("ks is: " + ks)
    unit_factor = 10
    ks_mm_hr = Times(ks, unit_factor)  # return ks (mm/hr)
    ks_mm_hr.save("ks_mm_hr")
#  groundwater
****************************************************************************************************
if groundwater != "":  # Check if gw data exist
    print("groundwater is: " + groundwater)
    unit_factor = 1000
    gw_t = Times(groundwater, unit_factor)
    gw_mm = Con(gw_t, 0, gw_t, "VALUE < 0")
    gw_mm.save("gw_mm")
#  Bedrock
****************************************************************************************************
if bedrock != "":  # Check if bedrock data exist
    print("Bedrock is: " + bedrock)
    unit_factor = 1000
    br_mm = Times(bedrock, unit_factor)
    br_mm.save("br_mm")
    if groundwater != '':  # Check if groundwater exist
**********************************************
        impermeable = [gw_mm, Times(br_mm, 0.5)]  # list of gw and bedrock (porosity considered)
        min_br_gw = FuzzyOverlay(impermeable, "AND")  # Set min_br_gw as minimum of gw and bedrock
(porosity considered)
        min_br_gw.save("min_br_gw")
    else:
        min_br_gw = Times(br_mm, 0.5)
        min_br_gw.save("min_br_gw")  # Set min_br_gw as only bedrock (porosity considered)
else:
    if groundwater != '' and bedrock != '':
        min_br_gw = gw_mm
        min_br_gw.save("min_br_gw")  # Set min_br_gw as only groundwater
    else:  # none of bedrock and groundwater exists
        min_br_gw = ""

# check if the depth is over 3 m
****************************************************************************************************
if min_br_gw != "":
    imprmbl_con = Con(min_br_gw, "3", min_br_gw, "VALUE > 3")  # check if the depth is over 3 m
    imprmbl_con.save("imprmbl_con")
    print("imprmbl_con created!")
else:
    imprmbl_con = ""
# Calculate the min of Ks and br and gw
****************************************************************************************************
if ks != "":
    if imprmbl_con != "":                                         # imprmbl_exists
        depth_min = FuzzyOverlay([imprmbl_con, ks_mm_hr], "AND")  # minimum ks and impermeable
        depth_min.save("depth_min")
        print("Both Ks and impemble exist and depth_min created!")
    else:
        depth_min = ks_mm_hr
        depth_min.save("depth_min")
        print("Ks exists, impemble does not exist and depth_min created!")
else:                                                             # ks does not exist
    if imprmbl_con != "":
        depth_min = imprmbl_con
        depth_min.save("depth_min")
```

```
        print("Ks does not exist, impemble exists and depth_min created!")
    else:                                                        # none of Ks and imprmbl_con exist
        depth_min = ""
        print("Both Ks and impemble does not exist and depth_min not created!")
# Calculate runoff
****************************************************************************************************
print(os.path.exists(work_space + "/" + "depth_min"))
if os.path.exists(work_space + "/" + "depth_min") is True:
    runoff_temp = Minus(r_mm_hr, depth_min)
else:
    runoff_temp = r_mm_hr
runoff_temp.save("runoff_temp")
runoff = Con("runoff_temp", "runoff_temp", 0, "VALUE > 0")
runoff_temp.save("runoff")
print("runoff created!")
# Calculate Slope factor
****************************************************************************************************
slope_con = Con("slope", 45, "slope", "VALUE > 45")
slope_nonlinear = 1 + Power(Tan(Times(slope_con, 3.14 / 180)), 0.385)
print("slope nonlinear created!")
# Calculate HHI
****************************************************************************************************
HHI = Times(slope_nonlinear, runoff)
HHI.save("HHI")
print("HHI created")
#
****************************************************************************************************
end_time = time.time() - start_time
print("run time =" + str(end_time) + " seconds")
This script generates LIDDI
# IMPORTANT!!!!!!! Items to check:  1- Work_space 2- seeni list 3- invers distance list 4- weight
list 4- HHI variable name
# Import system modules
****************************************************************************************************
import arcpy
from arcpy import env
from arcpy.sa import *
import time
import os
work_space = "E:/Sarah/O1/Toronto/"
env.workspace = work_space
env.overwriteOutput = True  # Allow to overwrite new files on the old files
start_time = time.time()
#os.system("C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py")
#open(r"C:/Users/Sarah/O1/HGML/HGML_HHI.py").read()
#from HGML.HGML_HHI import *

#  Create list of variables
****************************************************************************************************
# Enter the list of criteria, clipped and resampled in HGML_DataPreparation
# Criteria with _d are distance to the source files
seeni_list = ["air", "biodiv", "strms_d", "pavement_d", "pop_dens", "green_d", "school_d",
"hospital_d"]
# This list determines if items in seeni list needs invers distance or not
# Enter 0 if not required, 1 if required, the order should follow the seeni_list
inverse_dist = ["0", "0", "0", "1", "0", "0", "1", "1"]
# Enter the weight of input criteria, the order should follow the seeni_list
weight = ["0.125", "0.125", "0.125", "0.125", "0.125", "0.125", "0.125", "0.125"]

****************************************************************************************************
if len(seeni_list) != 0:
    criwei_list = []
    print(seeni_list)
    for i in range(len(seeni_list)): #  Iterate through seeni and weight list to rescale all data
        in_raster = seeni_list[i]
        print(in_raster)
```

```
        std_name = in_raster + "_s"
        if os.path.exists(work_space + "/" + std_name) is False:
            from_scale = "0"
            to_scale = "1"
            minimum = "0"
            lowerThreshold = "0"
            valueBelowThreshold = ""
            maximum = str(arcpy.GetRasterProperties_management(in_raster, "MAXIMUM"))
            print("maximum of " + in_raster + " is: " + maximum)  # Extract the maximum of the raster data
            upperThreshold = ""
            valueAboveThreshold = ""
            x = inverse_dist[i]
            if x == "1":
                from_scale = "1"
                to_scale = "0"
            my_TfLinear = TfLinear(minimum, maximum, lowerThreshold, valueBelowThreshold, upperThreshold, valueAboveThreshold)
            rescaled = RescaleByFunction(in_raster, my_TfLinear, from_scale, to_scale)  # Rescale the raster between from_scale and to_scale
            rescaled.save(std_name)
        w = weight[i]
        criwei_list.append([std_name, "VALUE", w])

****************************************************************************************************

    SEENI = WeightedSum(WSTable(criwei_list))
    print(SEENI)
    SEENI.save("SEENI")
    print("SEENI created")
****************************************************************************************************

    LIDDI = Times("HHI", Plus("SEENI", 1))
    LIDDI.save("LIDDI")
    print("LIDDI created")

****************************************************************************************************
    stat_list = ["LIDDI", "HHI", "SEENI"]
    for item in stat_list:
        in_zone_data = "C:/Users/Sarah/O1/Toronto/Toronto.shp"
        zone_field = "FID"
        in_value_raster = item
        out_table = item + "_tbl"
        out_graph = item + "_gra"
        ZonalHistogram(in_zone_data, zone_field, in_value_raster, out_table, out_graph)
        mean = str(arcpy.GetRasterProperties_management(item, "MEAN"))
        maximum = str(arcpy.GetRasterProperties_management(item, "MAXIMUM"))
        minimum = str(arcpy.GetRasterProperties_management(item, "MINIMUM"))
        print(item + " mean is: " + mean + " and maximum is: " + maximum + " and minimum is: " + minimum)

# eliminating existing lid
# exist_lid = input("Existing LID layer name : ")

end_time = time.time() - start_time
print("run time =" + str(end_time) + " seconds")
```

```
    ****************************************************************************************************
```

This code is to calculate and graph the statistics of the results

```
# This code is to derive the statistics for a list of raster data located in a workplace
# including mean, minimum, and maximum values; derive the histogram based on customized bins;
# plot the histogram; and write the results in a text file
****************************************************************************************************
import arcpy
from arcpy import env
from arcpy.sa import *
arcpy.CheckOutExtension("Spatial")
import numpy as np
import matplotlib.pyplot as plt


# This example uses an 8bit unsigned format TIFF image
work_spaces = ["E:/Sarah/O1/Vancouver/"]
data_list = ["hhi_00_sc0_rn", "hhi_00_sc1_rn", "hhi_00_sc2_rn", "hhi_36_sc0_rn", "hhi_36_sc1_rn",
"hhi_36_sc2_rn",
             "hhi_66_sc0_rn", "hhi_66_sc1_rn", "hhi_66_sc2_rn", "hhi_96_sc0_rn", "hhi_96_sc1_rn",
"hhi_96_sc2_rn"]

bin_hhi = [0,10,20,30,40,50,60,70,80,90,100]

****************************************************************************************************

for work_space in work_spaces:
    hist_list = []
    file1 = open("E:/Sarah/O1/hist.txt", "a")
    file1.write(str(work_space) + "\r\n")
    for data in data_list:
        # Convert raster to numpy array and calculate histogram
        tiff = work_space + data
        print(tiff)
        array = arcpy.RasterToNumPyArray(tiff)
        # numpy.histogram(a, bins=10, range=None, normed=None, weights=None, density=None)[source]
        # https://numpy.org/doc/1.18/reference/generated/numpy.histogram.html#numpy.histogram
        hist, bins = np.histogram(array, bins=bin_hhi)
        hist_list.append(hist)
        maximum = max(hist)
        print(maximum)
        """in_raster = arcpy.sa.RoundUp(tiff)
        mean = str(arcpy.GetRasterProperties_management(in_raster, "MEAN"))
        maximum = str(arcpy.GetRasterProperties_management(in_raster, "MAXIMUM"))
        minimum = str(arcpy.GetRasterProperties_management(in_raster, "MINIMUM"))
        print(data + " mean is: " + mean + " and maximum is: " + maximum + " and minimum is: " +
minimum)"""

        # Plot the histogram
        # plot(x, y, color='green', marker='o', linestyle='dashed', linewidth=2, markersize=12)
        """plt.plot(bins[:-1], hist, "-b")
        plt.xlim(min(bins), max(bins))
        plt.ylabel('Pixel Count')
        plt.xlabel('Pixel Values')
        #plt.save()"""
****************************************************************************************************
        # Program to show various ways to read and
        # write data in a file.
        file1 = open("E:/Sarah/O1/hist.txt", "a")
        file1.write(str(data) + " " + str(hist) + "\n")
        #file1.write(" minimum : " + str(minimum) + "\n")
        #file1.write(" mean : " + str(mean) + "\n")
        #file1.write(" maximum : " + str(maximum) + "\n")
        file1.close()  # to change file access modes
```

APPENDIX B: PYTHON CODE FOR CHAPTER 3

This script calculates HHI for a list of land cover and a list of rainfall scenarios and generates the combined HHI

```
# This script calculates HHI for a list of land cover and a list of rainfall scenarios and generates
the combined HHI
# scenarios and write the generated HHI as a raster
file***************************************************************

# Import system modules
************************************************************************************************
import arcpy
from arcpy import env
from arcpy.sa import *
import time
import os
#os.system("C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py")
#open(r"C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py").read()
#from HGML.HGML_DataPreparation import *
start_time = time.time()
work_space = "E:/Sarah/O1/Vancouver"
study_area = "city.shp"
env.workspace = work_space
env.overwriteOutput = True  # Allow to overwrite new files on the old files
env.cellSize = 5  # cell size of the results
env.extent = study_area

# Set the variables
****************************************************************************************************
# Select the variables from the my_path of HGML_DataPreparation
********************************************************
# If there is a file with "_r" suffix, it is prefered to the original name of the file
*********************************

toronto_data = ["ks_c", "gw_c", "bdrck_c", "dem_c"]
toronto_unit = [["rainfall", 1], ["ks", 10], ["gw", 1000], ["bdrck", 1000]]  # change the unit to
mm/hr is required

montreal_data = ["ks_c", "gw_c", "bdrck_virt", "dem_con"]
montreal_unit = [["rainfall", 1], ["ks", 1], ["gw", 1000], ["bdrck", 1000]]  # change the unit to
mm/hr is required

vancouver_data = ["ks_c", "gw", "bdrck", "dem_con"]
vancouver_unit = [["rainfall", 1], ["ks", 0.01], ["gw", 1000], ["bdrck", 1000]]  # change the unit
to mm/hr is required

#idf_list = ["idf_00", "idf_36", "idf_66", "idf_96"]
idf_list = ["idf_66", "idf_96"]
develop_list = ["ks_zero0", "ks_zero1", "ks_zero2"]  # ks_zero is extracted paved areas from the lc
scenarios

city_data = vancouver_data
city_unit = vancouver_unit

print("Slope calculation
*******************************************************************************************")
dem = city_data[3]
print(os.path.exists(work_space + "/" + "slope"))
if os.path.exists(work_space + "/" + "slope") is False:
    slope = Slope(dem, "DEGREE", 1)
```

```
    slope.save("slope")
    print("slope layer created")
else:
    print("slope exists")
# Calculate Slope factor
****************************************************************************************
slope_con = Con("slope", 45, "slope", "VALUE > 45")
slope_nonlinear = 1 + Power(Tan(Times(slope_con, 3.14 / 180)), 0.385)
print("slope nonlinear created!")

#
*****************************************************************************************************
******************
ks = city_data[0]  # the hydraulic conductivity raster (mm/hr):::: if unit is not correct set the
unit factor in the code
groundwater = city_data[1]  # in mm :::: if unit is not correct set the unit factor in the code
bedrock = city_data[2]  # the depth to impermeable layer raster (mm) :::: if unit is not correct set
the unit factor in the code
dem = city_data[3]

# ks (cm/hr)
****************************************************************************************************
if ks != "":  # Check if ks data exist
    print("ks is: " + ks + str(arcpy.GetRasterProperties_management(ks, "BANDCOUNT")))
    unit_factor = city_unit[1][1]
    ks_mm_hr = Times(ks, unit_factor)  # return ks (mm/hr)
    ks_mm_hr.save("ks_mm_hr")
#  groundwater
**************************************************************************************************
if groundwater != "":  # Check if gw data exist
    print("groundwater is: " + groundwater + str(arcpy.GetRasterProperties_management(groundwater,
"BANDCOUNT")))
    unit_factor = city_unit[2][1]
    gw_t = Times(groundwater, unit_factor)
    gw_mm = Con(gw_t, 0, gw_t, "VALUE < 0")
    gw_mm.save("gw_mm")
#  Bedrock
*****************************************************************************************************
*
if bedrock != "":  # Check if bedrock data exist
    print("Bedrock is: " + bedrock + str(arcpy.GetRasterProperties_management(bedrock,
"BANDCOUNT")))
    unit_factor = city_unit[3][1]
    br_mm = Times(bedrock, unit_factor/2)
    br_mm.save("br_mm")

for impervious in develop_list:
    print("calculation for impervious: " + impervious +
str(arcpy.GetRasterProperties_management(impervious, "BANDCOUNT")))
    for idf in idf_list:
        print("calculation for climate: " + idf)
        #
Rainfall*********************************************************************************************
*********
        rainfall = idf
        print("rainfall is: " + rainfall + str(arcpy.GetRasterProperties_management(rainfall,
"BANDCOUNT")))
        unit_factor = city_unit[0][1]
        r_mm_hr = Times(rainfall, unit_factor)  # change the unit to mm/hr
        r_mm_hr.save("r_mm_hr")
        #  Minimum depth to restrictive layer
***************************************************************************
        impermeable = ["ks_mm_hr", "gw_mm", "br_mm", impervious]
        temp = FuzzyOverlay(impermeable, "AND")
        temp.save("depth_min")
        # check if the depth is over 3 m
```

```
*******************************************************************************
        temp = Con("depth_min", "3", "depth_min", "VALUE > 3")  # check if the depth is over 3 m
        temp.save("depth_con")
        print("depth_con created!")
        # Calculate runoff
*********************************************************************************************
        runoff_temp = Minus("r_mm_hr", "depth_con")
        runoff_temp.save("runoff_temp")
        temp = Con("runoff_temp", "runoff_temp", 0, "VALUE > 0")
        temp.save("runoff")
        print("runoff created!")
        # Calculate HHI
************************************************************************************************
        HHI = Times(slope_nonlinear, "runoff")
        HHI.save("HHI_" + idf[-2:] + "_Sc" + impervious[-1:])
        print("HHI created")
        print(idf)
        print(impervious)
        #
****************************************************************************************************
**********
end_time = time.time() - start_time
print("run time =" + str(end_time) + " seconds")
```

APPENDIX C: PYTHON CODE FOR CHAPTER 4

This script IDENTIFY FEASIBIE SITES

```
# Import system modules
*********************************************************************************************
import arcpy
from arcpy import env
from arcpy.sa import *
import time
import os
os.system("C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py")
exec(open(r"C:/Users/Sarah/O1/HGML/HGML_DataPreparation.py").read())
from HGML.HGML_DataPreparation import *
start_time = time.time()

print("Calculate required criteria ********************************************************")

print("Create a buffer around buildings to exclude from the feasible cells****************")
building_buff = 4
cell_num = building_buff / cell_size
building_buff = Expand("building", cell_num, [1])  # create the buffer
building_buff.save("building_buff")
print("building_buff layer created")
arcpy.RasterToPolygon_conversion(building_buff, "building_buff", "NO_SIMPLIFY", "VALUE")  # convert
to polygon
print("building_buff.shp layer created")
con0_complementary = arcpy.Erase_analysis(study_area, "building_buff.shp")  # create the
complementary polygon
print("con0_complementary layer created")
con0_temp = arcpy.PolygonToRaster_conversion(con0_complementary, "id", "con0_building")  # convert
to raster
print("con0_building layer created")

print("Extract cells which has pass the limitation of sub-basin area************************")
flow_dir = FlowDirection(dem + "_c", "", "", "")
flow_dir.save("flow_dir")
print("flow_dir layer created")
flow_acc = FlowAccumulation(flow_dir, "", "FLOAT")
flow_acc.save("flow_acc")
print("flow_acc layer created")
con1_flow_acc = Con(flow_acc, flow_acc, "", "VALUE >=" + str(sheet1.cell_value(19, 1)))
con1_flow_acc.save("con1_flow_acc")
print("con1_flow_acc layer created")


print("Extract the cells which have suitable slope *****************************************")
gr_slope = "VALUE <" + str(sheet1.cell_value(20, 1))
pv_slope = "VALUE <" + str(sheet1.cell_value(21, 1))
con2_slope = Con(slope, slope, "", gr_slope)  # Extract the cells which have suitable slope
(slope<10%) for green roof
con2_slope.save("con2_slope")
print("con2_slope layer created")
con3_slope = Con(slope, slope, "", pv_slope)  # Extract the cells which have suitable slope
(slope<10%) for green roof
con3_slope.save("con3_slope")
print("con3_slope layer created")

print("# Find cells with groundwater (gw) depth of 3m (1m distance+2 m LID thickness) and less
****")
gw_shallow = Minus(sheet1.cell_value(4, 1) + "_c", sheet1.cell_value(18, 1) + 2)
```

```
gw_shallow.save("gw_shallow")
print("gw_shallow layer created")
con4_gw = Con(gw_shallow, gw_shallow, "", "VALUE > 0")
con4_gw.save("con4_gw")
print("con4_gw layer created")

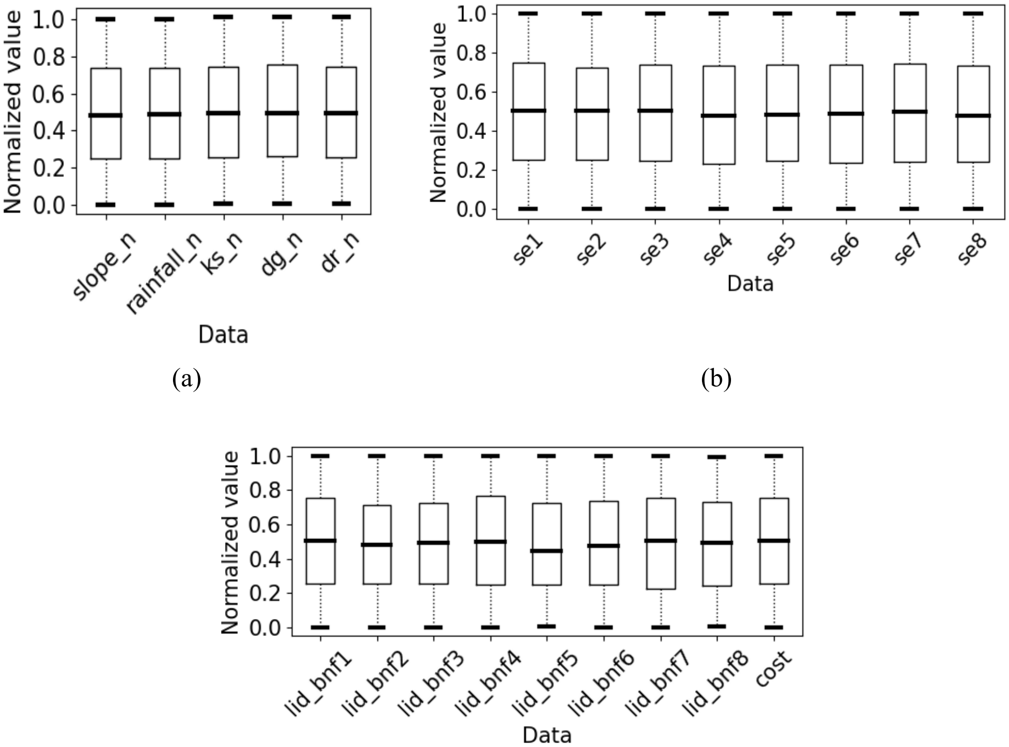
print("Identify feasible cells *****************************************************************")
# for green roof
con_list1 = ["building", "con2_slope"]
# for porous pavement
con_list2 = ["pavement", "con0_building", "con1_flow_acc", "con3_slope", "con4_gw"]
# for open space lids
con_list3 = ["open_space", "con0_building", "con1_flow_acc", "con4_gw"]
fuzzy_list = [con_list1, con_list2, con_list3]


for con_list in fuzzy_list:
    feasible = FuzzyOverlay(con_list, "AND")   # intersect the condition to find feasible cells
    print(fuzzy_list.index(con_list))
    if fuzzy_list.index(con_list) == 0:
        x = "feasible_gr"
        print("feasible_gr layer created")
    elif fuzzy_list.index(con_list) == 1:
        x = "feasible_pv"
        print("feasible_pv layer created")
    else:
        x = "feasible_os"
        print("feasible_os layer created")
    feasible.save(x)


end_time = time.time() - start_time
print("run time =" + str(end_time) + " seconds")
```

APPENDIX D: THE PROOF OF CONCEPT OF CHAPTER 4

We have proved the concept of SERA using the model used in Section 5.3 and generating 100 random scenarios. To do so, the input data were included in three categories: i) data for generating the hydraulic-hydrological index (HHI), ii) data used for generating socioeconomic-environmental demand-benefit index (SE), and iii) data related to the cost and benefits of the four LID types. These data were differently and randomly generated for the 100 scenarios, the normalized range of these data for all scenarios is presented in Figure D 1, which shows a good variety of data for all inputs all ranged from 0 to 1. This variety increases the reliability of the model in terms of its applicability in all possible scenarios in contrast to only some specific scenarios.

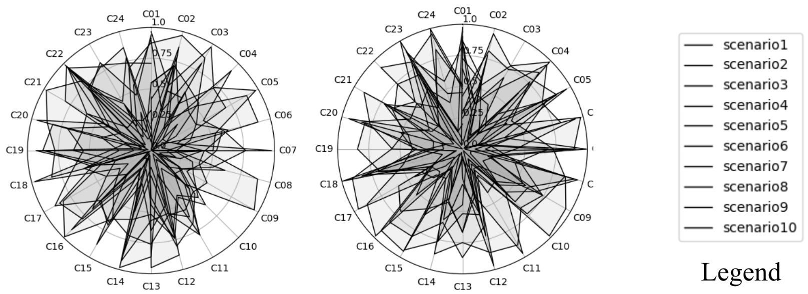


(a) (b)

(c)

Figure D 1 Box plot of the input data for 100 scenarios including (a) data for generating hydrological-hydraulic index (HHI), (b) data for generating socioeconomic-environmental index (denoteded as se1 to se8), and (c) data related to the LID benefit and LID cost (denoteded as lid_bnf1 to lid_bnf8 and cost)

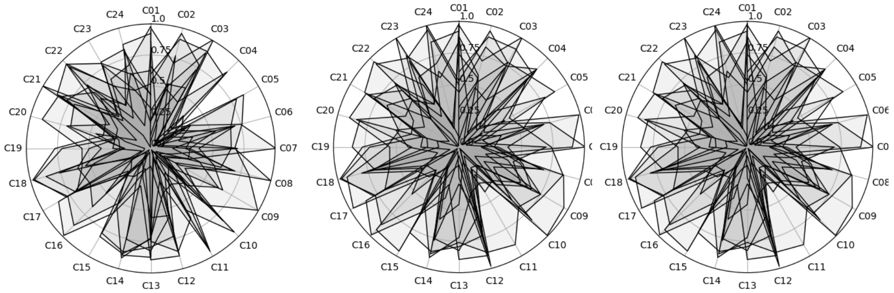
We also assessed the spatial distribution of the random input data in the sites of the catchment (C01 to C25). This was to increase the reliability and robustness of the model by using a good random spatial distribution of the data. The radar plot of input data for a sample of 10 scenarios are presented in Figure D 2. In these plots each radius represents one site so the plot has 25 radii, the normalized value of the input data is shown along the radius (the center of the plot shows zero and the circumference is 1).



(a) Normalized slope (s)

(b) Normalized rainfall (R)

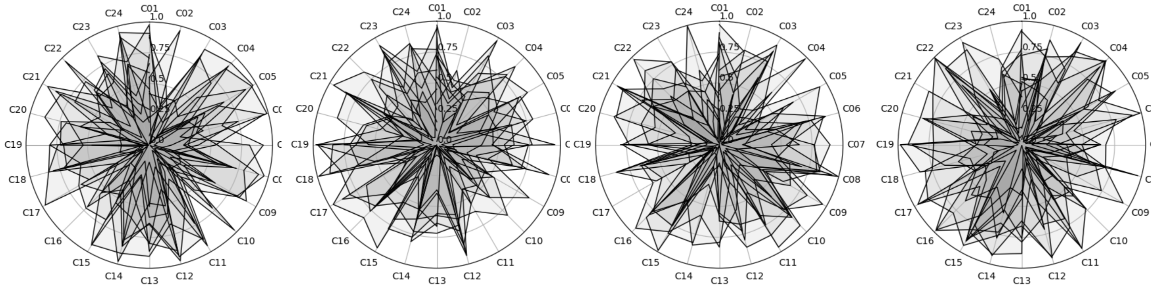
Legend



(c) Normalized hydraulic conductivity (Ks)

(d) Normalized depth to groundwater (Dg)

(e) Normalized depth to groundwater (Dg)

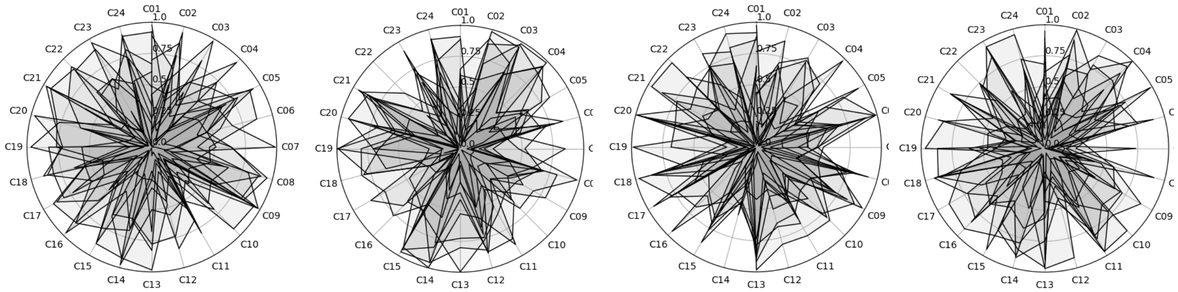


(f) Normalized environmental demand 1 (EI1)

(g) Normalized environmental demand 2 (EI2)

(h) Normalized environmental demand 3 (EI3)

(i) Normalized environmental demand 4 (EI4)



(j) Normalized socioeconomic demand 1 (SI1)

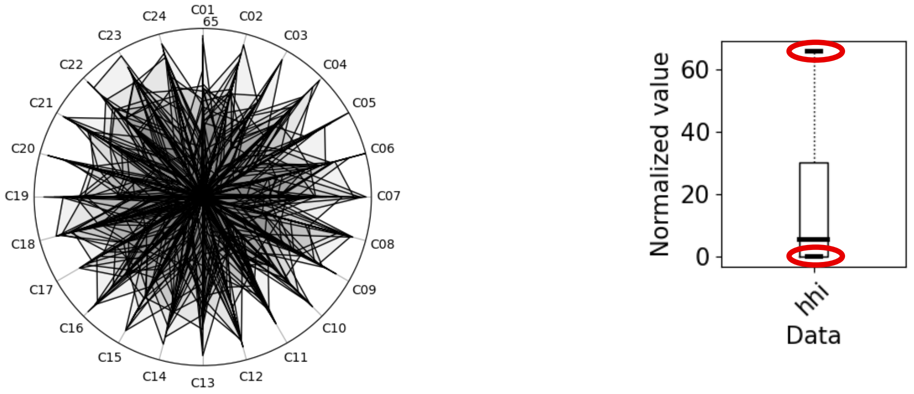
(k) Normalized socioeconomic demand 2 (SI2)

(l) Normalized socioeconomic demand 3 (SI3)

(m) Normalized socioeconomic demand 4 (SI4)

Figure D 2 The spatial distribution of input data for 10 sample scenarios

The input data were used for step b-1 of component (b). In this step, these data geospatially were overlaid using Eq. 4.1. As a result, the catchment was indexed based on its hydrological-hydraulic demand for LID for all 100 scenarios. Figure D 4 presents the actual and normalized values of HHI for all 100 scenarios using a radar plot and box plot, respectively.



(a) The radar plot for generated hydrological-hydraulic index (HHI) of 100 different scenarios, each radii axis representing one site

(b) The box plot for generated hydrological-hydraulic index (HHI) of 100 different scenarios, representing the range of this index before normalization

Figure D 3 The result of the component (b) step b-3 showing the value and range of the Hydrological-hydraulic demand for LID Types at different sites for all 100 scenarios

The HHCI was generated for each LID type. It was conducted by geospatial overlaying of HHI with the cost of each type of LID through a geospatial division operation. This overlaying process resulted in four geospatial data layers (corresponding to each LID type) per scenario (400 data layers overall). In the next step, the data layers of hydrological-hydraulic demand for LID Types in feasible sites were generated. To do this, first, the sub-catchments were delineated by considering feasible sites as pour point (outfall), as is demonstrated in Figure D 4. Then the value of HHCI at each feasible site was estimated through a geospatial zonal (subcatchments were the zones) statistic operation, for which the statistical operation was considered to be the sum of HHCI within the catchment of the feasible site. The value of HHCI for the infeasible sites was assigned to be No-Data.

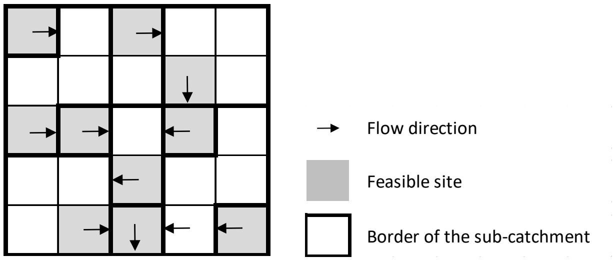
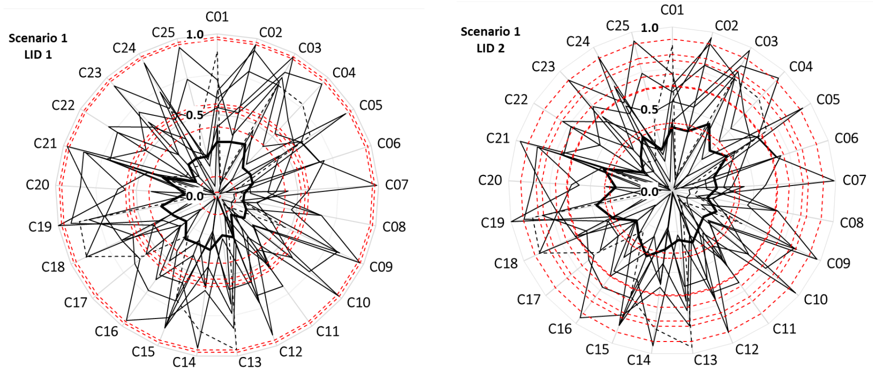
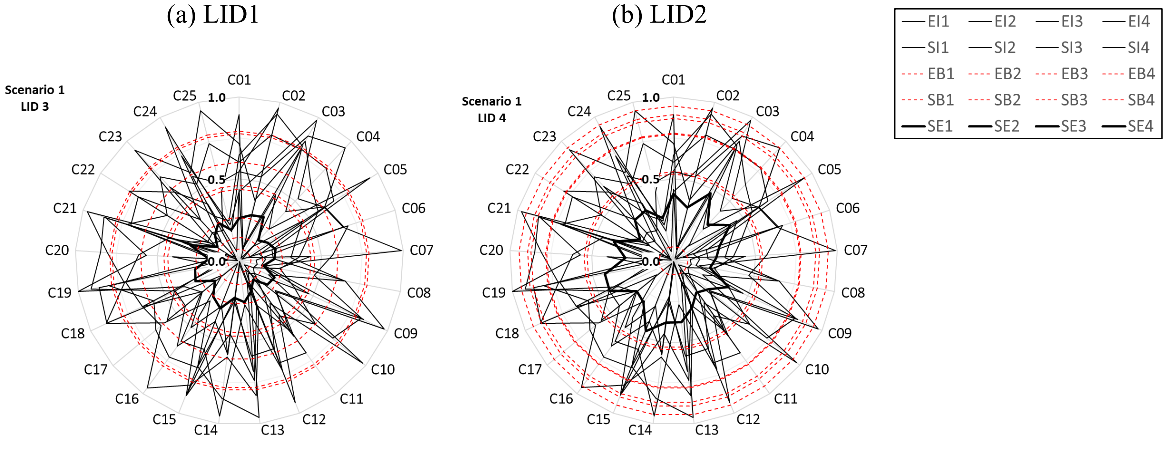


Figure D 4 Delineated sub-catchments based on the flow direction and the geographical location of the feasible sites

For component (c) were overlaid to their corresponding benefits using Eq. 4.3 to Eq. 4.6. The weights used in the weighted sum method were considered equal in this study. However other weighting methods (such as pairwise comparison, ranking, Delphi, etc.) are suggested for future investigations. The result indexed the catchment representing its demand for each type of LID, which led to four data layers corresponding to the four LID types. These indices were generated for all 100 scenarios (400 data layers overall). To demonstrate the application of the method a sample of distribution of the value of input data (environmental demand indices (EI) and benefit (EB), socioeconomic demand indices (SI) and benefit (SB), and output data (socioeconomic and environmental demand of each type of LID (SE)) are presented in Figure D 5. This figure shows the variation of SE for all four types of LID (plots (a) to (d)). Based on these plots it is evident the overall demand for LID3 and 4 is higher than LID 1 and 2. Also, each plot presents that wherein all eight demands and corresponding benefits are high at a specific site e.g., FigureD6 (a) C19, C21), and wherein both are low SE is low (e.g., Figure D 5(a) C11, C22).



(a) LID1 (b) LID2

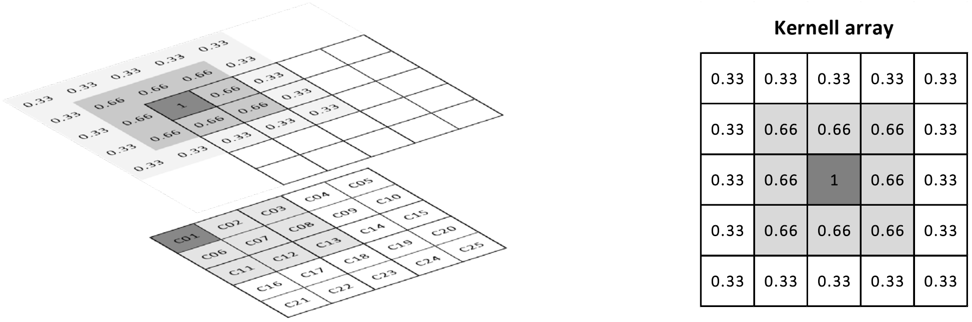


(c)LID3 (d)LID4

Figure D 5 The socioeconomic and environmental demand of each type of LID (SE): (a) LID 1 (b) LID2 (c) LID3 (d) LID4 derived from the environmental demand indices (EI) and benefit (EB), socioeconomic demand indices (SI) and benefit (SB)

In the next step, the data layers of Socioeconomic and Environmental demand for LID types in feasible sites were assumed. To do this, first, the value of SE at each feasible site was estimated through a geospatial focal weighted mean operation, for which the kernel array (weight array) was assumed to have a window size of 5 x 5 with values showed in Figure D 7 (a). In Figure D 7 (b), one corner site (C01) is highlighted as an example. The cells that are involved in the calculation of SE of this site are shown in grey shade. The weights of the kernel array also have been presented in the Figure D 7 (b). Like HHI, the value of SE for the infeasible sites was assigned to No-Data.

It is important to be noted that the size of the kernel array and the assigned weights to the neighborhood cells are an assumption in this study to demonstrate how the suggested model works. The size of the kernel array physically represents the radial influence of the implemented LID on the neighboring cells (e.g., how far C01 can influence surrounding sites in terms of decreasing air pollution or increasing access to amenities). The maximum distance needs to be investigated in future studies for individual socioeconomic and environmental impacts of LID.



Kernell array

0.33	0.33	0.33	0.33	0.33
0.33	0.66	0.66	0.66	0.33
0.33	0.66	1	0.66	0.33
0.33	0.66	0.66	0.66	0.33
0.33	0.33	0.33	0.33	0.33

(a) (b)

Figure D 6 Estimating the socioeconomic and environmental demand for LID types in feasible sites, using (b) focal weighted mean (C01 as an example) and (a) kernel array weights

The results of component (b) and (c) were overlaid using the method demonstrated in component (d) of this study. We considered that the level of importance for both components are equal in the weighted sum overlaying method. However, it is noteworthy that this assumption was made for the demonstration of the framework and actual weights need to be determined for each specific catchment according to the catchment needs, preferences, and priorities. This process (component (d)) was performed for all 100 scenarios.

The result agreed with initial assumptions and allowed us to rank the sites within the catchment for implementing LID as well as providing us the rank of LID types at each site. The numerical result of three sample catchments (01, 50, 99) are randomly selected and presented using bar and line graphs (see Figure D8). In these graphs, the x-axis shows the feasible sites (10 out of 25 sites), and the y axis presents the value of modified HHI based on cost (HHCI), socioeconomic-environmental demand (SE), cost of each LID type, and the result index, HSE. Overall, these graphs show that wherein both demands (HHCI, SE) are high, and the cost is low the HSE is higher (e.g., Scenario 01 at C09; Scenario 25 at C22, Scenario 50 at C23, Scenario 75 at C11, and Scenario 99 at C09). In contrast where both demands are low the HSE value and rank of sites are low (e.g., Scenario 01 at C25; Scenario 25 at C03, Scenario 50 at C18, Scenario 75 at C25, and Scenario 99 at C01). Whereas other sites are ranked in between. Therefore, based on the HSE value sites of the catchments (scenarios) were ranked. On this basis, sites with high HSE values are assigned the highest rank for implementing LID and this trend continued for the lower ranks. These results confirmed that in ranking the sites of a given catchment not only the feasibility of the site (here 10 feasible sites out of 25 sites) were considered but also the demand of sites for LID were integrated into site selection process with high demand for LID. These demands for LID included the hydrological-hydraulic demand of the feasible site and its catchment along with the socioeconomic-environmental demand of the feasible site and its neighborhood.

In addition to the rank of sites within the catchment, the second valuable and important information that can be derived from Figure D 7, HSE values, is the rank of different types of LID at each site. In this figure, each line plot represents the HSE value for each type of LID. Comparing these plots at each feasible site reveals the rank of the LID types at the site. For example, for scenario 50, if we decide to implement a unit of LID at the first rank site (C23) the highest suggested LID for the site is LID type 2 (dashed black line with black square shape marker) and the least suggested is LID type 4 (dashed red line with red square shape marker), and other two types are in between. The high rank of LID type 1 is due to its low price leading to a high HHCI2 (bar plot, dark grey shade) as well as high SE2, which is an indicator of the demand at this site for the benefits that this certain type of LID offers.

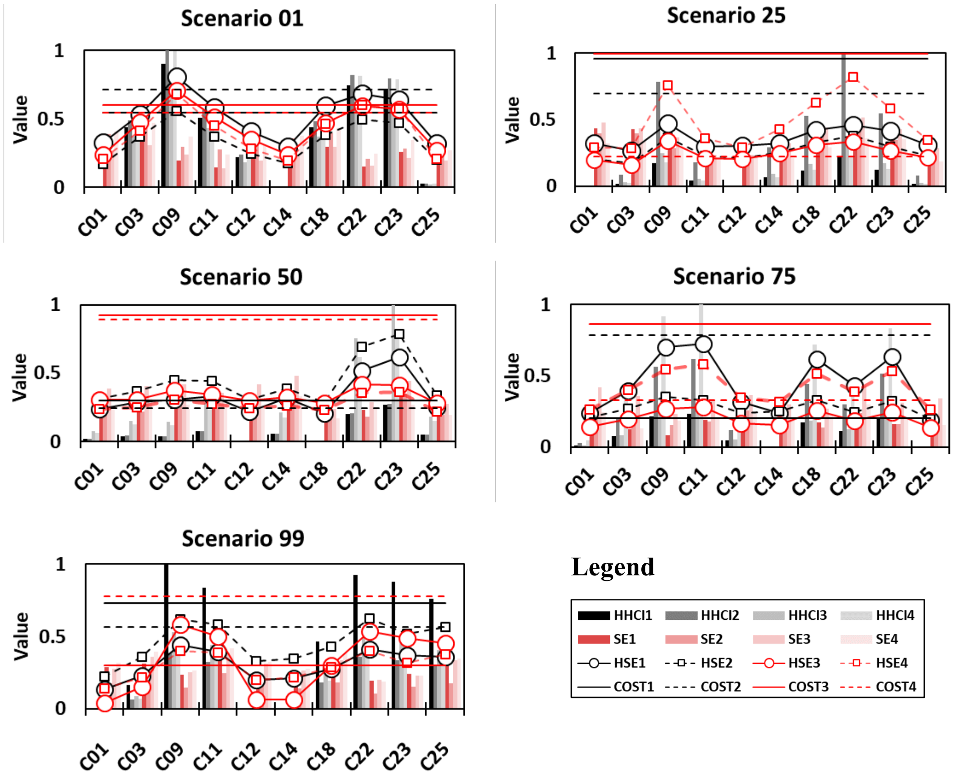


Figure D 7 The values of modified HHI based on cost (HHCI), socioeconomic-environmental demand (SE), cost of each LID type, and the result index, HSE for identifying optimized layout (site and type) for implementing LID for five sample scenarios (scenario 01, 25, 50, 75 and 99)

APPENDIX E: CODE AND INPUT DATA USED FOR THE SENSITIVITY ANALYSIS

Sensitivity analysis of HHI, LIDDI, and HSE to input parameters

```
# "This program creates a conceptual model to estimate HSE, adding the sensitivity ratio to the
parameter can produce data for sensitivity analysis purposes"
# help([object])
from typing import List

import numpy as np
import os
import pandas


import matplotlib
import matplotlib.pyplot as plt
from matplotlib import animation

import math
from math import pi
#import altair as alt

from matplotlib.patches import Circle, RegularPolygon
from matplotlib.path import Path
from matplotlib.projections.polar import PolarAxes
from matplotlib.projections import register_projection
from matplotlib.spines import Spine
from matplotlib.transforms import Affine2D

#  -----------------------------------------------input neccessary values------------------------------
---------------------
sc_num = 35
path = "C:/Users/kaykh/Google Drive/Sarah/YU/Research/Papers/Paper5/"
m = 5  # number of rows in the catchment
n = 5  # number of cols in the catchment
se_num = 8  # number of LID demanded benefit for catchment
lid_num = 3  # number of LID types


#  set dynamic variables )list, arrays, dataframes--------------------------------------------------
--------------------
test_list = []
my_cells = []
my_lid = []
lid_df1 = pandas.DataFrame()
lid_df = pandas.DataFrame()
df = pandas.DataFrame()
df1 =pandas.DataFrame()


#  generate a list of cell names and lid types------------------------------------------------------
--------------------
for i in range(m*n):
    if i <= 8:
        cell = 'C0' + str(i+1)
    else:
        cell = 'C' + str(i + 1)
    my_cells.append(cell)
for i in range(lid_num):
```

```
    if i <= 8:
        lid = 'lid0' + str(i + 1)
    else:
        lid = 'lid' + str(i+1)
    my_lid.append(lid)
#  add two columns to df: 'sc_id' and 'cell_id'--------------------------------------------------
--------------------
for sc in range(sc_num):
    rnd_seed = 1
    #create "Scenario id" column in df---------------------------------------------
    df1 = pandas.DataFrame(index=my_cells)
    lid_df1 = pandas.DataFrame(index=my_lid)
    sc_data = []
    for i in range(m*n):
        if sc <= 8:
            name ='sc0' + str(sc + 1)
        else:
            name = 'sc' + str(sc + 1)
        sc_data.append(name)
    df1['sc_id'] = sc_data
    df1['cell_id'] = my_cells
    # create "Scenario id" column in lid_df-----------------------------------------
    lid_data = []
    for j in range(lid_num):
        if sc <= 8:
            name ='sc0' + str(sc + 1)
        else:
            name = 'sc' + str(sc + 1)
        lid_data.append(name)
    lid_df1['sc_id']=lid_data
    lid_df1['lid_id']=my_lid

#  generate random input variables----------------------------------------------------------------
----------------
    #---------------------------------------####  lid_df variables ####----------------------------
----------------#
    #  Lid_arr is the array of benefits of different lid types------------------------
    np.random.seed(rnd_seed)
    lid_arr = np.random.random((se_num, lid_num))  # row=8 and col=4
    for i in range(se_num):
        lid_df1['lid_bnf' + str(i + 1)]= lid_arr[i]
    print(lid_df1)
    #  Cost generation-----------------------------------------------------------------
    np.random.seed(rnd_seed)
    cost_arr = np.random.random(lid_num)  # rows:lid_num cols:1 (1d array)
    lid_df1['cost'] = cost_arr

    #----------------------------------------####  df variables #######----------------------------
----------------#
    #  generate seeni for all cells and all SE and EN variables-------------------------
    np.random.seed(rnd_seed)
    seeni_arr = np.random.random((m * n, se_num))  # row=25 and col=8
    seeni_temp = np.hsplit(seeni_arr, se_num)
    for i in range(se_num):
        df1['se' + str(i+1)] = seeni_temp[i]
    #  Slope generation----------------------------------------------------------------
    np.random.seed(rnd_seed+1)
    min_slope = 0
    max_slope = 0.5
    slope_norm = np.random.random(m*n)
    slope = slope_norm * max_slope

    #  rainfall generation-------------------------------------------------------------
    np.random.seed(rnd_seed+25)
    min_rainfall = 35.2
    max_rainfall = 40.0
```

```
    rainfall = np.full(m*n, min_rainfall) + np.random.random(m*n) * (max_rainfall - min_rainfall)
    rainfall_norm = np.divide(rainfall-min_rainfall, max_rainfall-min_rainfall)

    #  ks generation----------------------------------------------------------------
    np.random.seed(rnd_seed+15)
    min_ks = 0.01
    max_ks = 69
    ks_norm = np.full(m*n, min_ks) + np.random.random(m*n)
    ks = ks_norm * (max_ks - min_ks)

    #  Dg generation-----------------------------------------------------------------
    np.random.seed(rnd_seed+20)
    min_dg = 0.01
    max_dg = 117
    dg_norm = np.full(m*n, min_dg) + np.random.random(m*n)
    dg = dg_norm * (max_dg - min_dg)

    #  Dr generation-----------------------------------------------------------------
    np.random.seed(rnd_seed+10)
    min_dr = 0.01
    max_dr = 117
    dr_norm = np.full(m*n, min_dr) + np.random.random(m*n)
    dr = dr_norm * (max_dr - min_dr)

    #write input file--------------------------------------------------------------------------------
--------------------
    #sns_ratio = 0.6+ sc*0.1
    sns_ratio = 1
    df1['rainfall'] = rainfall
    df1['slope'] = slope
    df1['ks'] = ks
    df1['dg'] = dg.reshape(m * n)
    df1['dr'] = dr.reshape(m * n)* sns_ratio
    df1['slope_n'] = slope_norm
    df1['rainfall_n'] = rainfall_norm
    df1['ks_n'] = ks_norm
    df1['dg_n'] = dg_norm.reshape(m * n)
    df1['dr_n'] = dr_norm.reshape(m * n)
    df = pandas.concat([df, df1], axis=0)
    lid_df = pandas.concat([lid_df, lid_df1], axis=0)


df.to_csv(path + "input_site.csv")
lid_df.to_csv(path + "iput_lid.csv")

#  Result generation--------------------------------------------------------------------------------
--------------------
#----------------------------------------------------reading inputs----------------------------------
--------------------
my_input = path + 'input_site.csv'
df = pandas.read_csv(my_input)
ks=np.array(df['ks'])
dr=np.array(df['dr'])
dg=np.array(df['dg'])
rainfall=np.array(df['rainfall'])
slope=np.array(df['slope'])

my_input = path + 'iput_lid.csv'
lid_df = pandas.read_csv(my_input)

# --------------------------------------------------HHI generation----------------------------------
--------------------
depth = np.minimum(ks, dr,dg)
runoff_temp = rainfall - ks
runoff = np.where(runoff_temp < 0, 0, runoff_temp)
s_nonlin = 1 + np.power(slope, 0.368)
```

```
hhi_temp = np.multiply(runoff, s_nonlin)
df['hhi'] = hhi_temp
df['runoff'] = runoff_temp
hhi = hhi_temp.reshape(sc_num, m, n)
#df['hhi'] = df['hhi'].replace(0 ,np.nan)
# -----------------------------------------------------Feasibility-----------------------------------
--------------------
feasible_num = 10  # number of feasible cells
feasible_row1 = [1,0,1,0,0]
feasible_row2 = [0,0,0,1,0]
feasible_row3 = [1,1,0,1,0]
feasible_row4 = [0,0,1,0,0]
feasible_row5 = [0,1,1,0,1]
feasible_cells = pandas.DataFrame([1,0,1,0,0, 0,0,0,1,0, 1,1,0,1,0, 0,0,1,0,0,0,1,1,0,1])

fsbl_cells = []
x= pandas.DataFrame()
for i in range(sc_num):
    x = pandas.concat([x, feasible_cells])

df['feasible'] = np.array(x)
df['feasible'] = df['feasible'].replace(0 ,np.nan)
# ----------------------------------------------Catchment HHI generation------------------------------
--------------------
# sum of hhi for each feasible cell:
hhi_catch = np.zeros_like(hhi)  # (sc_num, m, n)
for sc in range(sc_num):
    fsbl1_catch = hhi[sc][0, 0]
    fsbl2_catch = hhi[sc][2, 0] + hhi[sc][0, 1] + hhi[sc][1, 1] + hhi[sc][1, 0]
    fsbl3_catch = hhi[sc][2, 1]
    fsbl4_catch = hhi[sc][0, 2] + hhi[sc][1,2]
    fsbl5_catch = hhi[sc][3, 2] + hhi[sc][2, 2]
    fsbl6_catch = hhi[sc][1, 3] + hhi[sc][1, 4] + hhi[sc][0, 3]+ hhi[sc][0, 4]
    fsbl7_catch = hhi[sc][2, 3]
    fsbl8_catch = hhi[sc][4, 1] + hhi[sc][4, 0] + hhi[sc][3, 0] + hhi[sc][3, 1]
    fsbl9_catch = hhi[sc][4, 2] + hhi[sc][4, 3] + hhi[sc][3, 3] + hhi[sc][3, 4]+ hhi[sc][2, 4]
    fsbl10_catch = hhi[sc][4, 4]
    # Calculating sum of hhi based on catchment of each cell:
    for i in range(m):
        for j in range(n):
            if i == 0 and j == 0:
                hhi_catch[sc][i][j] = fsbl1_catch
            elif i == 2 and j == 0:
                hhi_catch[sc][i][j] = fsbl2_catch
            elif i == 2 and j == 1:
                hhi_catch[sc][i][j] = fsbl3_catch
            elif i == 0 and j == 2:
                hhi_catch[sc][i][j] = fsbl4_catch
            elif i == 3 and j == 2:
                hhi_catch[sc][i][j] = fsbl5_catch
            elif i == 1 and j == 3:
                hhi_catch[sc][i][j]= fsbl6_catch
            elif i == 2 and j == 3:
                hhi_catch[sc][i][j]= fsbl7_catch
            elif i == 4 and j == 1:
                hhi_catch[sc][i][j] = fsbl8_catch
            elif i == 4 and j == 2:
                hhi_catch[sc][i][j] = fsbl9_catch
            elif i == 4 and j == 4:
                hhi_catch[sc][i][j] = fsbl10_catch
hhi_catch_flat = np.ndarray.flatten(hhi_catch)
df['hhi_catch']=hhi_catch_flat
df['hhi_catch'] = df['hhi_catch'].replace(0 ,np.nan)
#-----------------------------------------------HHCI generation-----------------------------------
--------------------
hhci_catch = np.zeros(shape=(lid_num, sc_num, m, n))
```

```
for sc in range(sc_num):
    #------------------------------Reading data
    cost_col = lid_df.iloc[: , 11:12]
    cost_arr = np.array(cost_col).reshape(sc_num, lid_num)  # (sc_num, lid_num)
    # --------------------------hhci calculation
    for i in range(lid_num):
        hhci_catch[i][sc] = np.divide(hhi_catch[sc], cost_arr[sc][i])  #(lid_num, sc_num, m, n)

# flatten hhci_catch into lid_num number of columns array
hhci_flat = np.zeros(shape=(lid_num, sc_num * m * n))
for j in range(lid_num):
    hhci_flat[j] = np.ndarray.flatten(hhci_catch[j])  #(lid_num, sc_num* m* n)
hhci = np.array(hhci_flat).T  # (sc_num* m* n, lid_num)
hhci_n_arr = np.zeros_like(hhci)  # (sc_num* m* n)

hhci_n_lid = []
for j in range(sc_num):
    start_r = j*25
    step = m*n
    end_r = start_r+step
    hhci_sel = hhci[start_r:end_r, 0:lid_num]
    hhci_max = np.nanmax(hhci_sel)
    hhci_n = hhci_sel/hhci_max
    hhci_n_arr[start_r:end_r, 0:lid_num] = hhci_n

# store hhci array in df
for k in range(lid_num):
    hhci_temp = hhci[:,k]
    df['hhci_lid' + str(k+1)]=hhci_temp

# store the normalized hhci array in df
for k in range(lid_num):
    hhci_n_temp = hhci_n_arr[:, k]
    df['hhci_norm' + str(k + 1)] = hhci_n_temp

# ----------------------------------------------sei generation-------------------------------------
----------------

# seeni_arr (sc_num*m*n, seeni_num)------------
seeni_sel = df.iloc[:, 3: 3 + se_num]  # (sc_num*m*n, seeni_num) for sc_num=2 is (50, 8)
seeni_arr = np.reshape(seeni_sel.to_numpy(), (sc_num, m*n, 8) )  #  (50, 8) for sc_num=2
# lid_arr (seeni_num, lid_num)---------------
lid_sel = lid_df.iloc[:, 3: 3 + se_num]  # (sc_num*lid_num, seeni_num)
lid_arr1 = lid_sel.to_numpy() # (seeni_num, lid_num*sc_num)
lid_arr = np.reshape(lid_arr1, (sc_num, lid_num, se_num))

sei_list = []
for i in range(sc_num):
    lid_arr_t = lid_arr[i].T
    sei_temp1=np.dot(seeni_arr[i], lid_arr_t)  # (25, 8).(8, 4)
    sei_temp2=np.divide(np.array(sei_temp1), se_num)
    sei_list.append(sei_temp2)
a = np.array(sei_list)
c = []
for i in range(sc_num):
    b = np.hsplit(a[i], lid_num)
    c.append(b)
d = np.array(c)  #(sc_num, lid_num , m*n)
sei = np.reshape(d, (sc_num, lid_num, m , n))
#add sei to df------------------------------------
x = a.reshape(sc_num*m*n, lid_num)
for i in range(lid_num):
    name = 'sei' + str(i+1)
    y = x.T
    df[name] = y[i]
```

```
# ---------------------------------------------Estimation of sei_neighbour---------------------------
----------------
sei_nei = np.full_like(sei, 0)  #(sc_num, lid_num, m, n)
sei_nei_flat = []
indices1 = []
indices = np.full_like(sei, 0)
test_nei = np.full_like(sei, 0)
#iterate through sei_neigh
kernel_arr = [0.33, 0.66]  # weight of neighbour cells
for l in range(sc_num):
    for k in range(lid_num):
        for i in range(m): # iterate through rows
            for j in range(n): # iterate through columns
                right2 = j + 3
                left2 = j - 2
                right1 = j + 2
                left1 = j - 1  # left and right neighbour indices
                top2 = i - 2
                bot2 = i + 3
                top1 = i - 1
                bot1 = i + 2  # top and bottom neighbour indices
                indices1.append([left1, right1, top1, bot1, left2, right2, top2, bot2])  # list of
index of neighbour cells
                if right1 > n-1 :  # check if each boundary is in range and define the range
                    right1 = None
                if right2 > n-1:
                    right2 = None
                if bot1 > m-1 :
                    bot1 = None
                if bot2 > m-1 :
                    bot2 = None
                if left1 <= 0 :
                    left1 = None
                if left2 <= 0 :
                    left2 = None
                if top1 <= 0 :
                    top1 = None
                if top2 <= 0:
                    top2  = None
                indices[l][k][i][j] = left1
                center_val = sei[l][k][i][j]
                test = np.full_like(sei, 1)
                test_nei1= np.sum(test[l][k][left1:right1, top1:bot1])
                test_nei2 = np.sum(test[l][k][left2:right2, top2:bot2])
                test_nei[l][k][i][j] = test_nei2
                sei_nei1 = np.sum(sei[l][k][left1:right1, top1:bot1])
                sei_nei2 = np.sum(sei[l][k][left2:right2, top2:bot2])
                sei_nei3 = center_val + ((sei_nei2 - sei_nei1) * kernel_arr[0] + (sei_nei1 -
center_val)*kernel_arr[1])/((test_nei2-test_nei1)*0.66+(test_nei1-1)*0.33)
                sei_nei[l,k,i,j] = sei_nei3

e = np.reshape(sei_nei, (sc_num, lid_num, m*n))
e_list = []
for i in range(sc_num):
    e_t = e[i].T
    e_list.append(e_t)

f = np.array(e_list)
sei_df = pandas.DataFrame()
for i in range(sc_num):
    name = 'sei_nei_' + str(i + 1)
    g = pandas.DataFrame(f[i])
    sei_df = pandas.concat([g, sei_df], axis=0)


for i in range(lid_num):
```

```
   name = 'sei_nei_' + str(i+1)
   h = np.array(sei_df[i])
   df[name] = h


 # ------------------------------------------------generating hse---------------------------------
------------------
hse_temp1 = np.full_like(sei_nei, 0.00)  # (sc_num, lid_num, m, n)

for lid in range(lid_num):
    hhci_temp2 = df['hhci_norm' + str(lid+1)]
    sei_temp3 = df['sei_nei_' + str(lid+1)]
    hse = (hhci_temp2+sei_temp3)/2
    col_name = 'hse_lid' + str(lid+1)
    df[col_name] = hse
    #hse_max = df.max(col_name)
    #hse_norm = np.divide(hse, hse_max)
    #df['hse_norm_lid' + str(lid + 1)] = hse_norm

for i in range(lid_num):
    name1 = 'hhci_lid' + str(i+1)
    name2 = 'sei_nei_' +str(i+1)
    name3 = 'hse_lid' + str(i+1)
    df[name1] = df[name1].replace(0, np.nan)
    df[name2] = df[name2].replace(0, np.nan)
    df[name3] = df[name3].replace(0, np.nan)

# -------------------------------------------------generating Type_rnk-----------------------------
----------------------

df_sel = df[['hse_lid1', 'hse_lid2', 'hse_lid3']]
Type_rnk1 = df_sel.rank(axis=1, method='first', numeric_only=None, na_option='keep',
ascending=False, pct=False)
Type_rnk = Type_rnk1.rename(columns = {'hse_lid1':'Type_rnk1', 'hse_lid2':'Type_rnk2',
'hse_lid3':'Type_rnk3'}, inplace = False)
df = pandas.concat([df, Type_rnk], axis=1)
#--------------------------------------------------Adding coordinates-----------------------------
----------
x = []
y = []
for sc in range(sc_num):
    for i in range(m):
        xi = i + 1
        for j in range(n):
            yj = j+1
            y.append(yj)
            x.append(xi)
x_arr = np.array(x)
y_arr = np.array(y)
df['x'] = x_arr
df['y'] = y_arr
#  -------------------------------------saving all results in one data frame-----------------------
-------------------
df.to_csv(path+'output.csv')
df_feasible = df.dropna(how='all', subset=['feasible'])
df_feasible.to_csv(path + 'output_fsbl.csv')
```

Modified section of the code for sensitivity analysis of HSE to weights of HHCI and SEI

```
#By modifying this part of the previous code the weight sensitivity analysis can be performed
# -------------------------------------------------generating hse-----------------------------------
-----------------
hse_temp1 = np.full_like(sei_nei, 0.00)  # (sc_num, lid_num, m, n)
for w in range(1,11):
    w_hhi = w*0.1
    w_sei = 1-w_hhi
    for lid in range(lid_num):
        hhci_temp2 = df['hhci_norm' + str(lid+1)]
        sei_temp3 = df['sei_nei_' + str(lid+1)]
        hse = w_hhi * hhci_temp2 + w_sei * sei_temp3
        col_name = 'hse_lid' + str(lid+1) + "w" + str(w)
        df[col_name] = hse
        #df = pandas.concat([df, df2], axis=0)
        #hse_max = df.max(col_name)
        #hse_norm = np.divide(hse, hse_max)
        #df['hse_norm_lid' + str(lid + 1)] = hse_norm
```

Model data (input and outputs)

1. Sensitivity analysis of HHI, LIDDI and HSE to the inputs

```
          Unnamed: 0          Sc_id     cell_id   se1       se2       se3       se4       se5       se6       se7       se8       rainfall  slope
          ks        dg        dr        n         LIDDI     hhi       runoff    feasible  hhi_catch hhci_lid1 hhci_lid2 hhci_lid3 hhci_norm1
          hhci_norm2          hhci_norm3          sei1      sei2      sei3      sei_nei_1 sei_nei_2 sei_nei_3 hse_lid1  hse_lid2  hse_lid3
          Type_rnk1 Type_rnk2 Type_rnk3 x         y
0         C01       Sc01      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         33.00685266         0.217997451         16.09475155         6.870223806
          22.2596509          0.033847058         33.90848661         26.56699905         16.91210111         1         26.56699905
          22.13916588         44.27833175         221.3916588         0.025272231         0.050544461         0.252722307         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.167907644         0.162990632
          0.258030216         2         3         1         1         1
1         C02       Sc01      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          33.61584746         0.012963116         36.78293892         34.9928391          3.448308502
          0.172396809         0         0         -3.16709146                                                 0         0         0
          0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277         0.222682445
          0.189169138         0.193388639         1         3         2         1         2
2         C03       Sc01      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         34.33269727         0.274831239         38.68279349         85.51575292
          55.36183542         0.421304567         0         0         -4.35009622         1         35.57040589         29.64200491
          59.28400982         296.4200491         0.033836848         0.067673696         0.338368478         0.25038454          0.237553697
          0.192031501         0.413221665         0.397937162         0.354009513         0.223529256         0.232805429         0.346188996
          3         2         1         1         3
3         C04       Sc01      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         34.39295572         0.217661196         3.83597854          3.698785078
          85.97992038         0.01822255          68.76316915         47.99165001         30.55697718
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
4         C05       Sc01      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         34.62721874         0.210183901         25.57658235         25.26080431
          50.3295197          0.124450664         22.61652996         14.14858807         9.05063639
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
5         C06       Sc01      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         32.66121361         0.165167411         16.08025417         7.109863301
          57.96001621         0.035027674         39.4509017          25.12780432         16.58095944
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
```

```
6       C07     Sc01    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     32.89617511     0.102324317     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -15.30894279                                                    0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
7       C08     Sc01    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      33.54903337     0.309635483     11.98573101     78.84076537
        58.18750434     0.388419366     51.73217517     35.57040589     21.56330236
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
8       C09     Sc01    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     34.24867063     0.149827337     5.541612561     37.21620286
        111.3518603     0.183350502     66.28286726     42.98304685     28.70705807     1       105.1232849
        87.60273744     175.2054749     876.0273744     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
9       C10     Sc01    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     32.68146174     0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -32.92877751                                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
10      C11     Sc01    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     32.63766631     0.310566916     39.57827842     9.30900598
        86.56844337     0.045862038     0       0       -6.94061211     1       25.12780432     20.93983693
        41.87967387     209.3983693     0.023903176     0.047806353     0.239031765     0.316867923     0.266455347
        0.264174875     0.486389832     0.435666719     0.417511021     0.255146504     0.241736536     0.328271393
        2       3       1       3       1
11      C12     Sc01    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      33.67181962     0.264571047     6.070591495     102.6475506
        13.89093305     0.505706614     66.91032207     44.52214838     27.60122813     1       44.52214838
        37.10179032     74.20358064     371.0179032     0.042352318     0.084704637     0.423523184     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.227590998     0.249292262
        0.398354  3     2       1       3       2
12      C13     Sc01    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      32.93436494     0.067289973     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -17.61050392                                                    0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
13      C14     Sc01    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      34.31150682     0.256789061     11.62151545     22.00870416
        101.4483754     0.108428766     56.83555941     36.44809226     22.68999137     1       36.44809226
        30.37341021     60.74682043     303.7341021     0.034671759     0.069343518     0.346717592     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236884791       0.268492897
        0.358819046     3       2       1       3       4
14      C15     Sc01    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     32.89671567     0.092219933     17.95680735     59.18869803
        20.48338339     0.29160088      34.27952698     21.15436922     14.93990832
```

```
                0          0          0          0.251517278          0.292575574          0.225051384          0.421654228          0.461972982
        0.38826343          0.210827114          0.230986491          0.194131715          2          1          3          3          5
15      C16       Sc01       C16       0.019880134          0.026210987          0.028306488          0.246211068          0.860027949
        0.538831064          0.552821979          0.842030892          32.96533619          0.392667574          20.9375858          102.2141214
        75.14665628          0.503571269          28.55622033          20.55454145          12.02775039
                0          0          0          0.198021052          0.185581091          0.191572754          0.409469615          0.400700715
        0.376351488          0.204734808          0.200350357          0.188175744          1          2          3          4          1
16      C17       Sc01       C17       0.124173315          0.279183679          0.585759271          0.969595748          0.561030219
        0.018647289          0.800632673          0.232974274          34.89172787          0.426987646          48.74907317          89.95873932
        3.56627786          0.443193522          0          0          -13.8573453                                                        0
        0          0          0.154114011          0.183917483          0.218846089          0.390156452          0.422091592          0.424898731
        0.195078226          0.211045796          0.212449365          3          2          1          4          2
17      C18       Sc01       C18       0.807105196          0.387860644          0.863541855          0.747121643          0.556240234
        0.136455226          0.05991769          0.121343456          34.75005726          0.247118419          32.71947943          114.7069548
        14.82699307          0.56511885          4.736875041          3.244549979          2.03057783          1          3.244549979
        2.703791649          5.407583298          27.03791649          0.003086424          0.006172847          0.030864237          0.168545737
        0.230647918          0.139241534          0.36632712          0.427568554          0.327019619          0.184706772          0.216870701
        0.178941928          2          1          3          4          3
18      C19       Sc01       C19       0.044551879          0.107494129          0.225709339          0.71298898          0.559716982
        0.01255598          0.07197428          0.96727633          33.75634355          0.423280743          15.52703729          90.00070565
        38.18171179          0.443400275          42.15964078          31.51454714          18.22930626
                0          0          0.19335296          0.154863434          0.16721044          0.416396653          0.388253269
        0.385127801          0.208198327          0.194126634          0.192563901          1          2          3          4          4
19      C20       Sc01       C20       0.568100462          0.203293235          0.252325745          0.743825854          0.195429481
        0.581358927          0.970019989          0.846828801          33.51821798          0.039822739          31.51644382          46.12331125
        19.64406076          0.227232539          4.03760526          2.613086741          2.00177416
                0          0          0          0.266503103          0.213730709          0.290225506          0.462800059          0.417820608
        0.473734591          0.23140003          0.208910304          0.236867296          2          3          1          4          5
20      C21       Sc01       C21       0.239847759          0.493769714          0.619955718          0.8289809 0.156791395          0.018576202
        0.070022144          0.486345111          34.00266859          0.252623045          9.029325069          48.98585736          89.96292202
        0.241335248          54.60566745          40.02508472          24.97334352                                                        0
        0          0          0.167087112          0.139838178          0.158385453          0.368886507          0.35464928          0.331493863
        0.184443254          0.17732464          0.165746932          1          2          3          5          1
21      C22       Sc01       C22       0.606329462          0.568851437          0.317362409          0.988616154          0.579745219
        0.380141173          0.550948219          0.745334431          33.66549267          0.032643252          64.00112666          84.62593646
        96.89993412          0.41692077          0          0          -30.33563399          1          60.57962617          50.48302181
        100.9660436          504.8302181          0.05762722          0.115254439          0.576272195          0.273632139          0.256849416
        0.255171744          0.482159781          0.476288524          0.435601111          0.2698935 0.295771482          0.505936653          3
        2          1          5          2
22      C23       Sc01       C23       0.669232893          0.264919558          0.066334834          0.370084198          0.629717507
        0.21017401          0.752755554          0.066536481          34.98772802          0.214061164          39.76903222          32.83555671
        41.4875192          0.161768675          0          0          -4.7813042          1          55.2820031          46.06833592
        92.13667184          460.6833592          0.052587781          0.105175562          0.525877812          0.126338191          0.188706502
        0.135993177          0.31838757          0.379056788          0.311830131          0.185487676          0.242116175          0.418853972
        3          2          1          5          3
23      C24       Sc01       C24       0.260315099          0.804754564          0.193434283          0.639460881          0.524670309
        0.92480797          0.26329677          0.065961091          32.5289095          0.048265458          33.25451259          101.091395
```

```
          38.46617124     0.49804001      0       0       -0.72560309                                     0
          0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079     0.377206528
          0.204296641     0.204256539     0.188603264     1       2       3       5       4
24        C25     Sc01    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
          0.234362086     0.616778357     0.949016321     34.92898391     0.063579986     22.39183764     108.0009528
          14.23314753     0.532080852     28.10750344     17.08514789     12.53714627     1       17.08514789
          14.23762324     28.47524648     142.3762324     0.016252487     0.032504973     0.162524867     0.297089204
          0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.246390979     0.223666667
          0.311566865     2       3       1       5       5
25        C01     Sc02    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
          0.092338595     0.186260211     0.345560727     36.67466144     0.217997451     16.09475155     6.870223806
          22.2596509      0.033847058     41.26238333     32.32871202     20.57990989     1       32.32871202
          26.94059335     53.88118671     269.4059335     0.026239924     0.052479848     0.262399238     0.125908042
          0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.168391491     0.163958325
          0.262868682     2       3       1       1       1
26        C02     Sc02    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
          0.027387593     0.67046751      37.38515537     0.012963116     36.78293892     34.9928391      3.448308502
          0.172396809     1.069599618     0.723899385     0.60221645                                      0
          0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
          0.222682445     0.189169138     0.193388639     1       3       2       1       2
27        C03     Sc02    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
          0.968261576     0.313424178     0.692322616     38.22148014     0.274831239     38.68279349     85.51575292
          55.36183542     0.421304567     0       0       -0.46131335     1       41.76981399     34.80817833
          69.61635666     348.0817833     0.033902889     0.067805778     0.33902889      0.25038454      0.237553697
          0.192031501     0.413221665     0.397937162     0.354009513     0.223562277     0.23287147      0.346519202
          3       2       1       1       3
28        C04     Sc02    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
          0.878142503     0.098346834     0.421107625     38.29178167     0.217661196     3.83597854      3.698785078
          85.97992038     0.01822255      77.5367997      54.1150008      34.45580313
                  0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
          0.3266149 0.203942249       0.189644971     0.16330745      1       2       3       1       4
29        C05     Sc02    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
          0.834625672     0.018288277     0.750144315     38.56508853     0.210183901     25.57658235     25.26080431
          50.3295197      0.124450664     32.45682696     20.30454165     12.98850618
                  0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
          0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
30        C06     Sc02    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
          0.447893526     0.908595503     0.293614148     36.27141588     0.165167411     16.08025417     7.109863301
          57.96001621     0.035027674     48.04061783     30.59892658     20.19116171
                  0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
          0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
31        C07     Sc02    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
          0.265546659     0.491573159     0.053362545     36.54553763     0.102324317     48.2051179      36.53268887
          2.665127499     0.179983081     0       0       -11.65958027                                    0
          0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
          0.168102684     0.166496609     0.169732566     2       3       1       2       2
```

```
32        C08      Sc02      C08       0.574117605        0.146728575        0.589305537         0.69975836         0.102334429
          0.414055988        0.694400158        0.41417927          37.30720559        0.309635483        11.98573101         78.84076537
          58.18750434        0.388419366        60.74834627         41.76981399        25.32147458
                   0         0         0        0.195954796         0.182760584        0.225479264        0.378522006         0.365489003
          0.396290772        0.189261003        0.182744501         0.198145386        2         3        1         2         3
33        C09      Sc02      C09       0.049953459        0.535896406        0.663794645         0.514889112        0.944594756
          0.586555041        0.903401915        0.137474704         38.12344907        0.149827337        5.541612561         37.21620286
          111.3518603        0.183350502        75.2294972          48.7847484         32.58183651        1        123.2042908
          102.6702424        205.3404847        1026.702424         0.1      0.2       1         0.178780994        0.232017403
          0.229727169        0.392146196        0.44667726          0.432078559        0.246073098        0.32333863          0.716039279
          3        2         1         2         4
34        C10      Sc02      C10       0.139276347        0.807391289        0.397676837         0.165354197        0.92750858
          0.34776586         0.750812103        0.725997985         36.29503869        0.133413638        65.61023925         69.4442434
          100.7044175        0.342126169        0         0         -29.31520056                                                   0
          0        0         0.212063257        0.22017735          0.208648434        0.397570841        0.412858391         0.384413237
          0.19878542         0.206429195        0.192206618         2        1         3         2        5
35        C11      Sc02      C11       0.883306091        0.623672207        0.750942434         0.348898342        0.269927892
          0.895886218        0.42809119         0.964840047         36.24394403        0.310566916        39.57827842         9.30900598
          86.56844337        0.045862038        0         0         -3.33433439        1         31.32282596        26.10235497
          52.20470993        261.0235497        0.025423486         0.050846973        0.254234863        0.316867923         0.266455347
          0.264174875        0.486389832        0.435666719         0.417511021        0.255906659        0.243256846         0.335872942
          2        3         1         3         1
36        C12      Sc02      C12       0.663441498        0.62169572         0.114745973         0.949489259        0.449912133
          0.578389614        0.408136803        0.23702698          37.45045623        0.264571047        6.070591495         102.6475506
          13.89093305        0.505706614        76.0704142          50.61727644        31.37986473        1        50.61727644
          42.1810637         84.3621274         421.810637          0.041084021        0.082168042        0.410840208         0.220522508
          0.224798251        0.197499161        0.412829677         0.413879887        0.373184816        0.226956849         0.248023965
          0.392012512        3         2        1         3         2
37        C13      Sc02      C13       0.903379521        0.573679487        0.002870327         0.617144914        0.326644902
          0.527058102        0.885942099        0.35726976          36.59009243        0.067289973        50.54486886         16.75770835
          105.7477489        0.082559047        0         0         -13.95477643                                                   0
          0        0         0.221712208        0.223609096         0.217157743        0.387200912        0.389670791         0.373298543
          0.193600456        0.194835395        0.186649271         2        1         3         3        3
38        C14      Sc02      C14       0.908535151        0.623360116        0.015821243         0.929437234        0.690896918
          0.99732285         0.172340508        0.13713575          38.19675796        0.256789061        11.62151545         22.00870416
          101.4483754        0.108428766        66.56762226         42.68916964        26.57524251        1        42.68916964
          35.57430803        71.14861607        355.7430803         0.034649093        0.069298187        0.346490933         0.254748757
          0.280125362        0.188733628        0.439097823         0.467642276        0.3709205 0.236873458        0.268470231
          0.358705716        3         2        1         3         4
39        C15      Sc02      C15       0.932595463        0.696818161        0.066000173         0.755463053        0.753876188
          0.923024536        0.711524759        0.124270962         36.54616828        0.092219933        17.95680735         59.18869803
          20.48338339        0.29160088         42.65317336         26.32186197        18.58936093
                   0         0         0        0.251517278         0.292575574        0.225051384        0.421654228         0.461972982
          0.38826343         0.210827114        0.230986491         0.194131715        2         1        3         3         5
40        C16      Sc02      C16       0.019880134        0.026210987        0.028306488         0.246211068        0.860027949
          0.538831064        0.552821979        0.842030892         36.62622555        0.392667574        20.9375858          102.2141214
          75.14665628        0.503571269        37.24788417         26.81073231        15.68863975
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                  0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
41        C17       Sc02      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         38.87368252         0.426987646         48.74907317         89.95873932
          3.56627786          0.443193522         0         0         -9.87539065                                                    0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
42        C18       Sc02      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         38.70840014         0.247118419         32.71947943         114.7069548
          14.82699307         0.56511885          13.97078635         9.569370982         5.98892071          1         9.569370982
          7.974475818         15.94895164         79.74475818         0.007767076         0.015534152         0.077670761         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.187047098         0.221551353
          0.20234519          3         1         2         4         3
43        C19       Sc02      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          37.54906748         0.423280743         15.52703729         90.00070565
          38.18171179         0.443400275         50.93122409         38.07135054         22.02203019
                  0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
44        C20       Sc02      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         37.27125431         0.039822739         31.51644382         46.12331125
          19.64406076         0.227232539         11.60752974         7.512245531         5.75481049
                  0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
45        C21       Sc02      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         37.83644669         0.252623045         9.029325069         48.98585736         89.96292202
          0.241335248         62.98844615         46.16952802         28.80712162                                                    0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
46        C22       Sc02      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         37.44307478         0.032643252         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -26.55805188        1         72.98026033         60.81688361
          121.6337672         608.1688361         0.059235161         0.118470322         0.592351612         0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.270697471         0.297379423         0.513976362
          3         2         1         5         2
47        C23       Sc02      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         38.9856827          0.214061164         39.76903222         32.83555671
          41.4875192          0.161768675         0         0         -0.78334952         1         75.7062835          63.08856958
          126.1771392         630.8856958         0.061447765         0.122895531         0.614477653         0.126338191         0.188706502
          0.135993177         0.31838757          0.379056788         0.311830131         0.189917668         0.250976159         0.463153892
          3         2         1         5         3
48        C24       Sc02      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         36.11706108         0.048265458         33.25451259         101.091395
          38.46617124         0.49804001          5.547637798         3.800825465         2.86254849
                  0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
49        C25       Sc02      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         38.9171479          0.063579986         22.39183764         108.0009528
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        0.321697623        2        3        1        5        5
50      C01     Sc03    C01     0.417022005        0.720324493        0.000114375        0.302332573        0.146755891
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51      C02     Sc03    C02     0.396767474        0.538816734        0.419194514        0.6852195 0.20445225        0.878117436
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52      C03     Sc03    C03     0.417304802        0.558689828        0.140386939        0.198101489        0.800744569
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        44.60627262        89.21254525        446.0627262        0.037886127        0.075772254        0.378861271        0.25038454
        0.237553697        0.192031501        0.413221665        0.397937162        0.354009513        0.225553896        0.236854708
        0.366435392        3        2        1        1        3
53      C04     Sc03    C04     0.876389152        0.894606664        0.085044211        0.039054783        0.16983042
        0.878142503        0.098346834        0.421107625        42.19060763        0.217661196        3.83597854         3.698785078
        85.97992038        0.01822255         86.31043026        60.23835161        38.35462909
                0       0       0       0.214732899        0.18442312         0.126095549        0.407884499        0.379289941
        0.3266149 0.203942249        0.189644971        0.16330745        1        2        3        1        4
54      C05     Sc03    C05     0.95788953         0.533165285        0.691877114        0.315515631        0.686500928
        0.834625672        0.018288277        0.750144315        42.50295832        0.210183901        25.57658235        25.26080431
        50.3295197         0.124450664        42.29712396        26.46049523        16.92637597
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        0.365064068        0.222546725        0.225752801        0.182532034        2        1        3        1        5
55      C06     Sc03    C06     0.988861089        0.748165654        0.280443992        0.789279328        0.103226007
        0.447893526        0.908595503        0.293614148        39.88161814        0.165167411        16.08025417        7.109863301
        57.96001621        0.035027674        56.63033395        36.07004882        23.80136397
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        0.410044838        0.212181782        0.203205018        0.205022419        1        3        2        2        1
56      C07     Sc03    C07     0.287775339        0.130028572        0.019366958        0.678835533        0.211628116
        0.265546659        0.491573159        0.053362545        40.19490014        0.102324317        48.2051179         36.53268887
        2.665127499        0.179983081        0       0       -8.01021776                                                 0
        0       0          0.108835421        0.116048175        0.133699741        0.336205368        0.332993219        0.339465132
        0.168102684        0.166496609        0.169732566        2        3        1        2        2
57      C08     Sc03    C08     0.574117605        0.146728575        0.589305537        0.69975836         0.102334429
        0.414055988        0.694400158        0.41417927         41.06537782        0.309635483        11.98573101        78.84076537
        58.18750434        0.388419366        69.7645174         47.96922211        29.07964681
                0       0       0       0.195954796        0.182760584        0.225479264        0.378522006        0.365489003
        0.396290772        0.189261003        0.182744501        0.198145386        2        3        1        2        3
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58      C09     Sc03    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
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        111.3518603     0.183350502     84.17612713     54.58644995     36.45661495     1       141.2852968
        117.7377473     235.4754946     1177.377473     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
59      C10     Sc03    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     39.90861565     0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -25.7016236                                     0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
60      C11     Sc03    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     39.85022175     0.310566916     39.57827842     9.30900598
        86.56844337     0.045862038     0.738568111     0.448787815     0.27194333      1       41.77366452
        34.8113871      69.6227742      348.113871      0.029566887     0.059133775     0.295668873     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.25797836      0.247400247
        0.356589947     2       3       1       3       1
61      C12     Sc03    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      41.22909283     0.264571047     6.070591495     102.6475506
        13.89093305     0.505706614     85.23050631     56.71240447     35.15850134     1       56.71240447
        47.26033706     94.52067412     472.6033706     0.040140344     0.080280688     0.401403442     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226485011     0.247080288
        0.387294129     3       2       1       3       2
62      C13     Sc03    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      40.24581992     0.067289973     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -10.29904894                                    0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
63      C14     Sc03    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      42.0820091      0.256789061     11.62151545     22.00870416
        101.4483754     0.108428766     76.29968511     48.93024703     30.46049365     1       48.93024703
        40.77520585     81.55041171     407.7520585     0.034632229     0.069264457     0.346322286     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236865026       0.268453367
        0.358621393     3       2       1       3       4
64      C15     Sc03    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     40.1956209      0.092219933     17.95680735     59.18869803
        20.48338339     0.29160088      51.02681976     31.48935473     22.23881355
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
65      C16     Sc03    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     40.28711492     0.392667574     20.9375858      102.2141214
        75.14665628     0.503571269     45.93954804     33.06692319     19.34952912
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
66      C17     Sc03    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     42.85563716     0.426987646     48.74907317     89.95873932
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67      C18       Sc03      C18       0.807105196        0.387860644        0.863541855        0.747121643        0.556240234
        0.136455226         0.05991769         0.121343456        42.66674301        0.247118419        32.71947943        114.7069548
        14.82699307         0.56511885         23.20469764        15.89419197        9.94726358         1         15.89419197
        13.24515997         26.49031995        132.4515997        0.011249714        0.022499428        0.112497141        0.168545737
        0.230647918         0.139241534        0.36632712         0.427568554        0.327019619        0.188788417        0.225033991
        0.21975838          3         1         2         4         3
68      C19       Sc03      C19       0.044551879        0.107494129        0.225709339        0.71298898         0.559716982
        0.01255598          0.07197428         0.96727633         41.34179141        0.423280743        15.52703729        90.00070565
        38.18171179         0.443400275        59.70280739        44.62815393        25.81475412
                  0         0         0         0.19335296         0.154863434        0.16721044         0.416396653        0.388253269
        0.385127801         0.208198327        0.194126634        0.192563901        1         2         3         4         4
69      C20       Sc03      C20       0.568100462        0.203293235        0.252325745        0.743825854        0.195429481
        0.581358927         0.970019989        0.846828801        41.02429064        0.039822739        31.51644382        46.12331125
        19.64406076         0.227232539        19.17745423        12.41140432        9.50784682
                  0         0         0         0.266503103        0.213730709        0.290225506        0.462800059        0.417820608
        0.473734591         0.23140003         0.208910304        0.236867296        2         3         1         4         5
70      C21       Sc03      C21       0.239847759        0.493769714        0.619955718        0.8289809 0.156791395        0.018576202
        0.070022144         0.486345111        41.67022478        0.252623045        9.029325069        48.98585736        89.96292202
        0.241335248         71.37122482        52.31397131        32.64089971                                                   0
        0         0         0.167087112        0.139838178        0.158385453        0.368886507        0.35464928         0.331493863
        0.184443254         0.17732464         0.165746932        1         2         3         5         1
71      C22       Sc03      C22       0.606329462        0.568851437        0.317362409        0.988616154        0.579745219
        0.380141173         0.550948219        0.745334431        41.22065689        0.032643252        64.00112666        84.62593646
        96.89993412         0.41692077         0         0         -22.78046977       1         85.3808945         71.15074541
        142.3014908         711.5074541        0.06043155         0.1208631 0.604315498        0.273632139        0.256849416
        0.255171744         0.482159781        0.476288524        0.435601111        0.271295665        0.298575812        0.519958305
        3         2         1         5         2
72      C23       Sc03      C23       0.669232893        0.264919558        0.066334834        0.370084198        0.629717507
        0.21017401          0.752755554        0.066536481        42.98363737        0.214061164        39.76903222        32.83555671
        41.4875192          0.161768675        6.945321784        5.037516617        3.21460515         1         102.1315195
        85.10959956         170.2191991        851.0959956        0.072287437        0.144574873        0.722874367        0.126338191
        0.188706502         0.135993177        0.31838757         0.379056788        0.311830131        0.195337503        0.26181583
        0.517352249         3         2         1         5         3
73      C24       Sc03      C24       0.260315099        0.804754564        0.193434283        0.639460881        0.524670309
        0.92480797          0.26329677         0.065961091        39.70521266        0.048265458        33.25451259        101.091395
        38.46617124         0.49804001         12.50149916        8.565089876        6.45070007
                  0         0         0         0.195074589        0.194999729        0.172101157        0.408593283        0.408513079
        0.377206528         0.204296641        0.204256539        0.188603264        1         2         3         5         4
74      C25       Sc03      C25       0.735065963        0.77217803         0.907815853        0.931972069        0.013951573
        0.234362086         0.616778357        0.949016321        42.90531188        0.063579986        22.39183764        108.0009528
        14.23314753         0.532080852        45.98993546        27.95498541        20.51347424        1         27.95498541
        23.29582117         46.59164235        232.9582117        0.019786196        0.039572392        0.197861958        0.297089204
        0.234608961         0.294051043        0.476529471        0.414828361        0.460608863        0.248157833        0.227200376
        0.329235411         2         3         1         5         5
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75        C01       Sc04      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         16.09475155         6.870223806
          22.2596509          0.033847058         55.97017677         43.85213797         27.91552745         1         43.85213797
          36.54344831         73.08689662         365.4344831         0.027516569         0.055033137         0.275165686         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169029813         0.165234969
          0.269251906         2         3         1         1         1
76        C02       Sc04      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         36.78293892         34.9928391          3.448308502
          0.172396809         14.4589725          9.78575639          8.14083227                                                        0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
77        C03       Sc04      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         38.68279349         85.51575292
          55.36183542         0.421304567         17.92942341         11.86471894         7.31625241          1         66.03334916
          55.02779097         110.0555819         550.2779097         0.041434951         0.082869902         0.414349508         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.227328308         0.240403532
          0.384179511         3         2         1         1         3
78        C04       Sc04      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         3.83597854          3.698785078
          85.97992038         0.01822255          95.08406081         66.3617024          42.25345504
                   0         0         0        0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
79        C05       Sc04      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         25.57658235         25.26080431
          50.3295197          0.124450664         52.13742096         32.61644881         20.86424576
                   0         0         0        0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
80        C06       Sc04      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         16.08025417         7.109863301
          57.96001621         0.035027674         65.22005008         41.54117107         27.41156624
                   0         0         0        0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
81        C07       Sc04      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         48.2051179          36.53268887
          2.665127499         0.179983081         0         0         -4.36085524                                                       0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
82        C08       Sc04      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         11.98573101         78.84076537
          58.18750434         0.388419366         78.78068852         54.16863022         32.83781904
                   0         0         0        0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
83        C09       Sc04      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         5.541612561         37.21620286
          111.3518603         0.183350502         93.12275706         60.3881515          40.33139339         1         159.3663027
          132.8052523         265.6105045         1328.052523         0.1       0.2       1         0.178780994         0.232017403
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        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
84      C10     Sc04    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
85      C11     Sc04    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     9.30900598
        86.56844337     0.045862038     10.53282093     6.400224457     3.87822105      1       57.72715192
        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
86      C12     Sc04    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.070591495     102.6475506
        13.89093305     0.505706614     94.39059844     62.80753253     38.93713794     1       62.80753253
        52.33961044     104.6792209     523.3961044     0.039410799     0.078821597     0.394107986     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
87      C13     Sc04    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -6.64332145                                     0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
88      C14     Sc04    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        101.4483754     0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507       0.268440329
        0.358556204     3       2       1       3       4
89      C15     Sc04    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        20.48338339     0.29160088      59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
90      C16     Sc04    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      102.2141214
        75.14665628     0.503571269     54.63121188     39.32311405     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
91      C17     Sc04    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                     0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
92      C18     Sc04    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     114.7069548
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          18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
          0.233220321         3         2         1         4         3
93        C19       Sc04      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         15.52703729         90.00070565
          38.18171179         0.443400275         68.47439068         51.1849573          29.60747804
                    0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
94        C20       Sc04      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         31.51644382         46.12331125
          19.64406076         0.227232539         26.74737871         17.31056311         13.26088315
                    0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
95        C21       Sc04      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         45.50400288         0.252623045         9.029325069         48.98585736         89.96292202
          0.241335248         79.75400352         58.45841461         36.47467781                                                           0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
96        C22       Sc04      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         44.998239 0.032643252         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -19.00288766        1         97.78152866         81.48460722
          162.9692144         814.8460722         0.061356464         0.122712929         0.613564643         0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
          3         2         1         5         2
97        C23       Sc04      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         32.83555671
          41.4875192          0.161768675         15.58311099         11.30259806         7.21255982          1         129.7843202
          108.1536002         216.3072004         1081.536002         0.081437743         0.162875486         0.814377431         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
          0.563103781         3         2         1         5         3
98        C24       Sc04      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         101.091395
          38.46617124         0.49804001          19.45536051         13.32935429         10.03885165
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
99        C25       Sc04      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.063579986         22.39183764         108.0009528
          14.23314753         0.532080852         54.93115148         33.38990418         24.50163823         1         33.38990418
          27.82492015         55.64984029         278.2492015         0.020951671         0.041903343         0.209516715         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.248740571         0.228365852
          0.335062789         2         3         1         5         5
100       C01       Sc05      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         47.67808777         0.217997451         16.09475155         6.870223806
          22.2596509          0.033847058         63.32407347         49.61385093         31.58333622         1         49.61385093
          41.34487577         82.68975155         413.4487577         0.027959765         0.05591953          0.279597652         0.125908042
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        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169251412     0.165678166
        0.271467889     2       3       1       1       1
101     C02     Sc05    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      48.6930791      0.012963116     36.78293892     34.9928391      3.448308502
        0.172396809     21.15365894     14.31668489     11.91014018                                             0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
102     C03     Sc05    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     49.88782878     0.274831239     38.68279349     85.51575292
        55.36183542     0.421304567     27.45938916     18.17113284     11.20503529     1       78.53917118
        65.44930932     130.8986186     654.4930932     0.044260559     0.088521119     0.442605593     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.228741112     0.24322914
        0.398307553     3       2       1       1       3
103     C04     Sc05    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     49.98825953     0.217661196     3.83597854      3.698785078
        85.97992038     0.01822255      103.8576914     72.48505319     46.15228099
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
104     C05     Sc05    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     50.3786979      0.210183901     25.57658235     25.26080431
        50.3295197      0.124450664     61.97771796     38.7724024      24.80211555
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
105     C06     Sc05    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     47.10202268     0.165167411     16.08025417     7.109863301
        57.96001621     0.035027674     73.80976622     47.01229332     31.02176851
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
106     C07     Sc05    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     47.49362518     0.102324317     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -0.71149272                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
107     C08     Sc05    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      48.58172228     0.309635483     11.98573101     78.84076537
        58.18750434     0.388419366     87.79685965     60.36803834     36.59599127
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
108     C09     Sc05    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     49.74778439     0.149827337     5.541612561     37.21620286
        111.3518603     0.183350502     102.069387      66.18985304     44.20617183     1       177.4473086
        147.8727572     295.7455144     1478.727572     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
109     C10     Sc05    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     47.13576956     0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -18.47446969                                            0
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          0         0         0.212063257       0.22017735        0.208648434       0.397570841       0.412858391       0.384413237
          0.19878542        0.206429195       0.192206618       2         1         3         2         5
110       C11       Sc05      C11       0.883306091       0.623672207       0.750942434       0.348898342       0.269927892
          0.895886218       0.42809119        0.964840047       47.06277718       0.310566916       39.57827842       9.30900598
          86.56844337       0.045862038       20.32707371       12.35166108       7.48449876        1         73.6806393
          61.40053275       122.8010655       614.0053275       0.041522545       0.083045091       0.415225454       0.316867923
          0.266455347       0.264174875       0.486389832       0.435666719       0.417511021       0.263956189       0.259355905
          0.416368238       2         3         1         3         1
111       C12       Sc05      C12       0.663441498       0.62169572        0.114745973       0.949489259       0.449912133
          0.578389614       0.408136803       0.23702698        48.78636604       0.264571047       6.070591495       102.6475506
          13.89093305       0.505706614       103.5506905       68.90266056       42.71577454       1         68.90266056
          57.4188838        114.8377676       574.188838        0.038829927       0.077659854       0.388299271       0.220522508
          0.224798251       0.197499161       0.412829677       0.413879887       0.373184816       0.225829802       0.245769871
          0.380742043       3         2         1         3         2
112       C13       Sc05      C13       0.903379521       0.573679487       0.002870327       0.617144914       0.326644902
          0.527058102       0.885942099       0.35726976        47.5572749        0.067289973       50.54486886       16.75770835
          105.7477489       0.082559047       0         0         -2.98759396                                                 0
          0         0         0.221712208       0.223609096       0.217157743       0.387200912       0.389670791       0.373298543
          0.193600456       0.194835395       0.186649271       2         1         3         3         3
113       C14       Sc05      C14       0.908535151       0.623360116       0.015821243       0.929437234       0.690896918
          0.99732285        0.172340508       0.13713575        49.85251137       0.256789061       11.62151545       22.00870416
          101.4483754       0.108428766       95.76381078       61.41240178       38.23099592       1         61.41240178
          51.17700148       102.354003        511.7700148       0.03460881        0.06921762        0.346088099       0.254748757
          0.280125362       0.188733628       0.439097823       0.467642276       0.3709205 0.236853316       0.268429948
          0.3585043 3       2         1         3         4
114       C15       Sc05      C15       0.932595463       0.696818161       0.066000173       0.755463053       0.753876188
          0.923024536       0.711524759       0.124270962       47.49452612       0.092219933       17.95680735       59.18869803
          20.48338339       0.29160088        67.77411252       41.82434024       29.53771877
                    0         0         0         0.251517278       0.292575574       0.225051384       0.421654228       0.461972982
          0.38826343        0.210827114       0.230986491       0.194131715       2         1         3         3         5
115       C16       Sc05      C16       0.019880134       0.026210987       0.028306488       0.246211068       0.860027949
          0.538831064       0.552821979       0.842030892       47.60889364       0.392667574       20.9375858        102.2141214
          75.14665628       0.503571269       63.32287572       45.57930492       26.67130784
                    0         0         0         0.198021052       0.185581091       0.191572754       0.409469615       0.400700715
          0.376351488       0.204734808       0.200350357       0.188175744       1         2         3         4         1
116       C17       Sc05      C17       0.124173315       0.279183679       0.585759271       0.969595748       0.561030219
          0.018647289       0.800632673       0.232974274       50.81954646       0.426987646       48.74907317       89.95873932
          3.56627786        0.443193522       5.184619305       3.584252256       2.07047329
                    0         0         0         0.154114011       0.183917483       0.218846089       0.390156452       0.422091592
          0.424898731       0.195078226       0.211045796       0.212449365       3         2         1         4         2
117       C18       Sc05      C18       0.807105196       0.387860644       0.863541855       0.747121643       0.556240234
          0.136455226       0.05991769        0.121343456       50.58342877       0.247118419       32.71947943       114.7069548
          14.82699307       0.56511885        41.67252026       28.54383398       17.86394934       1         28.54383398
          23.78652831       47.57305663       237.8652831       0.016085808       0.032171617       0.160858083       0.168545737
          0.230647918       0.139241534       0.36632712        0.427568554       0.327019619       0.191206464       0.229870085
          0.243938851       3         2         1         4         3
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118       C19       Sc05      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          48.92723926         0.423280743         15.52703729         90.00070565
          38.18171179         0.443400275         77.24597398         57.74176069         33.40020197
                    0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
119       C20       Sc05      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         48.5303633          0.039822739         31.51644382         46.12331125
          19.64406076         0.227232539         34.3173032          22.2097219          17.01391948
                    0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
120       C21       Sc05      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         49.33778098         0.252623045         9.029325069         48.98585736         89.96292202
          0.241335248         88.13678221         64.6028579          40.30845591                                                           0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
121       C22       Sc05      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         48.77582111         0.032643252         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -15.22530555        1         113.7664151         94.8053459
          189.6106918         948.053459          0.064112787         0.128225574         0.64112787          0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.273136284         0.302257049         0.538364491
          3         2         1         5         2
122       C23       Sc05      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         50.97954671         0.214061164         39.76903222         32.83555671
          41.4875192          0.161768675         24.22090019         17.56767951         11.21051449         1         157.4371211
          131.1976009         262.3952018         1311.976009         0.088723307         0.177446615         0.887233074         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.203555439         0.278251701
          0.599531603         3         2         1         5         3
123       C24       Sc05      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         46.88151583         0.048265458         33.25451259         101.091395
          38.46617124         0.49804001          26.40922189         18.09361871         13.62700324
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          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
124       C25       Sc05      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         50.88163986         0.063579986         22.39183764         108.0009528
          14.23314753         0.532080852         63.8723675          38.82482294         28.48980222         1         38.82482294
          32.35401912         64.70803824         323.5401912         0.021879635         0.043759269         0.218796347         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.249204553         0.229293815
          0.339702605         2         3         1         5         5
125       C01       Sc06      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         51.34589655         0.217997451         16.09475155         6.870223806
          22.2596509          0.033847058         70.67797019         55.3755639          35.251145 1         55.3755639          46.14630325
          92.29260651         461.4630325         0.028320995         0.05664199          0.283209949         0.125908042         0.105685808
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126       C02       Sc06      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          52.46238701         0.012963116         36.78293892         34.9928391          3.448308502
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127       C03       Sc06      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         53.77661165         0.274831239         38.68279349         85.51575292
          55.36183542         0.421304567         36.98935487         24.47754673         15.09381816         1         91.04499316
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          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.229892625         0.245532166
          0.409822682         3         2         1         1         3
128       C04       Sc06      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         53.88708549         0.217661196         3.83597854          3.698785078
          85.97992038         0.01822255          112.6313219         78.608404 50.05110695
          0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
129       C05       Sc06      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         54.31656769         0.210183901         25.57658235         25.26080431
          50.3295197          0.124450664         71.81801496         44.92835598         28.73998534
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
130       C06       Sc06      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         50.71222495         0.165167411         16.08025417         7.109863301
          57.96001621         0.035027674         82.39948235         52.48341558         34.63197078
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
131       C07       Sc06      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         51.1429877          0.102324317         48.2051179          36.53268887
          2.665127499         0.179983081         5.332117802         4.207580453         2.9378698
          0         0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219
          0.339465132         0.168102684         0.166496609         0.169732566         2         3         1         2         2
132       C08       Sc06      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          52.3398945          0.309635483         11.98573101         78.84076537
          58.18750434         0.388419366         96.81303075         66.56744644         40.35416349
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
133       C09       Sc06      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         53.62256282         0.149827337         5.541612561         37.21620286
          111.3518603         0.183350502         111.0160169         71.99155458         48.08095026         1         195.5283146
          162.9402621         325.8805243         1629.402621         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
134       C10       Sc06      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         50.74934652         0.133413638         65.61023925         69.4442434
          100.7044175         0.342126169         0         0         -14.86089273                                                          0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
135       C11       Sc06      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         50.6690549          0.310566916         39.57827842         9.30900598
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          0.448725122     2       3       1       3       1
136       C12     Sc06    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
          0.578389614     0.408136803     0.23702698      52.56500265     0.264571047     6.070591495     102.6475506
          13.89093305     0.505706614     112.7107827     74.99778862     46.49441115     1       74.99778862
          62.49815718     124.9963144     624.9815718     0.038356485     0.07671297      0.38356485      0.220522508
          0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.225593081     0.245296429
          0.378374833     3       2       1       3       2
137       C13     Sc06    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
          0.527058102     0.885942099     0.35726976      51.21300239     0.067289973     50.54486886     16.75770835
          105.7477489     0.082559047     1.395630399     0.915618596     0.66813353
                  0       0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791
          0.373298543     0.193600456     0.194835395     0.186649271     2       1       3       3       3
138       C14     Sc06    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
          0.99732285      0.172340508     0.13713575      53.73776251     0.256789061     11.62151545     22.00870416
          101.4483754     0.108428766     105.4958736     67.65347916     42.11624706     1       67.65347916
          56.3778993      112.7557986     563.778993      0.034600349     0.069200698     0.34600349      0.254748757
          0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236849086       0.268421487
          0.358461995     3       2       1       3       4
139       C15     Sc06    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
          0.923024536     0.711524759     0.124270962     51.14397873     0.092219933     17.95680735     59.18869803
          20.48338339     0.29160088      76.1477589      46.99183299     33.18717138
                  0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
          0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
140       C16     Sc06    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
          0.538831064     0.552821979     0.842030892     51.26978301     0.392667574     20.9375858      102.2141214
          75.14665628     0.503571269     72.01453959     51.8354958      30.33219721
                  0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
          0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
141       C17     Sc06    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
          0.018647289     0.800632673     0.232974274     54.8015011      0.426987646     48.74907317     89.95873932
          3.56627786      0.443193522     15.15573026     10.47752152     6.05242793
                  0       0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592
          0.424898731     0.195078226     0.211045796     0.212449365     3       2       1       4       2
142       C18     Sc06    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
          0.136455226     0.05991769      0.121343456     54.54177164     0.247118419     32.71947943     114.7069548
          14.82699307     0.56511885      50.90643155     34.86865496     21.82229221     1       35.78427356
          29.82022797     59.64045593     298.2022797     0.018301326     0.036602651     0.183013256     0.168545737
          0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.192314223     0.232085603
          0.255016438     3       2       1       4       3
143       C19     Sc06    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
          0.01255598      0.07197428      0.96727633      52.71996318     0.423280743     15.52703729     90.00070565
          38.18171179     0.443400275     86.01755727     64.29856406     37.19292589
                  0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
          0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
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144       C20       Sc06      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         52.28339963         0.039822739         31.51644382         46.12331125
          19.64406076         0.227232539         41.88722768         27.10888069         20.76695581
                    0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
145       C21       Sc06      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         53.17155908         0.252623045         9.029325069         48.98585736         89.96292202
          0.241335248         96.51956091         70.7473012          44.14223401                                                           0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
146       C22       Sc06      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         52.55340322         0.032643252         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -11.44772344        1         133.0603185         110.8835988
          221.7671975         1108.835988         0.068051688         0.136103376         0.68051688          0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.275105734         0.30619595          0.558058996
          3         2         1         5         2
147       C23       Sc06      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         54.97750138         0.214061164         39.76903222         32.83555671
          41.4875192          0.161768675         32.8586894          23.83276096         15.20846916         1         185.0899218
          154.2416015         308.483203          1542.416015         0.094661442         0.189322884         0.946614419         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.206524506         0.284189836
          0.629222275         3         2         1         5         3
148       C24       Sc06      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         50.46966741         0.048265458         33.25451259         101.091395
          38.46617124         0.49804001          33.36308325         22.85788312         17.21515482
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
149       C25       Sc06      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         54.86980384         0.063579986         22.39183764         108.0009528
          14.23314753         0.532080852         72.8135835          44.2597417          32.4779662          1         44.2597417
          36.88311808         73.76623616         368.8311808         0.022635976         0.045271951         0.226359757         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.249582723         0.230050156
          0.34348431          2         3         1         5         5
150       C01       Sc07      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         55.01370533         0.217997451         16.09475155         6.870223806
          22.2596509          0.033847058         78.03186691         61.13727688         38.91895378         1         61.13727688
          50.94773073         101.8954615         509.4773073         0.028621072         0.057242143         0.286210717         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169582065         0.166339473
          0.274774422         2         3         1         1         1
151       C02       Sc07      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          56.23169492         0.012963116         36.78293892         34.9928391          3.448308502
          0.172396809         34.54303182         23.3785419          19.448756                                                   0         0
          0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
152       C03       Sc07      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         57.66539453         0.274831239         38.68279349         85.51575292
          55.36183542         0.421304567         46.51932062         30.78396063         18.98260104         1         103.5508152
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        86.29234598     172.584692      862.9234598     0.048476731     0.096953462     0.484767308     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.230849198     0.247445312
        0.41938841      3       2       1       1       3
153     C04     Sc07    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     57.78591144     0.217661196     3.83597854      3.698785078
        85.97992038     0.01822255      121.4049525     84.73175479     53.9499329
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
154     C05     Sc07    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     58.25443748     0.210183901     25.57658235     25.26080431
        50.3295197      0.124450664     81.65831195     51.08430956     32.67785513
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
155     C06     Sc07    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     54.32242722     0.165167411     16.08025417     7.109863301
        57.96001621     0.035027674     90.98919849     57.95453783     38.24217305
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
156     C07     Sc07    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     54.79235021     0.102324317     48.2051179      36.53268887
        2.665127499     0.179983081     11.95556681     9.434151883     6.58723231
                0       0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219
        0.339465132     0.168102684     0.166496609     0.169732566     2       3       1       2       2
157     C08     Sc07    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      56.09806673     0.309635483     11.98573101     78.84076537
        58.18750434     0.388419366     105.8292019     72.76685455     44.11233572
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
158     C09     Sc07    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     57.49734126     0.149827337     5.541612561     37.21620286
        111.3518603     0.183350502     119.9626468     77.79325612     51.9557287      1       213.6093205
        178.0077671     356.0155341     1780.077671     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
159     C10     Sc07    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     54.36292347     0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -11.24731578                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
160     C11     Sc07    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     54.27533262     0.310566916     39.57827842     9.30900598
        86.56844337     0.045862038     39.91557934     24.25453437     14.6970542      1       115.021766
        95.85147165     191.7029433     958.5147165     0.053846792     0.107693584     0.538467918     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.270118312     0.271680151
        0.477989469     3       2       1       3       1
161     C12     Sc07    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      56.34363925     0.264571047     6.070591495     102.6475506
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         13.89093305       0.505706614       121.8708748       81.09291665       50.27304776       1        81.09291665
         67.57743054       135.1548611       675.7743054       0.037963192       0.075926384       0.379631921       0.220522508
         0.224798251       0.197499161       0.412829677       0.413879887       0.373184816       0.225396435       0.244903136
         0.376408368       3        2        1        3        2
162      C13      Sc07     C13      0.903379521       0.573679487       0.002870327       0.617144914       0.326644902
         0.527058102       0.885942099       0.35726976        54.86872988       0.067289973       50.54486886       16.75770835
         105.7477489       0.082559047       9.031894986       5.925473545       4.32386102
                  0        0        0        0.221712208       0.223609096       0.217157743       0.387200912       0.389670791
         0.373298543       0.193600456       0.194835395       0.186649271       2        1        3        3        3
163      C14      Sc07     C14      0.908535151       0.623360116       0.015821243       0.929437234       0.690896918
         0.99732285        0.172340508       0.13713575        57.62301365       0.256789061       11.62151545       22.00870416
         101.4483754       0.108428766       115.2279365       73.89455655       46.0014982        1        73.89455655
         61.57879712       123.1575942       615.7879712       0.03459332        0.069186641       0.345933204       0.254748757
         0.280125362       0.188733628       0.439097823       0.467642276       0.3709205 0.236845571       0.268414458
         0.358426852       3        2        1        3        4
164      C15      Sc07     C15      0.932595463       0.696818161       0.066000173       0.755463053       0.753876188
         0.923024536       0.711524759       0.124270962       54.79343134       0.092219933       17.95680735       59.18869803
         20.48338339       0.29160088        84.52140528       52.15932574       36.83662399
                  0        0        0        0.251517278       0.292575574       0.225051384       0.421654228       0.461972982
         0.38826343        0.210827114       0.230986491       0.194131715       2        1        3        3        5
165      C16      Sc07     C16      0.019880134       0.026210987       0.028306488       0.246211068       0.860027949
         0.538831064       0.552821979       0.842030892       54.93067237       0.392667574       20.9375858        102.2141214
         75.14665628       0.503571269       80.70620343       58.09168666       33.99308657
                  0        0        0        0.198021052       0.185581091       0.191572754       0.409469615       0.400700715
         0.376351488       0.204734808       0.200350357       0.188175744       1        2        3        4        1
166      C17      Sc07     C17      0.124173315       0.279183679       0.585759271       0.969595748       0.561030219
         0.018647289       0.800632673       0.232974274       58.78345575       0.426987646       48.74907317       89.95873932
         3.56627786        0.443193522       25.12684124       17.37079081       10.03438258
                  0        0        0        0.154114011       0.183917483       0.218846089       0.390156452       0.422091592
         0.424898731       0.195078226       0.211045796       0.212449365       3        2        1        4        2
167      C18      Sc07     C18      0.807105196       0.387860644       0.863541855       0.747121643       0.556240234
         0.136455226       0.05991769        0.121343456       58.50011452       0.247118419       32.71947943       114.7069548
         14.82699307       0.56511885        60.14034286       41.19347597       25.78063509       1        47.11894951
         39.26579126       78.53158252       392.6579126       0.022058471       0.044116942       0.220584708       0.168545737
         0.230647918       0.139241534       0.36632712        0.427568554       0.327019619       0.194192795       0.235842748
         0.273802164       3        2        1        4        3
168      C19      Sc07     C19      0.044551879       0.107494129       0.225709339       0.71298898        0.559716982
         0.01255598        0.07197428        0.96727633        56.51268711       0.423280743       15.52703729       90.00070565
         38.18171179       0.443400275       94.78914057       70.85536745       40.98564982
                  0        0        0        0.19335296        0.154863434       0.16721044        0.416396653       0.388253269
         0.385127801       0.208198327       0.194126634       0.192563901       1        2        3        4        4
169      C20      Sc07     C20      0.568100462       0.203293235       0.252325745       0.743825854       0.195429481
         0.581358927       0.970019989       0.846828801       56.03643596       0.039822739       31.51644382       46.12331125
         19.64406076       0.227232539       49.45715216       32.00803948       24.51999214
                  0        0        0        0.266503103       0.213730709       0.290225506       0.462800059       0.417820608
         0.473734591       0.23140003        0.208910304       0.236867296       2        3        1        4        5
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170       C21       Sc07      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         57.00533717         0.252623045         9.029325069         48.98585736         89.96292202
          0.241335248         104.9023396         76.89174449         47.9760121                                                            0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
171       C22       Sc07      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         56.33098534         0.032643252         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -7.67014132         1         152.354222          126.9618516
          253.9237033         1269.618516         0.071323771         0.142647541         0.713237707         0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.276741776         0.309468033         0.574419409
          3         2         1         5         2
172       C23       Sc07      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         58.97545605         0.214061164         39.76903222         32.83555671
          41.4875192          0.161768675         41.4964786          30.09784241         19.20642383         1         212.7427226
          177.2856022         354.5712044         1772.856022         0.099594307         0.199188614         0.995943071         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.208990939         0.289122701
          0.653886601         3         2         1         5         3
173       C24       Sc07      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         54.05781899         0.048265458         33.25451259         101.091395
          38.46617124         0.49804001          40.31694461         27.62214754         20.8033064
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
174       C25       Sc07      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         58.85796783         0.063579986         22.39183764         108.0009528
          14.23314753         0.532080852         81.75479952         49.69466047         36.46613019         1         49.69466047
          41.41221705         82.82443411         414.1221705         0.023264275         0.046528551         0.232642753         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.249896873         0.230678456
          0.346625808         2         3         1         5         5
175       C01       Sc08      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.152598216         16.09475155         6.870223806
          22.2596509          0.033847058         53.46814953         41.89182178         27.91552745         1         41.89182178
          34.90985148         69.81970297         349.0985148         0.027472193         0.054944385         0.274721927         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169007626         0.165190594
          0.269030027         2         3         1         1         1
176       C02       Sc08      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.009074181         36.78293892         34.9928391          3.448308502
          0.172396809         14.16000836         9.583419037         8.14083227                                                            0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
177       C03       Sc08      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.192381867         38.68279349         85.51575292
          55.36183542         0.421304567         17.08394204         11.30522527         7.31625241          1         62.85001433
          52.37501194         104.7500239         523.7501194         0.041216343         0.082432687         0.412163433         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.227219004         0.240184924
          0.383086473         3         2         1         1         3
178       C04       Sc08      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.152362837         3.83597854          3.698785078
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        85.97992038     0.01822255      90.83506783     63.39621686     42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
179     C05     Sc08    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.147128731     25.57658235     25.26080431
        50.3295197      0.124450664     49.82662114     31.17084444     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
180     C06     Sc08    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.115617187     16.08025417     7.109863301
        57.96001621     0.035027674     62.49130739     39.80312937     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
181     C07     Sc08    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.071627022     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -4.36085524                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
182     C08     Sc08    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.216744838     11.98573101     78.84076537
        58.18750434     0.388419366     74.9646789      51.54478905     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
183     C09     Sc08    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.104879136     5.541612561     37.21620286
        111.3518603     0.183350502     89.31827978     57.92102791     40.33139339     1       152.4880892
        127.0734077     254.1468153     1270.734077     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
184     C10     Sc08    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.093389546     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                            0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
185     C11     Sc08    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.217396841     39.57827842     9.30900598
        86.56844337     0.045862038     10.02228614     6.090000138     3.87822105      1       55.47654854
        46.23045712     92.46091423     462.3045712     0.036380906     0.072761812     0.363809061     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261385369     0.254214266
        0.390660041     2       3       1       3       1
186     C12     Sc08    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.185199733     6.070591495     102.6475506
        13.89093305     0.505706614     89.97787433     59.87130458     38.93713794     1       59.87130458
        49.89275382     99.78550764     498.9275382     0.039262938     0.078525877     0.392629384     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226046308     0.246202882
        0.3829071 3     2       1       3       2
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187     C13     Sc08    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.047102981     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -6.64332145                                             0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
188     C14     Sc08    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.179752342     11.62151545     22.00870416
        101.4483754     0.108428766     82.03715428     52.60963029     34.34574479     1       52.60963029
        43.84135857     87.68271714     438.4135857     0.034500813     0.069001626     0.345008129     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236799318       0.268321951
        0.357964314     3       2       1       3       4
189     C15     Sc08    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.064553953     17.95680735     59.18869803
        20.48338339     0.29160088      57.25400315     35.33223555     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
190     C16     Sc08    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.274867302     20.9375858      102.2141214
        75.14665628     0.503571269     51.84349392     37.31653673     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
191     C17     Sc08    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.298891352     48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                             0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
192     C18     Sc08    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.172982893     32.71947943     114.7069548
        14.82699307     0.56511885      30.94565418     21.19640496     13.90560646     1       21.19640496
        17.6636708      35.32734161     176.636708      0.013900368     0.027800735     0.139003676     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190113744     0.227684645
        0.233011648     3       2       1       4       3
193     C19     Sc08    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.29629652      15.52703729     90.00070565
        38.18171179     0.443400275     64.92366836     48.53077421     29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
194     C20     Sc08    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.027875917     31.51644382     46.12331125
        19.64406076     0.227232539     25.97767972     16.81242372     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
195     C21     Sc08    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395       0.018576202
        0.070022144     0.486345111     45.50400288     0.176836132     9.029325069     48.98585736     89.96292202
        0.241335248     76.06476153     55.75425897     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
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196       C22       Sc08      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         44.998239 0.022850277         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -19.00288766        1         93.0707957          77.55899642
          155.1179928         775.5899642         0.061034797         0.122069594         0.61034797          0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.271597289         0.299179059         0.522974541
          3         2         1         5         2
197       C23       Sc08      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         46.98159204         0.149842815         39.76903222         32.83555671
          41.4875192          0.161768675         14.88947213         10.79949433         7.21255982          1         124.3995269
          103.6662724         207.3325448         1036.662724         0.081579832         0.163159664         0.815798319         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199983701         0.271108226
          0.563814225         3         2         1         5         3
198       C24       Sc08      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.03378582          33.25451259         101.091395
          38.46617124         0.49804001          18.86458484         12.92459909         10.03885165
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
199       C25       Sc08      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.04450599          22.39183764         108.0009528
          14.23314753         0.532080852         53.13248457         32.29658437         24.50163823         1         32.29658437
          26.91382031         53.82764061         269.1382031         0.021179742         0.042359485         0.211797423         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.248854607         0.228593923
          0.336203143         2         3         1         5         5
200       C01       Sc09      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.174397961         16.09475155         6.870223806
          22.2596509          0.033847058         54.36661906         42.5957647          27.91552745         1         42.5957647
          35.49647058         70.99294117         354.9647058         0.027488581         0.054977163         0.274885813         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.16901582          0.165206982
          0.26911197          2         3         1         1         1
201       C02       Sc09      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.010370493         36.78293892         34.9928391          3.448308502
          0.172396809         14.2673654          9.656077715         8.14083227                                                    0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
202       C03       Sc09      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.219864991         38.68279349         85.51575292
          55.36183542         0.421304567         17.38755155         11.50613756         7.31625241          1         63.99313913
          53.32761594         106.6552319         533.2761594         0.041297078         0.082594156         0.412970778         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.227259371         0.240265659
          0.383490145         3         2         1         1         3
203       C04       Sc09      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.174128957         3.83597854          3.698785078
          85.97992038         0.01822255          92.36086687         64.46111271         42.25345504
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
204       C05       Sc09      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.168147121         25.57658235         25.26080431
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          50.3295197          0.124450664         50.65642155         31.68995608         20.86424576
                   0          0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
205       C06       Sc09      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.132133928         16.08025417         7.109863301
          57.96001621         0.035027674         63.47118965         40.42725426         27.41156624
                   0          0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
206       C07       Sc09      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.081859454         48.2051179          36.53268887
          2.665127499         0.179983081         0         0         -4.36085524                                                           0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
207       C08       Sc09      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.247708387         11.98573101         78.84076537
          58.18750434         0.388419366         76.33499509         52.48700157         32.83781904
                   0          0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
208       C09       Sc09      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.119861869         5.541612561         37.21620286
          111.3518603         0.183350502         90.68445466         58.80696361         40.33139339         1         154.9580324
          129.1316937         258.2633873         1291.316937         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
209       C10       Sc09      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.10673091          65.61023925         69.4442434
          100.7044175         0.342126169         0         0         -22.08804665                                                          0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
210       C11       Sc09      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.248453533         39.57827842         9.30900598
          86.56844337         0.045862038         10.20561746         6.201400644         3.87822105          1         56.28473262
          46.90394385         93.80788769         469.0394385         0.036322565         0.072645131         0.363225654         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261356199         0.254155925
          0.390368337         2         3         1         3         1
211       C12       Sc09      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.211656838         6.070591495         102.6475506
          13.89093305         0.505706614         91.56246866         60.92569413         38.93713794         1         60.92569413
          50.77141177         101.5428235         507.7141177         0.039317545         0.07863509          0.39317545          0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226073611         0.246257489
          0.383180133         3         2         1         3         2
212       C13       Sc09      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.053831978         50.54486886         16.75770835
          105.7477489         0.082559047         0         0         -6.64332145                                                           0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
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213     C14     Sc09    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.205431249     11.62151545     22.00870416
        101.4483754     0.108428766     83.47159941     53.52952601     34.34574479     1       53.52952601
        44.60793834     89.21587669     446.0793834     0.034544531     0.069089063     0.345445313     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236821177       0.268365669
        0.358182907     3       2       1       3       4
214     C15     Sc09    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.073775946     17.95680735     59.18869803
        20.48338339     0.29160088      58.02479073     35.8078992      25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
215     C16     Sc09    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.314134059     20.9375858      102.2141214
        75.14665628     0.503571269     52.84455401     38.03709186     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
216     C17     Sc09    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.341590117     48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                             0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
217     C18     Sc09    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.197694735     32.71947943     114.7069548
        14.82699307     0.56511885      31.4817692      21.56362004     13.90560646     1       21.56362004
        17.96968337     35.93936674     179.6968337     0.013915781     0.027831561     0.139157807     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.19012145      0.227700058
        0.233088713     3       2       1       4       3
218     C19     Sc09    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.338624594     15.52703729     90.00070565
        38.18171179     0.443400275     66.19872074     49.48388238     29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
219     C20     Sc09    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.031858191     31.51644382     46.12331125
        19.64406076     0.227232539     26.25407603     16.99130389     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
220     C21     Sc09    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395       0.018576202
        0.070022144     0.486345111     45.50400288     0.202098436     9.029325069     48.98585736     89.96292202
        0.241335248     77.38955584     56.72531211     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
221     C22     Sc09    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.026114602       64.00112666     84.62593646
        96.89993412     0.41692077      0       0       -19.00288766    1       94.76240397     78.96866997
        157.9373399     789.6866997     0.061153593     0.122307185     0.611535927     0.273632139     0.256849416
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        0.255171744     0.482159781     0.476288524     0.435601111     0.271656687     0.299297855     0.523568519
        3       2       1       5       2
222     C23     Sc09    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.171248931     39.76903222     32.83555671
        41.4875192      0.161768675     15.13855549     10.98015718     7.21255982      1       126.333188
        105.2776566     210.5553133     1052.776566     0.081527357     0.163054714     0.815273568     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199957463     0.271055751
        0.56355185      3       2       1       5       3
223     C24     Sc09    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.038612366     33.25451259     101.091395
        38.46617124     0.49804001      19.07673039     13.06994531     10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
224     C25     Sc09    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.050863989     22.39183764     108.0009528
        14.23314753     0.532080852     53.77837981     32.68919184     24.50163823     1       32.68919184
        27.2409932      54.48198639     272.409932      0.021095513     0.042191026     0.21095513      0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248812492     0.228509694
        0.335781997     2       3       1       5       5
225     C01     Sc10    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.196197706     16.09475155     6.870223806
        22.2596509      0.033847058     55.19661429     43.24605862     27.91552745     1       43.24605862
        36.03838218     72.07676437     360.3838218     0.027503263     0.055006527     0.275032633     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169023161     0.165221664
        0.26918538      2       3       1       1       1
226     C02     Sc10    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      44.92377119     0.011666804     36.78293892     34.9928391      3.448308502
        0.172396809     14.36654045     9.723198867     8.14083227                                              0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
227     C03     Sc10    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.247348115     38.68279349     85.51575292
        55.36183542     0.421304567     17.66802232     11.69173789     7.31625241      1       65.04914391
        54.20761993     108.4152399     542.0761993     0.041369405     0.082738811     0.413694054     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227295535     0.240337987
        0.383851784     3       2       1       1       3
228     C04     Sc10    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.195895077     3.83597854      3.698785078
        85.97992038     0.01822255      93.7703815      65.44485057     42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
229     C05     Sc10    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.189165511     25.57658235     25.26080431
        50.3295197      0.124450664     51.42298108     32.16950512     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
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230       C06       Sc10      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.148650669         16.08025417         7.109863301
          57.96001621         0.035027674         64.37639299         41.00381325         27.41156624
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
231       C07       Sc10      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.092091885         48.2051179          36.53268887
          2.665127499         0.179983081         0         0         -4.36085524                                                           0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
232       C08       Sc10      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.278671935         11.98573101         78.84076537
          58.18750434         0.388419366         77.6008765          53.35740602         32.83781904
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
233       C09       Sc10      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.134844603         5.541612561         37.21620286
          111.3518603         0.183350502         91.9465105          59.62538031         40.33139339         1         157.239736
          131.0331133         262.0662267         1310.331133         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
234       C10       Sc10      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.120072274         65.61023925         69.4442434
          100.7044175         0.342126169         0         0         -22.08804665                                                          0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
235       C11       Sc10      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.279510225         39.57827842         9.30900598
          86.56844337         0.045862038         10.3749767          6.304311078         3.87822105          1         57.0313232
          47.52610267         95.05220533         475.2610267         0.0362703 0.072540599         0.362702995         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261330066         0.254103659
          0.390107008         2         3         1         3         1
236       C12       Sc10      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.238113942         6.070591495         102.6475506
          13.89093305         0.505706614         93.02629761         61.89972635         38.93713794         1         61.89972635
          51.58310529         103.1662106         515.8310529         0.039366465         0.078732931         0.393664655         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226098071         0.246306409
          0.383424735         3         2         1         3         2
237       C13       Sc10      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.060560975         50.54486886         16.75770835
          105.7477489         0.082559047         0         0         -6.64332145                                                           0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
238       C14       Sc10      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.231110155         11.62151545         22.00870416
          101.4483754         0.108428766         84.79672234         54.37931448         34.34574479         1         54.37931448
          45.3160954          90.6321908          453.160954          0.034583697         0.069167395         0.345836974         0.254748757
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        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.23684076      0.268404836
        0.358378737     3       2       1       3       4
239     C15     Sc10    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.08299794      17.95680735     59.18869803
        20.48338339     0.29160088      58.73683501     36.24731156     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
240     C16     Sc10    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.353400817     20.9375858      102.2141214
        75.14665628     0.503571269     53.76932119     38.70273195     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
241     C17     Sc10    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.384288882     48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                     0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
242     C18     Sc10    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.222406577     32.71947943     114.7069548
        14.82699307     0.56511885      31.97702573     21.90284888     13.90560646     1       21.90284888
        18.25237406     36.50474813     182.5237406     0.013929589     0.027859178     0.139295889     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190128354     0.227713866
        0.233157754     3       2       1       4       3
243     C19     Sc10    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.380952668     15.52703729     90.00070565
        38.18171179     0.443400275     67.37659864     50.36435213     29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
244     C20     Sc10    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.035840465     31.51644382     46.12331125
        19.64406076     0.227232539     26.50940758     17.15655122     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
245     C21     Sc10    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.227360741     9.029325069     48.98585736     89.96292202
        0.241335248     78.61338479     57.62235924     36.47467781                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
246     C22     Sc10    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.029378927     64.00112666     84.62593646
        96.89993412     0.41692077      0       0       -19.00288766    1       96.3250912      80.27090933
        160.5418187     802.7090933     0.061260018     0.122520037     0.612600184     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.2717099 0.299404281     0.524100648     3
        2       1       5       2
247     C23     Sc10    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.192655047     39.76903222     32.83555671
        41.4875192      0.161768675     15.36865568     11.14705132     7.21255982      1       128.1194806
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         106.7662339     213.5324677     1067.662339     0.081480346     0.162960692     0.814803458     0.126338191
         0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199933958     0.27100874
         0.563316795     3         2         1         5         3
248      C24       Sc10      C24       0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
         0.92480797      0.26329677      0.065961091     43.29336424     0.043438912     33.25451259     101.091395
         38.46617124     0.49804001      19.27270787     13.20421439     10.03885165
                   0     0         0     0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
         0.377206528     0.204296641     0.204256539     0.188603264     1         2         3         5         4
249      C25       Sc10      C25       0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
         0.234362086     0.616778357     0.949016321     46.89347587     0.057221987     22.39183764     108.0009528
         14.23314753     0.532080852     54.3750499      33.05187779     24.50163823     1         33.05187779
         27.54323149     55.08646299     275.4323149     0.021020054     0.042040108     0.210200542     0.297089204
         0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248774763     0.228434235
         0.335404703     2         3         1         5         5
250      C01       Sc11      C01       0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
         0.092338595     0.186260211     0.345560727     44.010279 0.217997451     16.09475155     6.870223806
         22.2596509      0.033847058     55.97017677     43.85213797     27.91552745     1         43.85213797
         36.54344831     73.08689662     365.4344831     0.027516569     0.055033137     0.275165686     0.125908042
         0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169029813     0.165234969
         0.269251906     2         3         1         1         1
251      C02       Sc11      C02       0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
         0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     34.9928391      3.448308502
         0.172396809     14.4589725      9.78575639      8.14083227                                                      0
         0         0     0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
         0.222682445     0.189169138     0.193388639     1         3         2         1         2
252      C03       Sc11      C03       0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
         0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     85.51575292
         55.36183542     0.421304567     17.92942341     11.86471894     7.31625241      1         66.03334916
         55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
         0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
         0.384179511     3         2         1         1         3
253      C04       Sc11      C04       0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
         0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      3.698785078
         85.97992038     0.01822255      95.08406081     66.3617024      42.25345504
                   0     0         0     0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
         0.3266149 0.203942249     0.189644971     0.16330745      1         2         3         1         4
254      C05       Sc11      C05       0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
         0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     25.26080431
         50.3295197      0.124450664     52.13742096     32.61644881     20.86424576
                   0     0         0     0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
         0.365064068     0.222546725     0.225752801     0.182532034     2         1         3         1         5
255      C06       Sc11      C06       0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
         0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     7.109863301
         57.96001621     0.035027674     65.22005008     41.54117107     27.41156624
                   0     0         0     0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
         0.410044838     0.212181782     0.203205018     0.205022419     1         3         2         2         1
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256       C07       Sc11      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         48.2051179          36.53268887
          2.665127499         0.179983081         0         0         -4.36085524                                                           0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
257       C08       Sc11      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         11.98573101         78.84076537
          58.18750434         0.388419366         78.78068852         54.16863022         32.83781904
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
258       C09       Sc11      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         5.541612561         37.21620286
          111.3518603         0.183350502         93.12275706         60.3881515          40.33139339         1         159.3663027
          132.8052523         265.6105045         1328.052523         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
259       C10       Sc11      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         65.61023925         69.4442434
          100.7044175         0.342126169         0         0         -22.08804665                                                          0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
260       C11       Sc11      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         9.30900598
          86.56844337         0.045862038         10.53282093         6.400224457         3.87822105          1         57.72715192
          48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
          0.389870185         2         3         1         3         1
261       C12       Sc11      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         6.070591495         102.6475506
          13.89093305         0.505706614         94.39059844         62.80753253         38.93713794         1         62.80753253
          52.33961044         104.6792209         523.3961044         0.039410799         0.078821597         0.394107986         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226120238         0.246350742
          0.383646401         3         2         1         3         2
262       C13       Sc11      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         16.75770835
          105.7477489         0.082559047         0         0         -6.64332145                                                           0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
263       C14       Sc11      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         11.62151545         22.00870416
          101.4483754         0.108428766         86.03174795         55.17132441         34.34574479         1         55.17132441
          45.97610368         91.95220735         459.7610368         0.034619191         0.069238382         0.346191908         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236858507         0.268440329
          0.358556204         3         2         1         3         4
264       C15       Sc11      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         17.95680735         59.18869803
          20.48338339         0.29160088          59.40046614         36.65684749         25.88826616
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                 0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
         0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
265      C16       Sc11      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
         0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         20.9375858          102.2141214
         75.14665628         0.503571269         54.63121188         39.32311405         23.01041848
                 0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
         0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
266      C17       Sc11      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
         0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         89.95873932
         3.56627786          0.443193522         0         0         -1.91148136                                                          0
         0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
         0.195078226         0.211045796         0.212449365         3         2         1         4         2
267      C18       Sc11      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
         0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         114.7069548
         14.82699307         0.56511885          32.43860895         22.21901297         13.90560646         1         22.21901297
         18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
         0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
         0.233220321         3         2         1         4         3
268      C19       Sc11      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
         0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         15.52703729         90.00070565
         38.18171179         0.443400275         68.47439068         51.1849573          29.60747804
                 0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
         0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
269      C20       Sc11      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
         0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         31.51644382         46.12331125
         19.64406076         0.227232539         26.74737871         17.31056311         13.26088315
                 0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
         0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
270      C21       Sc11      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
         0.070022144         0.486345111         45.50400288         0.252623045         9.029325069         48.98585736         89.96292202
         0.241335248         79.75400352         58.45841461         36.47467781                                                          0
         0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
         0.184443254         0.17732464          0.165746932         1         2         3         5         1
271      C22       Sc11      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
         0.380141173         0.550948219         0.745334431         44.998239 0.032643252         64.00112666         84.62593646
         96.89993412         0.41692077          0         0         -19.00288766        1         97.78152866         81.48460722
         162.9692144         814.8460722         0.061356464         0.122712929         0.613564643         0.273632139         0.256849416
         0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
         3         2         1         5         2
272      C23       Sc11      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
         0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         32.83555671
         41.4875192          0.161768675         15.58311099         11.30259806         7.21255982          1         129.7843202
         108.1536002         216.3072004         1081.536002         0.081437743         0.162875486         0.814377431         0.126338191
         0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
         0.563103781         3         2         1         5         3
273      C24       Sc11      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
         0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         101.091395
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        38.46617124     0.49804001      19.45536051     13.32935429     10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
274     C25     Sc11    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     108.0009528
        14.23314753     0.532080852     54.93115148     33.38990418     24.50163823     1       33.38990418
        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
        0.335062789     2       3       1       5       5
275     C01     Sc12    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.239797196       16.09475155     6.870223806
        22.2596509      0.033847058     56.69626181     44.42101917     27.91552745     1       44.42101917
        37.01751597     74.03503195     370.1751597     0.027528738     0.055057476     0.275287382     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169035898     0.165247139
        0.269312754     2       3       1       1       1
276     C02     Sc12    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225    0.878117436
        0.027387593     0.67046751      44.92377119     0.014259428     36.78293892     34.9928391      3.448308502
        0.172396809     14.54573152     9.844474439     8.14083227                                      0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
277     C03     Sc12    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.302314363     38.68279349     85.51575292
        55.36183542     0.421304567     18.174781 12.02708327   7.31625241      1       66.95714877     55.79762397
        111.5952479     557.9762397     0.041494902     0.082989803     0.414949015     0.25038454      0.237553697
        0.192031501     0.413221665     0.397937162     0.354009513     0.227358283     0.240463483     0.384479264
        3       2       1       1       3
278     C04     Sc12    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.239427316     3.83597854      3.698785078
        85.97992038     0.01822255      96.31711303     67.22228244     42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
279     C05     Sc12    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.231202291     25.57658235     25.26080431
        50.3295197      0.124450664     52.80801205     33.03596132     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
280     C06     Sc12    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.181684152     16.08025417     7.109863301
        57.96001621     0.035027674     66.01192763     42.04554849     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
281     C07     Sc12    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.112556749     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -4.36085524                                     0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
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282	C08	Sc12	C08	0.574117605	0.146728575	0.589305537	0.69975836	0.102334429
	0.414055988	0.694400158	0.41417927	44.82355005	0.340599031	11.98573101	78.84076537
	58.18750434	0.388419366	79.88808952	54.93006549	32.83781904
		0	0	0	0.195954796	0.182760584	0.225479264	0.378522006	0.365489003
	0.396290772	0.189261003	0.182744501	0.198145386	2	3	1	2	3
283	C09	Sc12	C09	0.049953459	0.535896406	0.663794645	0.514889112	0.944594756
	0.586555041	0.903401915	0.137474704	45.87300595	0.164810071	5.541612561	37.21620286
	111.3518603	0.183350502	94.22681143	61.10410755	40.33139339	1	161.3623513
	134.4686261	268.9372522	1344.686261	0.1	0.2	1	0.178780994	0.232017403
	0.229727169	0.392146196	0.44667726	0.432078559	0.246073098	0.32333863	0.716039279
	3	2	1	2	4
284	C10	Sc12	C10	0.139276347	0.807391289	0.397676837	0.165354197	0.92750858
	0.34776586	0.750812103	0.725997985	43.5221926	0.146755001	65.61023925	69.4442434
	100.7044175	0.342126169	0	0	-22.08804665				0
	0	0	0.212063257	0.22017735	0.208648434	0.397570841	0.412858391	0.384413237
	0.19878542	0.206429195	0.192206618	2	1	3	2	5
285	C11	Sc12	C11	0.883306091	0.623672207	0.750942434	0.348898342	0.269927892
	0.895886218	0.42809119	0.964840047	43.45649947	0.341623608	39.57827842	9.30900598
	86.56844337	0.045862038	10.68097745	6.49025115	3.87822105	1	58.38027408
	48.6502284	97.3004568	486.502284	0.036179613	0.072359226	0.361796129	0.316867923
	0.266455347	0.264174875	0.486389832	0.435666719	0.417511021	0.261284722	0.254012973
	0.389653575	2	3	1	3	1
286	C12	Sc12	C12	0.663441498	0.62169572	0.114745973	0.949489259	0.449912133
	0.578389614	0.408136803	0.23702698	45.00772944	0.291028152	6.070591495	102.6475506
	13.89093305	0.505706614	95.67116522	63.65962205	38.93713794	1	63.65962205
	53.04968504	106.0993701	530.4968504	0.039451348	0.078902695	0.394513476	0.220522508
	0.224798251	0.197499161	0.412829677	0.413879887	0.373184816	0.226140512	0.246391291
	0.383849146	3	2	1	3	2
287	C13	Sc12	C13	0.903379521	0.573679487	0.002870327	0.617144914	0.326644902
	0.527058102	0.885942099	0.35726976	43.90154741	0.07401897	50.54486886	16.75770835
	105.7477489	0.082559047	0	0	-6.64332145				0
	0	0	0.221712208	0.223609096	0.217157743	0.387200912	0.389670791	0.373298543
	0.193600456	0.194835395	0.186649271	2	1	3	3	3
288	C14	Sc12	C14	0.908535151	0.623360116	0.015821243	0.929437234	0.690896918
	0.99732285	0.172340508	0.13713575	45.96726024	0.282467967	11.62151545	22.00870416
	101.4483754	0.108428766	87.1909738	55.91472469	34.34574479	1	55.91472469
	46.59560391	93.19120781	465.9560391	0.034651655	0.069303309	0.346516546	0.254748757
	0.280125362	0.188733628	0.439097823	0.467642276	0.3709205 0.236874739	0.268472793
	0.358718523	3	2	1	3	4
289	C15	Sc12	C15	0.932595463	0.696818161	0.066000173	0.755463053	0.753876188
	0.923024536	0.711524759	0.124270962	43.84507351	0.101441926	17.95680735	59.18869803
	20.48338339	0.29160088	60.02336688	37.04124812	25.88826616
		0	0	0	0.251517278	0.292575574	0.225051384	0.421654228	0.461972982
	0.38826343	0.210827114	0.230986491	0.194131715	2	1	3	3	5
290	C16	Sc12	C16	0.019880134	0.026210987	0.028306488	0.246211068	0.860027949
	0.538831064	0.552821979	0.842030892	43.94800428	0.431934331	20.9375858	102.2141214
	75.14665628	0.503571269	55.44020398	39.90542017	23.01041848
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291       C17       Sc12      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.469686411         48.74907317         89.95873932
          3.56627786          0.443193522         0         0         -1.91148136                                                           0
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292       C18       Sc12      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.271830261         32.71947943         114.7069548
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          18.76314373         37.52628747         187.6314373         0.013953548         0.027907095         0.139535476         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190140334         0.227737825
          0.233277548         3         2         1         4         3
293       C19       Sc12      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          45.13451533         0.465608817         15.52703729         90.00070565
          38.18171179         0.443400275         69.50480564         51.95519776         29.60747804
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          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
294       C20       Sc12      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         44.77732697         0.043805012         31.51644382         46.12331125
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          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
295       C21       Sc12      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         45.50400288         0.27788535          9.029325069         48.98585736         89.96292202
          0.241335248         80.82461675         59.24315706         36.47467781                                                           0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
296       C22       Sc12      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         44.998239 0.035907577         64.00112666         84.62593646
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          0.56290895          3         2         1         5         3
298       C24       Sc12      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
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        56.52439722     113.0487944     565.2439722     0.041550154     0.083100307     0.415501536     0.25038454
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        0.834625672     0.018288277     0.750144315     46.44082811     0.252220681     25.57658235     25.26080431
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        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
305     C06     Sc13    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
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        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
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        0.265546659     0.491573159     0.053362545     43.84426266     0.12278918      48.2051179      36.53268887
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        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
309     C10     Sc13    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.160096365     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                            0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
310     C11     Sc13    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.3726803 39.57827842       9.30900598
        86.56844337     0.045862038     10.82084701     6.575242297     3.87822105      1       58.99686452
        49.16405376     98.32810753     491.6405376     0.036139686     0.072279373     0.361396863     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261264759     0.253973046
        0.389453942     2       3       1       3       1
311     C12     Sc13    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.317485257     6.070591495     102.6475506
        13.89093305     0.505706614     96.88010489     64.46405087     38.93713794     1       64.46405087
        53.72004239     107.4400848     537.2004239     0.039488719     0.078977437     0.394887186     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226159198     0.246428662
        0.384036001     3       2       1       3       2
312     C13     Sc13    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.080747967     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -6.64332145                                             0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
313     C14     Sc13    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.308146873     11.62151545     22.00870416
        101.4483754     0.108428766     88.2853596      56.61654367     34.34574479     1       56.61654367
        47.18045306     94.36090612     471.8045306     0.034681574     0.069363148     0.346815741     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236889698       0.268502712
        0.358868121     3       2       1       3       4
314     C15     Sc13    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.110663919     17.95680735     59.18869803
        20.48338339     0.29160088      60.61142633     37.40414773     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
315     C16     Sc13    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.471201089     20.9375858      102.2141214
        75.14665628     0.503571269     56.203946 40.45515563       23.01041848
        0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
316     C17     Sc13    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.512385176     48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                             0
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317       C18       Sc13      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.296542102         32.71947943         114.7069548
          14.82699307         0.56511885          33.28088241         22.79593305         13.90560646         1         22.79593305
          18.99661088         37.99322176         189.9661088         0.013964096         0.027928192         0.139640958         0.168545737
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          0.233330289         3         2         1         4         3
318       C19       Sc13      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          45.13451533         0.507936891         15.52703729         90.00070565
          38.18171179         0.443400275         70.47758546         52.68235565         29.60747804
                    0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
319       C20       Sc13      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         44.77732697         0.047787286         31.51644382         46.12331125
          19.64406076         0.227232539         27.18161622         17.5915961          13.26088315
                    0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
320       C21       Sc13      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         45.50400288         0.303147654         9.029325069         48.98585736         89.96292202
          0.241335248         81.83534635         59.98400576         36.47467781                                                   0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
321       C22       Sc13      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         44.998239 0.039171903         64.00112666         84.62593646
          96.89993412         0.41692077          0         0         -19.00288766        1         100.4391614         83.69930116
          167.3986023         836.9930116         0.061525978         0.123051956         0.61525978          0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.271842879         0.29967024          0.525430446
          3         2         1         5         2
322       C23       Sc13      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         46.98159204         0.256873397         39.76903222         32.83555671
          41.4875192          0.161768675         15.97443806         11.5864318          7.21255982          1         132.8222344
          110.6851954         221.3703907         1106.851954         0.081362864         0.162725729         0.813628645         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199875217         0.270891258
          0.562729388         3         2         1         5         3
323       C24       Sc13      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.057918549         33.25451259         101.091395
          38.46617124         0.49804001          19.78865569         13.55770316         10.03885165
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
324       C25       Sc13      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.076295983         22.39183764         108.0009528
          14.23314753         0.532080852         55.94589716         34.0067174          24.50163823         1         34.0067174
          28.33893117         56.67786234         283.3893117         0.020831482         0.041662963         0.208314817         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.248680476         0.228245662
          0.33446184          2         3         1         5         5
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325     C01     Sc14    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.283396686     16.09475155     6.870223806
        22.2596509      0.033847058     58.03198663     45.46754775     27.91552745     1       45.46754775
        37.88962312     75.77924624     378.8962312     0.027550357     0.055100713     0.275503567     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169046708     0.165268758
        0.269420847     2       3       1       1       1
326     C02     Sc14    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      44.92377119     0.016852051     36.78293892     34.9928391      3.448308502
        0.172396809     14.70533561     9.952493641     8.14083227                                              0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
327     C03     Sc14    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.357280611     38.68279349     85.51575292
        55.36183542     0.421304567     18.62614718     12.3257729      7.31625241      1       68.65659445
        57.21382871     114.4276574     572.1382871     0.041601401     0.083202801     0.416014006     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227411533     0.240569982
        0.38501176      3       2       1       1       3
328     C04     Sc14    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.282959555     3.83597854      3.698785078
        85.97992038     0.01822255      98.58546778     68.80542772     42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
329     C05     Sc14    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.273239071     25.57658235     25.26080431
        50.3295197      0.124450664     54.04164877     33.80770737     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
330     C06     Sc14    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.214717634     16.08025417     7.109863301
        57.96001621     0.035027674     67.46868606     42.97341425     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
331     C07     Sc14    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.133021612     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -4.36085524                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
332     C08     Sc14    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.402526128     11.98573101     78.84076537
        58.18750434     0.388419366     81.92529308     56.33082155     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
333     C09     Sc14    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.194775538     5.541612561     37.21620286
        111.3518603     0.183350502     96.25785834     62.42119881     40.33139339     1       165.0343339
        137.5286116     275.0572232     1375.286116     0.1     0.2     1       0.178780994     0.232017403
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        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
334     C10     Sc14    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.173437729     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                            0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
335     C11     Sc14    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.403736991     39.57827842     9.30900598
        86.56844337     0.045862038     10.95353003     6.655866582     3.87822105      1       59.58177447
        49.65147873     99.30295746     496.5147873     0.036102654     0.072205308     0.36102654      0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261246243     0.253936014
        0.38926878      2       3       1       3       1
336     C12     Sc14    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.343942361     6.070591495     102.6475506
        13.89093305     0.505706614     98.02692899     65.22714797     38.93713794     1       65.22714797
        54.35595664     108.7119133     543.5595664     0.039523381     0.079046761     0.395233806     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226176529     0.246463324
        0.384209311     3       2       1       3       2
337     C13     Sc14    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.087476965     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -6.64332145                                             0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
338     C14     Sc14    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.333825779     11.62151545     22.00870416
        101.4483754     0.108428766     89.32351568     57.28230308     34.34574479     1       57.28230308
        47.73525257     95.47050514     477.3525257     0.034709325     0.06941865      0.347093249     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236903574       0.268530463
        0.359006874     3       2       1       3       4
339     C15     Sc14    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.119885913     17.95680735     59.18869803
        20.48338339     0.29160088      61.16927125     37.74840153     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
340     C16     Sc14    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.510467846     20.9375858      102.2141214
        75.14665628     0.503571269     56.92844681     40.97664558     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
341     C17     Sc14    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.55508394      48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                             0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
342     C18     Sc14    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.321253945     32.71947943     114.7069548
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        14.82699307     0.56511885      33.66888687     23.06169895     13.90560646     1       23.06169895
        19.21808246     38.43616492     192.1808246     0.013973879     0.027947759     0.139738795     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.1901505 0.227758156
        0.233379207     3       2       1       4       3
343     C19     Sc14    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.550264966     15.52703729     90.00070565
        38.18171179     0.443400275     71.40038372     53.37215206     29.60747804
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        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
344     C20     Sc14    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.051769561     31.51644382     46.12331125
        19.64406076     0.227232539     27.38165357     17.72105772     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
345     C21     Sc14    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.328409959     9.029325069     48.98585736     89.96292202
        0.241335248     82.79414453     60.68678955     36.47467781                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
346     C22     Sc14    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.042436228       64.00112666     84.62593646
        96.89993412     0.41692077      0       0       -19.00288766    1       101.6634351     84.71952928
        169.4390586     847.1952928     0.061601385     0.12320277      0.616013848     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271880583     0.299745647     0.52580748
        3       2       1       5       2
347     C23     Sc14    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.278279513     39.76903222     32.83555671
        41.4875192      0.161768675     16.15470806     11.71718357     7.21255982      1       134.22169 111.8514083
        223.7028167     1118.514083     0.081329555     0.162659111     0.813295554     0.126338191     0.188706502
        0.135993177     0.31838757      0.379056788     0.311830131     0.199858563     0.270857949     0.562562843
        3       2       1       5       3
348     C24     Sc14    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.062745095     33.25451259     101.091395
        38.46617124     0.49804001      19.94219255     13.6628951      10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
349     C25     Sc14    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.082653982     22.39183764     108.0009528
        14.23314753     0.532080852     56.41335324     34.29086062     24.50163823     1       34.29086062
        28.57571718     57.15143436     285.7571718     0.020778016     0.041556032     0.207780162     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248653744     0.228192197
        0.334194513     2       3       1       5       5
350     C01     Sc15    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451       16.09475155     6.870223806
        15.58175563     0.033847058     55.97017677     43.85213797     27.91552745     1       43.85213797
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        0.269251906     2       3       1       1       1
351     C02     Sc15    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     34.9928391      2.413815951
        0.172396809     14.4589725      9.78575639      8.14083227                                                    0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
352     C03     Sc15    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     85.51575292
        38.75328479     0.421304567     17.92942341     11.86471894     7.31625241      1       66.03334916
        55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
        0.384179511     3       2       1       1       3
353     C04     Sc15    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      3.698785078
        60.18594426     0.01822255      95.08406081     66.3617024      42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
354     C05     Sc15    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     25.26080431
        35.23066379     0.124450664     52.13742096     32.61644881     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
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355     C06     Sc15    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     7.109863301
        40.57201135     0.035027674     65.22005008     41.54117107     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
356     C07     Sc15    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      36.53268887
        1.865589249     0.179983081     0       0       -4.36085524                                                   0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
357     C08     Sc15    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     78.84076537
        40.73125304     0.388419366     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
358     C09     Sc15    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     37.21620286
        77.94630218     0.183350502     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
359     C10     Sc15    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        70.49309225     0.342126169     0       0       -22.08804665                                                  0
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          0.19878542          0.206429195         0.192206618         2         1         3         2         5
360       C11       Sc15      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         9.30900598
          60.59791036         0.045862038         10.53282093         6.400224457         3.87822105          1         57.72715192
          48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
          0.389870185         2         3         1         3         1
361       C12       Sc15      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         6.070591495         102.6475506
          9.723653134         0.505706614         94.39059844         62.80753253         38.93713794         1         62.80753253
          52.33961044         104.6792209         523.3961044         0.039410799         0.078821597         0.394107986         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226120238         0.246350742
          0.383646401         3         2         1         3         2
362       C13       Sc15      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         16.75770835
          74.02342422         0.082559047         0         0         -6.64332145                                                       0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
363       C14       Sc15      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         11.62151545         22.00870416
          71.01386276         0.108428766         86.03174795         55.17132441         34.34574479         1         55.17132441
          45.97610368         91.95220735         459.7610368         0.034619191         0.069238382         0.346191908         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236858507         0.268440329
          0.358556204         3         2         1         3         4
364       C15       Sc15      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         17.95680735         59.18869803
          14.33836837         0.29160088          59.40046614         36.65684749         25.88826616
                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
365       C16       Sc15      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         20.9375858          102.2141214
          52.60265939         0.503571269         54.63121188         39.32311405         23.01041848
                    0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
366       C17       Sc15      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         89.95873932
          2.496394502         0.443193522         0         0         -1.91148136                                                       0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
367       C18       Sc15      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         114.7069548
          10.37889515         0.56511885          32.43860895         22.21901297         13.90560646         1         22.21901297
          18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
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368     C19     Sc15    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     90.00070565
        26.72719825     0.443400275     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
369     C20     Sc15    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        13.75084253     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
370     C21     Sc15    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     62.97404541
        0.241335248     79.75400352     58.45841461     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
371     C22     Sc15    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     84.62593646
        67.82995388     0.41692077      0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
372     C23     Sc15    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     32.83555671
        29.04126344     0.161768675     15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
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373     C24     Sc15    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     101.091395
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        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
374     C25     Sc15    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
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        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
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375     C01     Sc16    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
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        44.28946833       0.421304567       17.92942341       11.86471894       7.31625241        1         66.03334916
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378     C04       Sc16      C04       0.876389152       0.894606664       0.085044211       0.039054783       0.16983042
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        0.3266149 0.203942249       0.189644971       0.16330745        1         2         3         1         4
379     C05       Sc16      C05       0.95788953        0.533165285       0.691877114       0.315515631       0.686500928
        0.834625672       0.018288277       0.750144315       46.44082811       0.210183901       25.57658235       25.26080431
        40.26361576       0.124450664       52.13742096       32.61644881       20.86424576
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        0.365064068       0.222546725       0.225752801       0.182532034       2         1         3         1         5
380     C06       Sc16      C06       0.988861089       0.748165654       0.280443992       0.789279328       0.103226007
        0.447893526       0.908595503       0.293614148       43.49182041       0.165167411       16.08025417       7.109863301
        46.36801297       0.035027674       65.22005008       41.54117107       27.41156624
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        0.410044838       0.212181782       0.203205018       0.205022419       1         3         2         2         1
381     C07       Sc16      C07       0.287775339       0.130028572       0.019366958       0.678835533       0.211628116
        0.265546659       0.491573159       0.053362545       43.84426266       0.102324317       48.2051179        36.53268887
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        0.168102684       0.166496609       0.169732566       2         3         1         2         2
382     C08       Sc16      C08       0.574117605       0.146728575       0.589305537       0.69975836        0.102334429
        0.414055988       0.694400158       0.41417927        44.82355005       0.309635483       11.98573101       78.84076537
        46.55000347       0.388419366       78.78068852       54.16863022       32.83781904
                  0         0         0         0.195954796       0.182760584       0.225479264       0.378522006       0.365489003
        0.396290772       0.189261003       0.182744501       0.198145386       2         3         1         2         3
383     C09       Sc16      C09       0.049953459       0.535896406       0.663794645       0.514889112       0.944594756
        0.586555041       0.903401915       0.137474704       45.87300595       0.149827337       5.541612561       37.21620286
        89.08148821       0.183350502       93.12275706       60.3881515        40.33139339       1         159.3663027
        132.8052523       265.6105045       1328.052523       0.1       0.2       1         0.178780994       0.232017403
        0.229727169       0.392146196       0.44667726        0.432078559       0.246073098       0.32333863        0.716039279
        3         2         1         2         4
384     C10       Sc16      C10       0.139276347       0.807391289       0.397676837       0.165354197       0.92750858
        0.34776586        0.750812103       0.725997985       43.5221926        0.133413638       65.61023925       69.4442434
        80.563534 0.342126169       0         0         -22.08804665                                      0         0
        0         0.212063257       0.22017735        0.208648434       0.397570841       0.412858391       0.384413237
        0.19878542        0.206429195       0.192206618       2         1         3         2         5
385     C11       Sc16      C11       0.883306091       0.623672207       0.750942434       0.348898342       0.269927892
        0.895886218       0.42809119        0.964840047       43.45649947       0.310566916       39.57827842       9.30900598
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          0.383646401         3         2         1         3         2
387       C13       Sc16      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         16.75770835
          84.59819911         0.082559047         0         0         -6.64332145                                                       0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
388       C14       Sc16      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         11.62151545         22.00870416
          81.15870029         0.108428766         86.03174795         55.17132441         34.34574479         1         55.17132441
          45.97610368         91.95220735         459.7610368         0.034619191         0.069238382         0.346191908         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236858507         0.268440329
          0.358556204         3         2         1         3         4
389       C15       Sc16      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         17.95680735         59.18869803
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                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
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391       C17       Sc16      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         89.95873932
          2.853022288         0.443193522         0         0         -1.91148136                                                       0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
392       C18       Sc16      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         114.7069548
          11.86159446         0.56511885          32.43860895         22.21901297         13.90560646         1         22.21901297
          18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
          0.233220321         3         2         1         4         3
393       C19       Sc16      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         15.52703729         90.00070565
          30.54536943         0.443400275         68.47439068         51.1849573          29.60747804
                    0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
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394     C20     Sc16    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        15.71524861     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
395     C21     Sc16    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     71.97033762
        0.241335248     79.75400352     58.45841461     36.47467781                                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
396     C22     Sc16    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     84.62593646
        77.51994729     0.41692077      0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
397     C23     Sc16    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     32.83555671
        33.19001536     0.161768675     15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
        0.563103781     3       2       1       5       3
398     C24     Sc16    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     101.091395
        30.772937 0.49804001    19.45536051     13.32935429     10.03885165
        0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
399     C25     Sc16    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     108.0009528
        11.38651802     0.532080852     54.93115148     33.38990418     24.50163823     1       33.38990418
        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
        0.335062789     2       3       1       5       5
400     C01     Sc17    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451     16.09475155     6.870223806
        20.03368581     0.033847058     55.97017677     43.85213797     27.91552745     1       43.85213797
        36.54344831     73.08689662     365.4344831     0.027516569     0.055033137     0.275165686     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169029813     0.165234969
        0.269251906     2       3       1       1       1
401     C02     Sc17    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     34.9928391      3.103477651
        0.172396809     14.4589725      9.78575639      8.14083227                                                      0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
402     C03     Sc17    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     85.51575292
        49.82565187     0.421304567     17.92942341     11.86471894     7.31625241      1       66.03334916
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          55.02779097         110.0555819         550.2779097         0.041434951         0.082869902         0.414349508         0.25038454
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          0.384179511         3         2         1         1         3
403       C04       Sc17      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         3.83597854          3.698785078
          77.38192834         0.01822255          95.08406081         66.3617024          42.25345504
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
404       C05       Sc17      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         25.57658235         25.26080431
          45.29656773         0.124450664         52.13742096         32.61644881         20.86424576
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
405       C06       Sc17      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         16.08025417         7.109863301
          52.16401459         0.035027674         65.22005008         41.54117107         27.41156624
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
406       C07       Sc17      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         48.2051179          36.53268887
          2.398614749         0.179983081         0         0         -4.36085524                                                           0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
407       C08       Sc17      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         11.98573101         78.84076537
          52.36875391         0.388419366         78.78068852         54.16863022         32.83781904
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
408       C09       Sc17      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         5.541612561         37.21620286
          100.2166742         0.183350502         93.12275706         60.3881515          40.33139339         1         159.3663027
          132.8052523         265.6105045         1328.052523         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
409       C10       Sc17      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         65.61023925         69.4442434
          90.63397576         0.342126169         0         0         -22.08804665                                                          0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
410       C11       Sc17      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         9.30900598
          77.91159903         0.045862038         10.53282093         6.400224457         3.87822105          1         57.72715192
          48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
          0.389870185         2         3         1         3         1
411       C12       Sc17      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
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        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
412     C13     Sc17    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     16.75770835
        95.17297399     0.082559047     0       0       -6.64332145                                     0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
413     C14     Sc17    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        91.30353783     0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507       0.268440329
        0.358556204     3       2       1       3       4
414     C15     Sc17    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        18.43504505     0.29160088      59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
415     C16     Sc17    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      102.2141214
        67.63199065     0.503571269     54.63121188     39.32311405     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
416     C17     Sc17    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     89.95873932
        3.209650074     0.443193522     0       0       -1.91148136                                     0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
417     C18     Sc17    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     114.7069548
        13.34429377     0.56511885      32.43860895     22.21901297     13.90560646     1       22.21901297
        18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
        0.233220321     3       2       1       4       3
418     C19     Sc17    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     90.00070565
        34.36354061     0.443400275     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
419     C20     Sc17    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        17.67965468     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
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420     C21     Sc17    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     80.96662982
        0.241335248     79.75400352     58.45841461     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
421     C22     Sc17    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252       64.00112666     84.62593646
        87.2099407      0.41692077      0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
422     C23     Sc17    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     32.83555671
        37.33876728     0.161768675     15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
        0.563103781     3       2       1       5       3
423     C24     Sc17    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     101.091395
        34.61955412     0.49804001      19.45536051     13.32935429     10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
424     C25     Sc17    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     108.0009528
        12.80983278     0.532080852     54.93115148     33.38990418     24.50163823     1       33.38990418
        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
        0.335062789     2       3       1       5       5
425     C01     Sc18    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451       16.09475155     6.870223806
        22.2596509      0.033847058     55.97017677     43.85213797     27.91552745     1       43.85213797
        36.54344831     73.08689662     365.4344831     0.027516569     0.055033137     0.275165686     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169029813     0.165234969
        0.269251906     2       3       1       1       1
426     C02     Sc18    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     34.9928391      3.448308502
        0.172396809     14.4589725      9.78575639      8.14083227                                              0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
427     C03     Sc18    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     85.51575292
        55.36183542     0.421304567     17.92942341     11.86471894     7.31625241      1       66.03334916
        55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
        0.384179511     3       2       1       1       3
428     C04     Sc18    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      3.698785078
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        85.97992038     0.01822255      95.08406081     66.3617024      42.25345504
                  0     0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
429     C05     Sc18    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     25.26080431
        50.3295197      0.124450664     52.13742096     32.61644881     20.86424576
                  0     0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
430     C06     Sc18    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     7.109863301
        57.96001621     0.035027674     65.22005008     41.54117107     27.41156624
                  0     0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
431     C07     Sc18    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -4.36085524                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
432     C08     Sc18    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     78.84076537
        58.18750434     0.388419366     78.78068852     54.16863022     32.83781904
                  0     0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
433     C09     Sc18    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     37.21620286
        111.3518603     0.183350502     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
434     C10     Sc18    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                            0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
435     C11     Sc18    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     9.30900598
        86.56844337     0.045862038     10.53282093     6.400224457     3.87822105      1       57.72715192
        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
436     C12     Sc18    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.070591495     102.6475506
        13.89093305     0.505706614     94.39059844     62.80753253     38.93713794     1       62.80753253
        52.33961044     104.6792209     523.3961044     0.039410799     0.078821597     0.394107986     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
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437     C13     Sc18    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -6.64332145                                             0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
438     C14     Sc18    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        101.4483754     0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507       0.268440329
        0.358556204     3       2       1       3       4
439     C15     Sc18    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        20.48338339     0.29160088      59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
440     C16     Sc18    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      102.2141214
        75.14665628     0.503571269     54.63121188     39.32311405     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
441     C17     Sc18    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     89.95873932
        3.56627786      0.443193522     0       0       -1.91148136                                             0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
442     C18     Sc18    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     114.7069548
        14.82699307     0.56511885      32.43860895     22.21901297     13.90560646     1       22.21901297
        18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
        0.233220321     3       2       1       4       3
443     C19     Sc18    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     90.00070565
        38.18171179     0.443400275     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
444     C20     Sc18    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        19.64406076     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
445     C21     Sc18    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395       0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     89.96292202
        0.241335248     79.75400352     58.45841461     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
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446	C22	Sc18	C22	0.606329462	0.568851437	0.317362409	0.988616154	0.579745219
	0.380141173	0.550948219	0.745334431	44.998239 0.032643252	64.00112666	84.62593646
	96.89993412	0.41692077	0	0	-19.00288766	1	97.78152866	81.48460722
	162.9692144	814.8460722	0.061356464	0.122712929	0.613564643	0.273632139	0.256849416
	0.255171744	0.482159781	0.476288524	0.435601111	0.271758123	0.299500727	0.524582877
	3	2	1	5	2
447	C23	Sc18	C23	0.669232893	0.264919558	0.066334834	0.370084198	0.629717507
	0.21017401	0.752755554	0.066536481	46.98159204	0.214061164	39.76903222	32.83555671
	41.4875192	0.161768675	15.58311099	11.30259806	7.21255982	1	129.7843202
	108.1536002	216.3072004	1081.536002	0.081437743	0.162875486	0.814377431	0.126338191
	0.188706502	0.135993177	0.31838757	0.379056788	0.311830131	0.199912657	0.270966137
	0.563103781	3	2	1	5	3
448	C24	Sc18	C24	0.260315099	0.804754564	0.193434283	0.639460881	0.524670309
	0.92480797	0.26329677	0.065961091	43.29336424	0.048265458	33.25451259	101.091395
	38.46617124	0.49804001	19.45536051	13.32935429	10.03885165
		0	0	0	0.195074589	0.194999729	0.172101157	0.408593283	0.408513079
	0.377206528	0.204296641	0.204256539	0.188603264	1	2	3	5	4
449	C25	Sc18	C25	0.735065963	0.77217803	0.907815853	0.931972069	0.013951573
	0.234362086	0.616778357	0.949016321	46.89347587	0.063579986	22.39183764	108.0009528
	14.23314753	0.532080852	54.93115148	33.38990418	24.50163823	1	33.38990418
	27.82492015	55.64984029	278.2492015	0.020951671	0.041903343	0.209516715	0.297089204
	0.234608961	0.294051043	0.476529471	0.414828361	0.460608863	0.248740571	0.228365852
	0.335062789	2	3	1	5	5
450	C01	Sc19	C01	0.417022005	0.720324493	0.000114375	0.302332573	0.146755891
	0.092338595	0.186260211	0.345560727	44.010279 0.217997451	16.09475155	6.870223806
	24.48561599	0.033847058	55.97017677	43.85213797	27.91552745	1	43.85213797
	36.54344831	73.08689662	365.4344831	0.027516569	0.055033137	0.275165686	0.125908042
	0.105685808	0.089720661	0.310543058	0.275436802	0.263338126	0.169029813	0.165234969
	0.269251906	2	3	1	1	1
451	C02	Sc19	C02	0.396767474	0.538816734	0.419194514	0.6852195 0.20445225	0.878117436
	0.027387593	0.67046751	44.92377119	0.012963116	36.78293892	34.9928391	3.793139352
	0.172396809	14.4589725	9.78575639	8.14083227							0
	0	0	0.257404041	0.194814404	0.208494062	0.445364891	0.378338276	0.386777277
	0.222682445	0.189169138	0.193388639	1	3	2	1	2
452	C03	Sc19	C03	0.417304802	0.558689828	0.140386939	0.198101489	0.800744569
	0.968261576	0.313424178	0.692322616	45.9990459	0.274831239	38.68279349	85.51575292
	60.89801896	0.421304567	17.92942341	11.86471894	7.31625241	1	66.03334916
	55.02779097	110.0555819	550.2779097	0.041434951	0.082869902	0.414349508	0.25038454
	0.237553697	0.192031501	0.413221665	0.397937162	0.354009513	0.227328308	0.240403532
	0.384179511	3	2	1	1	3
453	C04	Sc19	C04	0.876389152	0.894606664	0.085044211	0.039054783	0.16983042
	0.878142503	0.098346834	0.421107625	46.08943358	0.217661196	3.83597854	3.698785078
	94.57791241	0.01822255	95.08406081	66.3617024	42.25345504
		0	0	0	0.214732899	0.18442312	0.126095549	0.407884499	0.379289941
	0.3266149 0.203942249	0.189644971	0.16330745	1	2	3	1	4
454	C05	Sc19	C05	0.95788953	0.533165285	0.691877114	0.315515631	0.686500928
	0.834625672	0.018288277	0.750144315	46.44082811	0.210183901	25.57658235	25.26080431
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         55.36247167         0.124450664         52.13742096         32.61644881         20.86424576
                   0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
         0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
455      C06       Sc19      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
         0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         16.08025417         7.109863301
         63.75601784         0.035027674         65.22005008         41.54117107         27.41156624
                   0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
         0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
456      C07       Sc19      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
         0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         48.2051179          36.53268887
         2.931640249         0.179983081         0         0         -4.36085524                                                           0
         0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
         0.168102684         0.166496609         0.169732566         2         3         1         2         2
457      C08       Sc19      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
         0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         11.98573101         78.84076537
         64.00625477         0.388419366         78.78068852         54.16863022         32.83781904
                   0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
         0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
458      C09       Sc19      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
         0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         5.541612561         37.21620286
         122.4870463         0.183350502         93.12275706         60.3881515          40.33139339         1         159.3663027
         132.8052523         265.6105045         1328.052523         0.1       0.2       1         0.178780994         0.232017403
         0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
         3         2         1         2         4
459      C10       Sc19      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
         0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         65.61023925         69.4442434
         110.7748593         0.342126169         0         0         -22.08804665                                                          0
         0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
         0.19878542          0.206429195         0.192206618         2         1         3         2         5
460      C11       Sc19      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
         0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         9.30900598
         95.22528771         0.045862038         10.53282093         6.400224457         3.87822105          1         57.72715192
         48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
         0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
         0.389870185         2         3         1         3         1
461      C12       Sc19      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
         0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         6.070591495         102.6475506
         15.28002635         0.505706614         94.39059844         62.80753253         38.93713794         1         62.80753253
         52.33961044         104.6792209         523.3961044         0.039410799         0.078821597         0.394107986         0.220522508
         0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226120238         0.246350742
         0.383646401         3         2         1         3         2
462      C13       Sc19      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
         0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         16.75770835
         116.3225238         0.082559047         0         0         -6.64332145                                                           0
         0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
         0.193600456         0.194835395         0.186649271         2         1         3         3         3
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463     C14     Sc19    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        111.5932129     0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507     0.268440329
        0.358556204     3       2       1       3       4
464     C15     Sc19    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        22.53172173     0.29160088      59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
465     C16     Sc19    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      102.2141214
        82.6613219      0.503571269     54.63121188     39.32311405     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
466     C17     Sc19    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     89.95873932
        3.922905646     0.443193522     0       0       -1.91148136                                     0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
467     C18     Sc19    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     114.7069548
        16.30969238     0.56511885      32.43860895     22.21901297     13.90560646     1       22.21901297
        18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
        0.233220321     3       2       1       4       3
468     C19     Sc19    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     90.00070565
        41.99988296     0.443400275     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
469     C20     Sc19    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        21.60846683     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
470     C21     Sc19    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     98.95921422
        0.241335248     79.75400352     58.45841461     36.47467781                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
471     C22     Sc19    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     84.62593646
        106.5899275     0.41692077      0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
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          0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
          3         2         1         5         2
472       C23       Sc19      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         32.83555671
          45.63627112         0.161768675         15.58311099         11.30259806         7.21255982          1         129.7843202
          108.1536002         216.3072004         1081.536002         0.081437743         0.162875486         0.814377431         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
          0.563103781         3         2         1         5         3
473       C24       Sc19      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         101.091395
          42.31278837         0.49804001          19.45536051         13.32935429         10.03885165
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
474       C25       Sc19      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.063579986         22.39183764         108.0009528
          15.65646228         0.532080852         54.93115148         33.38990418         24.50163823         1         33.38990418
          27.82492015         55.64984029         278.2492015         0.020951671         0.041903343         0.209516715         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.248740571         0.228365852
          0.335062789         2         3         1         5         5
475       C01       Sc20      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         16.09475155         6.870223806
          26.71158108         0.033847058         55.97017677         43.85213797         27.91552745         1         43.85213797
          36.54344831         73.08689662         365.4344831         0.027516569         0.055033137         0.275165686         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169029813         0.165234969
          0.269251906         2         3         1         1         1
476       C02       Sc20      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         36.78293892         34.9928391          4.137970202
          0.172396809         14.4589725          9.78575639          8.14083227                                                  0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
477       C03       Sc20      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         38.68279349         85.51575292
          66.4342025          0.421304567         17.92942341         11.86471894         7.31625241          1         66.03334916
          55.02779097         110.0555819         550.2779097         0.041434951         0.082869902         0.414349508         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.227328308         0.240403532
          0.384179511         3         2         1         1         3
478       C04       Sc20      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         3.83597854          3.698785078
          103.1759045         0.01822255          95.08406081         66.3617024          42.25345504
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
479       C05       Sc20      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         25.57658235         25.26080431
          60.39542364         0.124450664         52.13742096         32.61644881         20.86424576
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
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480     C06     Sc20    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     7.109863301
        69.55201946     0.035027674     65.22005008     41.54117107     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
481     C07     Sc20    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      36.53268887
        3.198152999     0.179983081     0       0       -4.36085524                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
482     C08     Sc20    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     78.84076537
        69.82500521     0.388419366     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
483     C09     Sc20    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     37.21620286
        133.6222323     0.183350502     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
484     C10     Sc20    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        120.845301      0.342126169     0       0       -22.08804665                                            0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
485     C11     Sc20    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     9.30900598
        103.882132      0.045862038     10.53282093     6.400224457     3.87822105      1       57.72715192
        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
486     C12     Sc20    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.070591495     102.6475506
        16.66911966     0.505706614     94.39059844     62.80753253     38.93713794     1       62.80753253
        52.33961044     104.6792209     523.3961044     0.039410799     0.078821597     0.394107986     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
487     C13     Sc20    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     16.75770835
        126.8972987     0.082559047     0       0       -6.64332145                                             0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
488     C14     Sc20    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        121.7380504     0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
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        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507     0.268440329
        0.358556204     3       2       1       3       4
489     C15     Sc20    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        24.58006007     0.29160088      59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
490     C16     Sc20    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      102.2141214
        90.17598753     0.503571269     54.63121188     39.32311405     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
491     C17     Sc20    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     89.95873932
        4.279533433     0.443193522     0       0       -1.91148136                                             0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
492     C18     Sc20    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     114.7069548
        17.79239169     0.56511885      32.43860895     22.21901297     13.90560646     1       22.21901297
        18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
        0.233220321     3       2       1       4       3
493     C19     Sc20    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     90.00070565
        45.81805414     0.443400275     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
494     C20     Sc20    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        23.57287291     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
495     C21     Sc20    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     107.9555064
        0.241335248     79.75400352     58.45841461     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
496     C22     Sc20    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     84.62593646
        116.2799209     0.41692077      0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
497     C23     Sc20    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     32.83555671
        49.78502304     0.161768675     15.58311099     11.30259806     7.21255982      1       129.7843202
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          108.1536002         216.3072004         1081.536002         0.081437743         0.162875486         0.814377431         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
          0.563103781         3         2         1         5         3
498       C24       Sc20      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         101.091395
          46.15940549         0.49804001          19.45536051         13.32935429         10.03885165
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
499       C25       Sc20      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.063579986         22.39183764         108.0009528
          17.07977704         0.532080852         54.93115148         33.38990418         24.50163823         1         33.38990418
          27.82492015         55.64984029         278.2492015         0.020951671         0.041903343         0.209516715         0.297089204
          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.248740571         0.228365852
          0.335062789         2         3         1         5         5
500       C01       Sc21      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         16.09475155         6.870223806
          28.93754617         0.033847058         55.97017677         43.85213797         27.91552745         1         43.85213797
          36.54344831         73.08689662         365.4344831         0.027516569         0.055033137         0.275165686         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169029813         0.165234969
          0.269251906         2         3         1         1         1
501       C02       Sc21      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         36.78293892         34.9928391          4.482801053
          0.172396809         14.4589725          9.78575639          8.14083227                                                            0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
502       C03       Sc21      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         38.68279349         85.51575292
          71.97038605         0.421304567         17.92942341         11.86471894         7.31625241          1         66.03334916
          55.02779097         110.0555819         550.2779097         0.041434951         0.082869902         0.414349508         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.227328308         0.240403532
          0.384179511         3         2         1         1         3
503       C04       Sc21      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         3.83597854          3.698785078
          111.7738965         0.01822255          95.08406081         66.3617024          42.25345504
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
504       C05       Sc21      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         25.57658235         25.26080431
          65.42837561         0.124450664         52.13742096         32.61644881         20.86424576
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
505       C06       Sc21      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         16.08025417         7.109863301
          75.34802107         0.035027674         65.22005008         41.54117107         27.41156624
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
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506     C07     Sc21    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      36.53268887
        3.464665749     0.179983081     0       0       -4.36085524                                                 0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
507     C08     Sc21    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     78.84076537
        75.64375564     0.388419366     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
508     C09     Sc21    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     37.21620286
        144.7574184     0.183350502     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
509     C10     Sc21    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        130.9157428     0.342126169     0       0       -22.08804665                                                0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
510     C11     Sc21    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     9.30900598
        112.5389764     0.045862038     10.53282093     6.400224457     3.87822105      1       57.72715192
        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
511     C12     Sc21    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.070591495     102.6475506
        18.05821297     0.505706614     94.39059844     62.80753253     38.93713794     1       62.80753253
        52.33961044     104.6792209     523.3961044     0.039410799     0.078821597     0.394107986     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
512     C13     Sc21    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     16.75770835
        137.4720736     0.082559047     0       0       -6.64332145                                                 0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
513     C14     Sc21    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        131.882888      0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507       0.268440329
        0.358556204     3       2       1       3       4
514     C15     Sc21    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        26.62839841     0.29160088      59.40046614     36.65684749     25.88826616
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                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
515       C16       Sc21      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         20.9375858          102.2141214
          97.69065316         0.503571269         54.63121188         39.32311405         23.01041848
                    0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
516       C17       Sc21      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         89.95873932
          4.636161218         0.443193522         0         0         -1.91148136                                                           0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
517       C18       Sc21      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         114.7069548
          19.27509099         0.56511885          32.43860895         22.21901297         13.90560646         1         22.21901297
          18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
          0.233220321         3         2         1         4         3
518       C19       Sc21      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
          0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         15.52703729         90.00070565
          49.63622533         0.443400275         68.47439068         51.1849573          29.60747804
                    0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
          0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
519       C20       Sc21      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         31.51644382         46.12331125
          25.53727899         0.227232539         26.74737871         17.31056311         13.26088315
                    0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
          0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
520       C21       Sc21      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         45.50400288         0.252623045         9.029325069         48.98585736         116.9517986
          0.241335248         79.75400352         58.45841461         36.47467781                                                           0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
521       C22       Sc21      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         44.998239 0.032643252         64.00112666         84.62593646
          125.9699144         0.41692077          0         0         -19.00288766        1         97.78152866         81.48460722
          162.9692144         814.8460722         0.061356464         0.122712929         0.613564643         0.273632139         0.256849416
          0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
          3         2         1         5         2
522       C23       Sc21      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         32.83555671
          53.93377496         0.161768675         15.58311099         11.30259806         7.21255982          1         129.7843202
          108.1536002         216.3072004         1081.536002         0.081437743         0.162875486         0.814377431         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
          0.563103781         3         2         1         5         3
523       C24       Sc21      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
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         0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
524      C25     Sc21    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
         0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     108.0009528
         18.50309179     0.532080852     54.93115148     33.38990418     24.50163823     1       33.38990418
         27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
         0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
         0.335062789     2       3       1       5       5
525      C01     Sc22    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
         0.092338595     0.186260211     0.345560727     44.010279 0.217997451       16.09475155     4.809156664
         22.2596509      0.023692941     55.97017677     43.85213797     27.91552745     1       43.85213797
         36.54344831     73.08689662     365.4344831     0.027516569     0.055033137     0.275165686     0.125908042
         0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169029813     0.165234969
         0.269251906     2       3       1       1       1
526      C02     Sc22    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225        0.878117436
         0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     24.49498737     3.448308502
         0.120677766     14.4589725      9.78575639      8.14083227                                              0
         0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
         0.222682445     0.189169138     0.193388639     1       3       2       1       2
527      C03     Sc22    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
         0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     59.86102704
         55.36183542     0.294913197     17.92942341     11.86471894     7.31625241      1       66.03334916
         55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
         0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
         0.384179511     3       2       1       1       3
528      C04     Sc22    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
         0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      2.589149554
         85.97992038     0.012755785     95.08406081     66.3617024      42.25345504
                 0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
         0.3266149 0.203942249       0.189644971     0.16330745      1       2       3       1       4
529      C05     Sc22    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
         0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     17.68256302
         50.3295197      0.087115465     52.13742096     32.61644881     20.86424576
                 0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
         0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
530      C06     Sc22    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
         0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     4.976904311
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                 0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
         0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
531      C07     Sc22    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
         0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      25.57288221
         2.665127499     0.125988157     0       0       -4.36085524                                             0
         0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
         0.168102684     0.166496609     0.169732566     2       3       1       2       2
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532     C08     Sc22    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     55.18853576
        58.18750434     0.271893556     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
533     C09     Sc22    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     26.05134201
        111.3518603     0.128345352     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
534     C10     Sc22    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     48.61097038
        100.7044175     0.239488318     0       0       -22.08804665                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
535     C11     Sc22    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     6.516304186
        86.56844337     0.032103427     10.53282093     6.400224457     3.87822105      1       57.72715192
        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
536     C12     Sc22    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.070591495     71.85328541
        13.89093305     0.35399463      94.39059844     62.80753253     38.93713794     1       62.80753253
        52.33961044     104.6792209     523.3961044     0.039410799     0.078821597     0.394107986     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
537     C13     Sc22    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     11.73039584
        105.7477489     0.057791333     0       0       -6.64332145                                     0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
538     C14     Sc22    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     15.40609291
        101.4483754     0.075900136     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507       0.268440329
        0.358556204     3       2       1       3       4
539     C15     Sc22    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     41.43208862
        20.48338339     0.204120616     59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
540     C16     Sc22    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      71.54988499
        75.14665628     0.352499888     54.63121188     39.32311405     23.01041848
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541      C17       Sc22      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
         0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         62.97111752
         3.56627786          0.310235466         0         0         -1.91148136                                                   0
         0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
         0.195078226         0.211045796         0.212449365         3         2         1         4         2
542      C18       Sc22      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
         0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         80.29486837
         14.82699307         0.395583195         32.43860895         22.21901297         13.90560646         1         22.21901297
         18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
         0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
         0.233220321         3         2         1         4         3
543      C19       Sc22      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
         0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         15.52703729         63.00049396
         38.18171179         0.310380192         68.47439068         51.1849573          29.60747804
                  0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
         0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
544      C20       Sc22      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
         0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         31.51644382         32.28631788
         19.64406076         0.159062778         26.74737871         17.31056311         13.26088315
                  0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
         0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
545      C21       Sc22      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
         0.070022144         0.486345111         45.50400288         0.252623045         9.029325069         34.29010015         89.96292202
         0.168934674         79.75400352         58.45841461         36.47467781                                                   0
         0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
         0.184443254         0.17732464          0.165746932         1         2         3         5         1
546      C22       Sc22      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
         0.380141173         0.550948219         0.745334431         44.998239 0.032643252         64.00112666         59.23815552
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         0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
         3         2         1         5         2
547      C23       Sc22      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
         0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         22.98488969
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         0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
         0.563103781         3         2         1         5         3
548      C24       Sc22      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
         0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         70.7639765
         38.46617124         0.348628007         19.45536051         13.32935429         10.03885165
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         0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
549      C25       Sc22      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
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550     C01     Sc23    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
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        22.2596509      0.027077647     55.97017677     43.85213797     27.91552745     1       43.85213797
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551     C02     Sc23    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225    0.878117436
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        0.137917447     14.4589725      9.78575639      8.14083227                                      0
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        0.222682445     0.189169138     0.193388639     1       3       2       1       2
552     C03     Sc23    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     68.41260233
        55.36183542     0.337043654     17.92942341     11.86471894     7.31625241      1       66.03334916
        55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
        0.384179511     3       2       1       1       3
553     C04     Sc23    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      2.959028062
        85.97992038     0.01457804      95.08406081     66.3617024      42.25345504
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        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
554     C05     Sc23    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     20.20864345
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555     C06     Sc23    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
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        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
556     C07     Sc23    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      29.2261511
        2.665127499     0.143986465     0       0       -4.36085524                                     0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
557     C08     Sc23    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     63.07261229
        58.18750434     0.310735493     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
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          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         5.541612561         29.77296229
          111.3518603         0.146680402         93.12275706         60.3881515          40.33139339         1         159.3663027
          132.8052523         265.6105045         1328.052523         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
559       C10       Sc23      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         65.61023925         55.55539472
          100.7044175         0.273700935         0         0         -22.08804665                                              0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
560       C11       Sc23      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         7.447204784
          86.56844337         0.036689631         10.53282093         6.400224457         3.87822105          1         57.72715192
          48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
          0.389870185         2         3         1         3         1
561       C12       Sc23      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         6.070591495         82.11804047
          13.89093305         0.404565292         94.39059844         62.80753253         38.93713794         1         62.80753253
          52.33961044         104.6792209         523.3961044         0.039410799         0.078821597         0.394107986         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226120238         0.246350742
          0.383646401         3         2         1         3         2
562       C13       Sc23      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         13.40616668
          105.7477489         0.066047238         0         0         -6.64332145                                               0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
563       C14       Sc23      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         11.62151545         17.60696332
          101.4483754         0.086743013         86.03174795         55.17132441         34.34574479         1         55.17132441
          45.97610368         91.95220735         459.7610368         0.034619191         0.069238382         0.346191908         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236858507         0.268440329
          0.358556204         3         2         1         3         4
564       C15       Sc23      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         17.95680735         47.35095843
          20.48338339         0.233280704         59.40046614         36.65684749         25.88826616
                   0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
565       C16       Sc23      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         20.9375858          81.77129713
          75.14665628         0.402857015         54.63121188         39.32311405         23.01041848
                   0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
566       C17       Sc23      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         71.96699145
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567     C18     Sc23    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     91.76556385
        14.82699307     0.45209508      32.43860895     22.21901297     13.90560646     1       22.21901297
        18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
        0.233220321     3       2       1       4       3
568     C19     Sc23    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     72.00056452
        38.18171179     0.35472022      68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
569     C20     Sc23    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     36.898649
        19.64406076     0.181786031     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
570     C21     Sc23    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     39.18868589     89.96292202
        0.193068198     79.75400352     58.45841461     36.47467781                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
571     C22     Sc23    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     67.70074917
        96.89993412     0.333536616     0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
572     C23     Sc23    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     26.26844536
        41.4875192      0.12941494      15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
        0.563103781     3       2       1       5       3
573     C24     Sc23    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     80.873116
        38.46617124     0.398432008     19.45536051     13.32935429     10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
574     C25     Sc23    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     86.40076224
        14.23314753     0.425664682     54.93115148     33.38990418     24.50163823     1       33.38990418
        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
        0.335062789     2       3       1       5       5
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575       C01       Sc24      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         16.09475155         6.183201425
          22.2596509          0.030462352         55.97017677         43.85213797         27.91552745         1         43.85213797
          36.54344831         73.08689662         365.4344831         0.027516569         0.055033137         0.275165686         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169029813         0.165234969
          0.269251906         2         3         1         1         1
576       C02       Sc24      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         36.78293892         31.49355519         3.448308502
          0.155157128         14.4589725          9.78575639          8.14083227                                                            0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
577       C03       Sc24      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         38.68279349         76.96417762
          55.36183542         0.379174111         17.92942341         11.86471894         7.31625241          1         66.03334916
          55.02779097         110.0555819         550.2779097         0.041434951         0.082869902         0.414349508         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.227328308         0.240403532
          0.384179511         3         2         1         1         3
578       C04       Sc24      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         3.83597854          3.32890657
          85.97992038         0.016400295         95.08406081         66.3617024          42.25345504
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
579       C05       Sc24      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         25.57658235         22.73472388
          50.3295197          0.112005598         52.13742096         32.61644881         20.86424576
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
580       C06       Sc24      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         16.08025417         6.398876971
          57.96001621         0.031524906         65.22005008         41.54117107         27.41156624
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
581       C07       Sc24      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         48.2051179          32.87941999
          2.665127499         0.161984773         0         0         -4.36085524                                                           0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
582       C08       Sc24      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         11.98573101         70.95668883
          58.18750434         0.34957743          78.78068852         54.16863022         32.83781904
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
583       C09       Sc24      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         5.541612561         33.49458258
          111.3518603         0.165015452         93.12275706         60.3881515          40.33139339         1         159.3663027
          132.8052523         265.6105045         1328.052523         0.1       0.2       1         0.178780994         0.232017403
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584       C10       Sc24      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         65.61023925         62.49981906
          100.7044175         0.307913552         0         0         -22.08804665                                                          0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
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585       C11       Sc24      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         8.378105382
          86.56844337         0.041275834         10.53282093         6.400224457         3.87822105          1         57.72715192
          48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
          0.389870185         2         3         1         3         1
586       C12       Sc24      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         6.070591495         92.38279552
          13.89093305         0.455135953         94.39059844         62.80753253         38.93713794         1         62.80753253
          52.33961044         104.6792209         523.3961044         0.039410799         0.078821597         0.394107986         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226120238         0.246350742
          0.383646401         3         2         1         3         2
587       C13       Sc24      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         15.08193751
          105.7477489         0.074303142         0         0         -6.64332145                                                           0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
588       C14       Sc24      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         11.62151545         19.80783374
          101.4483754         0.09758589          86.03174795         55.17132441         34.34574479         1         55.17132441
          45.97610368         91.95220735         459.7610368         0.034619191         0.069238382         0.346191908         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236858507         0.268440329
          0.358556204         3         2         1         3         4
589       C15       Sc24      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         17.95680735         53.26982823
          20.48338339         0.262440792         59.40046614         36.65684749         25.88826616
                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
590       C16       Sc24      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         20.9375858          91.99270928
          75.14665628         0.453214142         54.63121188         39.32311405         23.01041848
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          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
591       C17       Sc24      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
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          0.195078226         0.211045796         0.212449365         3         2         1         4         2
592       C18       Sc24      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
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          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
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593       C19       Sc24      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
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594       C20       Sc24      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         31.51644382         41.51098013
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          0.070022144         0.486345111         45.50400288         0.252623045         9.029325069         44.08727163         89.96292202
          0.217201723         79.75400352         58.45841461         36.47467781                                                           0
          0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
          0.184443254         0.17732464          0.165746932         1         2         3         5         1
596       C22       Sc24      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         44.998239 0.032643252         64.00112666         76.16334281
          96.89993412         0.375228693         0         0         -19.00288766        1         97.78152866         81.48460722
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          0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
          3         2         1         5         2
597       C23       Sc24      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         29.55200103
          41.4875192          0.145591807         15.58311099         11.30259806         7.21255982          1         129.7843202
          108.1536002         216.3072004         1081.536002         0.081437743         0.162875486         0.814377431         0.126338191
          0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
          0.563103781         3         2         1         5         3
598       C24       Sc24      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         90.98225549
          38.46617124         0.448236009         19.45536051         13.32935429         10.03885165
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          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
599       C25       Sc24      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.063579986         22.39183764         97.20085752
          14.23314753         0.478872767         54.93115148         33.38990418         24.50163823         1         33.38990418
          27.82492015         55.64984029         278.2492015         0.020951671         0.041903343         0.209516715         0.297089204
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          0.335062789         2         3         1         5         5
600       C01       Sc25      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         16.09475155         6.870223806
          22.2596509          0.033847058         55.97017677         43.85213797         27.91552745         1         43.85213797
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        0.269251906     2       3       1       1       1
601     C02     Sc25    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225    0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     34.9928391      3.448308502
        0.172396809     14.4589725      9.78575639      8.14083227                                              0
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        0.222682445     0.189169138     0.193388639     1       3       2       1       2
602     C03     Sc25    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     85.51575292
        55.36183542     0.421304567     17.92942341     11.86471894     7.31625241      1       66.03334916
        55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
        0.384179511     3       2       1       1       3
603     C04     Sc25    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      3.698785078
        85.97992038     0.01822255      95.08406081     66.3617024      42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
604     C05     Sc25    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     25.26080431
        50.3295197      0.124450664     52.13742096     32.61644881     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
605     C06     Sc25    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
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                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
606     C07     Sc25    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -4.36085524                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
607     C08     Sc25    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     78.84076537
        58.18750434     0.388419366     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
608     C09     Sc25    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     37.21620286
        111.3518603     0.183350502     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
609     C10     Sc25    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                            0
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610       C11       Sc25      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         9.30900598
          86.56844337         0.045862038         10.53282093         6.400224457         3.87822105          1         57.72715192
          48.10595993         96.21191986         481.0595993         0.036222935         0.07244587          0.362229348         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.261306383         0.254056294
          0.389870185         2         3         1         3         1
611       C12       Sc25      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         6.070591495         102.6475506
          13.89093305         0.505706614         94.39059844         62.80753253         38.93713794         1         62.80753253
          52.33961044         104.6792209         523.3961044         0.039410799         0.078821597         0.394107986         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226120238         0.246350742
          0.383646401         3         2         1         3         2
612       C13       Sc25      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         50.54486886         16.75770835
          105.7477489         0.082559047         0         0         -6.64332145                                                     0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
613       C14       Sc25      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         11.62151545         22.00870416
          101.4483754         0.108428766         86.03174795         55.17132441         34.34574479         1         55.17132441
          45.97610368         91.95220735         459.7610368         0.034619191         0.069238382         0.346191908         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236858507         0.268440329
          0.358556204         3         2         1         3         4
614       C15       Sc25      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         17.95680735         59.18869803
          20.48338339         0.29160088          59.40046614         36.65684749         25.88826616
                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
615       C16       Sc25      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         20.9375858          102.2141214
          75.14665628         0.503571269         54.63121188         39.32311405         23.01041848
                    0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
616       C17       Sc25      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         89.95873932
          3.56627786          0.443193522         0         0         -1.91148136                                                     0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
617       C18       Sc25      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         114.7069548
          14.82699307         0.56511885          32.43860895         22.21901297         13.90560646         1         22.21901297
          18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
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        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     90.00070565
        38.18171179     0.443400275     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
619     C20     Sc25    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     46.12331125
        19.64406076     0.227232539     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
620     C21     Sc25    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     48.98585736     89.96292202
        0.241335248     79.75400352     58.45841461     36.47467781                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
621     C22     Sc25    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     84.62593646
        96.89993412     0.41692077      0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
622     C23     Sc25    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     32.83555671
        41.4875192      0.161768675     15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
        0.563103781     3       2       1       5       3
623     C24     Sc25    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     101.091395
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        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
624     C25     Sc25    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     108.0009528
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        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
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625     C01     Sc26    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
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628       C04       Sc26      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
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          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
630       C06       Sc26      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
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          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         48.2051179          40.18595776
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          111.3518603         0.201685552         93.12275706         60.3881515          40.33139339         1         159.3663027
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          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
634       C10       Sc26      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         65.61023925         76.38866775
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635       C11       Sc26      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         39.57827842         10.23990658
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          0.383646401     3       2       1       3       2
637       C13     Sc26    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
          0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     18.43347918
          105.7477489     0.090814952     0       0       -6.64332145                                     0
          0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
          0.193600456     0.194835395     0.186649271     2       1       3       3       3
638       C14     Sc26    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
          0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     24.20957457
          101.4483754     0.119271643     86.03174795     55.17132441     34.34574479     1       55.17132441
          45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
          0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507     0.268440329
          0.358556204     3       2       1       3       4
639       C15     Sc26    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
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                  0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
          0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
640       C16     Sc26    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
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641       C17     Sc26    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
          0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     98.95461325
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          0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     126.1776503
          14.82699307     0.621630735     32.43860895     22.21901297     13.90560646     1       22.21901297
          18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
          0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
          0.233220321     3       2       1       4       3
643       C19     Sc26    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
          0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     99.00077622
          38.18171179     0.487740302     68.47439068     51.1849573      29.60747804
                  0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
          0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
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644     C20     Sc26    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     50.73564238
        19.64406076     0.249955793     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
645     C21     Sc26    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     53.8844431      89.96292202
        0.265468773     79.75400352     58.45841461     36.47467781                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
646     C22     Sc26    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     93.0885301
        96.89993412     0.458612847     0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
647     C23     Sc26    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     36.11911238
        41.4875192      0.177945542     15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
        0.563103781     3       2       1       5       3
648     C24     Sc26    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     111.2005345
        38.46617124     0.547844011     19.45536051     13.32935429     10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
649     C25     Sc26    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     118.8010481
        14.23314753     0.585288938     54.93115148     33.38990418     24.50163823     1       33.38990418
        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
        0.335062789     2       3       1       5       5
650     C01     Sc27    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451     16.09475155     8.244268567
        22.2596509      0.04061647      55.97017677     43.85213797     27.91552745     1       43.85213797
        36.54344831     73.08689662     365.4344831     0.027516569     0.055033137     0.275165686     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169029813     0.165234969
        0.269251906     2       3       1       1       1
651     C02     Sc27    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225      0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     41.99140692     3.448308502
        0.206876171     14.4589725      9.78575639      8.14083227                                      0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
652     C03     Sc27    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     102.6189035
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        0.384179511     3       2       1       1       3
653     C04     Sc27    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      4.438542093
        85.97992038     0.021867059     95.08406081     66.3617024      42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
654     C05     Sc27    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     30.31296517
        50.3295197      0.149340797     52.13742096     32.61644881     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
655     C06     Sc27    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     8.531835961
        57.96001621     0.042033208     65.22005008     41.54117107     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
656     C07     Sc27    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      43.83922665
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        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
657     C08     Sc27    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     94.60891844
        58.18750434     0.466103239     78.78068852     54.16863022     32.83781904
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        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
658     C09     Sc27    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     44.65944344
        111.3518603     0.220020603     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
659     C10     Sc27    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     83.33309209
        100.7044175     0.410551403     0       0       -22.08804665                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
660     C11     Sc27    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     11.17080718
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        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
661     C12     Sc27    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
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          0.224798251    0.197499161    0.412829677    0.413879887    0.373184816    0.226120238    0.246350742
          0.383646401    3         2         1         3         2
662       C13       Sc27      C13       0.903379521    0.573679487    0.002870327    0.617144914    0.326644902
          0.527058102    0.885942099    0.35726976     43.90154741    0.067289973    50.54486886    20.10925002
          105.7477489    0.099070856    0         0         -6.64332145                                  0
          0         0         0.221712208    0.223609096    0.217157743    0.387200912    0.389670791    0.373298543
          0.193600456    0.194835395    0.186649271    2         1         3         3         3
663       C14       Sc27      C14       0.908535151    0.623360116    0.015821243    0.929437234    0.690896918
          0.99732285     0.172340508    0.13713575     45.96726024    0.256789061    11.62151545    26.41044499
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          45.97610368    91.95220735    459.7610368    0.034619191    0.069238382    0.346191908    0.254748757
          0.280125362    0.188733628    0.439097823    0.467642276    0.3709205 0.236858507    0.268440329
          0.358556204    3         2         1         3         4
664       C15       Sc27      C15       0.932595463    0.696818161    0.066000173    0.755463053    0.753876188
          0.923024536    0.711524759    0.124270962    43.84507351    0.092219933    17.95680735    71.02643764
          20.48338339    0.349921056    59.40046614    36.65684749    25.88826616
                    0         0         0         0.251517278    0.292575574    0.225051384    0.421654228    0.461972982
          0.38826343     0.210827114    0.230986491    0.194131715    2         1         3         3         5
665       C16       Sc27      C16       0.019880134    0.026210987    0.028306488    0.246211068    0.860027949
          0.538831064    0.552821979    0.842030892    43.94800428    0.392667574    20.9375858     122.6569457
          75.14665628    0.604285523    54.63121188    39.32311405    23.01041848
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          0.376351488    0.204734808    0.200350357    0.188175744    1         2         3         4         1
666       C17       Sc27      C17       0.124173315    0.279183679    0.585759271    0.969595748    0.561030219
          0.018647289    0.800632673    0.232974274    46.83759181    0.426987646    48.74907317    107.9504872
          3.56627786     0.531832227    0         0         -1.91148136                                  0
          0         0         0.154114011    0.183917483    0.218846089    0.390156452    0.422091592    0.424898731
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667       C18       Sc27      C18       0.807105196    0.387860644    0.863541855    0.747121643    0.556240234
          0.136455226    0.05991769     0.121343456    46.62508589    0.247118419    32.71947943    137.6483458
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          18.51584414    37.03168829    185.1584414    0.013942102    0.027884205    0.139421023    0.168545737
          0.230647918    0.139241534    0.36632712     0.427568554    0.327019619    0.190134611    0.227726379
          0.233220321    3         2         1         4         3
668       C19       Sc27      C19       0.044551879    0.107494129    0.225709339    0.71298898     0.559716982
          0.01255598     0.07197428     0.96727633     45.13451533    0.423280743    15.52703729    108.0008468
          38.18171179    0.53208033     68.47439068    51.1849573     29.60747804
                    0         0         0         0.19335296     0.154863434    0.16721044     0.416396653    0.388253269
          0.385127801    0.208198327    0.194126634    0.192563901    1         2         3         4         4
669       C20       Sc27      C20       0.568100462    0.203293235    0.252325745    0.743825854    0.195429481
          0.581358927    0.970019989    0.846828801    44.77732697    0.039822739    31.51644382    55.34797351
          19.64406076    0.272679047    26.74737871    17.31056311    13.26088315
                    0         0         0         0.266503103    0.213730709    0.290225506    0.462800059    0.417820608
          0.473734591    0.23140003     0.208910304    0.236867296    2         3         1         4         5
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670       C21      Sc27      C21      0.239847759        0.493769714        0.619955718        0.8289809 0.156791395        0.018576202
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          0.289602298        79.75400352        58.45841461        36.47467781                                                        0
          0        0         0.167087112        0.139838178        0.158385453        0.368886507        0.35464928         0.331493863
          0.184443254        0.17732464         0.165746932        1        2         3        5         1
671       C22      Sc27      C22      0.606329462        0.568851437        0.317362409        0.988616154        0.579745219
          0.380141173        0.550948219        0.745334431        44.998239 0.032643252       64.00112666        101.5511237
          96.89993412        0.500304924        0        0         -19.00288766       1        97.78152866        81.48460722
          162.9692144        814.8460722        0.061356464        0.122712929        0.613564643        0.273632139        0.256849416
          0.255171744        0.482159781        0.476288524        0.435601111        0.271758123        0.299500727        0.524582877
          3        2         1        5         2
672       C23      Sc27      C23      0.669232893        0.264919558        0.066334834        0.370084198        0.629717507
          0.21017401         0.752755554        0.066536481        46.98159204        0.214061164        39.76903222        39.40266805
          41.4875192         0.19412241         15.58311099        11.30259806        7.21255982         1        129.7843202
          108.1536002        216.3072004        1081.536002        0.081437743        0.162875486        0.814377431        0.126338191
          0.188706502        0.135993177        0.31838757         0.379056788        0.311830131        0.199912657        0.270966137
          0.563103781        3        2         1        5         3
673       C24      Sc27      C24      0.260315099        0.804754564        0.193434283        0.639460881        0.524670309
          0.92480797         0.26329677         0.065961091        43.29336424        0.048265458        33.25451259        121.309674
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                    0        0        0         0.195074589        0.194999729        0.172101157        0.408593283        0.408513079
          0.377206528        0.204296641        0.204256539        0.188603264        1        2         3        5         4
674       C25      Sc27      C25      0.735065963        0.77217803         0.907815853        0.931972069        0.013951573
          0.234362086        0.616778357        0.949016321        46.89347587        0.063579986        22.39183764        129.6011434
          14.23314753        0.638497023        54.93115148        33.38990418        24.50163823        1        33.38990418
          27.82492015        55.64984029        278.2492015        0.020951671        0.041903343        0.209516715        0.297089204
          0.234608961        0.294051043        0.476529471        0.414828361        0.460608863        0.248740571        0.228365852
          0.335062789        2        3         1        5         5
675       C01      Sc28      C01      0.417022005        0.720324493        0.000114375        0.302332573        0.146755891
          0.092338595        0.186260211        0.345560727        44.010279 0.217997451       16.09475155        8.931290948
          22.2596509         0.044001176        55.97017677        43.85213797        27.91552745        1        43.85213797
          36.54344831        73.08689662        365.4344831        0.027516569        0.055033137        0.275165686        0.125908042
          0.105685808        0.089720661        0.310543058        0.275436802        0.263338126        0.169029813        0.165234969
          0.269251906        2        3         1        1         1
676       C02      Sc28      C02      0.396767474        0.538816734        0.419194514        0.6852195 0.20445225         0.878117436
          0.027387593        0.67046751         44.92377119        0.012963116        36.78293892        45.49069083        3.448308502
          0.224115852        14.4589725         9.78575639         8.14083227                                                         0
          0        0         0.257404041        0.194814404        0.208494062        0.445364891        0.378338276        0.386777277
          0.222682445        0.189169138        0.193388639        1        3         2        1         2
677       C03      Sc28      C03      0.417304802        0.558689828        0.140386939        0.198101489        0.800744569
          0.968261576        0.313424178        0.692322616        45.9990459         0.274831239        38.68279349        111.1704788
          55.36183542        0.547695938        17.92942341        11.86471894        7.31625241         1        66.03334916
          55.02779097        110.0555819        550.2779097        0.041434951        0.082869902        0.414349508        0.25038454
          0.237553697        0.192031501        0.413221665        0.397937162        0.354009513        0.227328308        0.240403532
          0.384179511        3        2         1        1         3
678       C04      Sc28      C04      0.876389152        0.894606664        0.085044211        0.039054783        0.16983042
          0.878142503        0.098346834        0.421107625        46.08943358        0.217661196        3.83597854         4.808420601
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          85.97992038        0.023689314        95.08406081        66.3617024         42.25345504
                   0         0         0        0.214732899        0.18442312         0.126095549        0.407884499        0.379289941
          0.3266149 0.203942249        0.189644971        0.16330745         1         2         3         1         4
679       C05       Sc28       C05       0.95788953         0.533165285        0.691877114        0.315515631        0.686500928
          0.834625672        0.018288277        0.750144315        46.44082811        0.210183901        25.57658235        32.8390456
          50.3295197         0.161785863        52.13742096        32.61644881        20.86424576
                   0         0         0        0.286047241        0.291180307        0.19489221         0.44509345         0.451505602
          0.365064068        0.222546725        0.225752801        0.182532034        2         1         3         1         5
680       C06       Sc28       C06       0.988861089        0.748165654        0.280443992        0.789279328        0.103226007
          0.447893526        0.908595503        0.293614148        43.49182041        0.165167411        16.08025417        9.242822291
          57.96001621        0.045535976        65.22005008        41.54117107        27.41156624
                   0         0         0        0.231167154        0.224930393        0.238148451        0.424363564        0.406410035
          0.410044838        0.212181782        0.203205018        0.205022419        1         3         2         2         1
681       C07       Sc28       C07       0.287775339        0.130028572        0.019366958        0.678835533        0.211628116
          0.265546659        0.491573159        0.053362545        43.84426266        0.102324317        48.2051179         47.49249553
          2.665127499        0.233978005        0         0         -4.36085524                                                         0
          0         0         0.108835421        0.116048175        0.133699741        0.336205368        0.332993219        0.339465132
          0.168102684        0.166496609        0.169732566        2         3         1         2         2
682       C08       Sc28       C08       0.574117605        0.146728575        0.589305537        0.69975836         0.102334429
          0.414055988        0.694400158        0.41417927         44.82355005        0.309635483        11.98573101        102.492995
          58.18750434        0.504945176        78.78068852        54.16863022        32.83781904
                   0         0         0        0.195954796        0.182760584        0.225479264        0.378522006        0.365489003
          0.396290772        0.189261003        0.182744501        0.198145386        2         3         1         2         3
683       C09       Sc28       C09       0.049953459        0.535896406        0.663794645        0.514889112        0.944594756
          0.586555041        0.903401915        0.137474704        45.87300595        0.149827337        5.541612561        48.38106372
          111.3518603        0.238355653        93.12275706        60.3881515         40.33139339        1         159.3663027
          132.8052523        265.6105045        1328.052523        0.1       0.2       1         0.178780994        0.232017403
          0.229727169        0.392146196        0.44667726         0.432078559        0.246073098        0.32333863         0.716039279
          3         2         1         2         4
684       C10       Sc28       C10       0.139276347        0.807391289        0.397676837        0.165354197        0.92750858
          0.34776586         0.750812103        0.725997985        43.5221926         0.133413638        65.61023925        90.27751642
          100.7044175        0.444764019        0         0         -22.08804665                                                        0
          0         0         0.212063257        0.22017735         0.208648434        0.397570841        0.412858391        0.384413237
          0.19878542         0.206429195        0.192206618        2         1         3         2         5
685       C11       Sc28       C11       0.883306091        0.623672207        0.750942434        0.348898342        0.269927892
          0.895886218        0.42809119         0.964840047        43.45649947        0.310566916        39.57827842        12.10170777
          86.56844337        0.05962065         10.53282093        6.400224457        3.87822105         1         57.72715192
          48.10595993        96.21191986        481.0595993        0.036222935        0.07244587         0.362229348        0.316867923
          0.266455347        0.264174875        0.486389832        0.435666719        0.417511021        0.261306383        0.254056294
          0.389870185        2         3         1         3         1
686       C12       Sc28       C12       0.663441498        0.62169572         0.114745973        0.949489259        0.449912133
          0.578389614        0.408136803        0.23702698         45.00772944        0.264571047        6.070591495        133.4418158
          13.89093305        0.657418599        94.39059844        62.80753253        38.93713794        1         62.80753253
          52.33961044        104.6792209        523.3961044        0.039410799        0.078821597        0.394107986        0.220522508
          0.224798251        0.197499161        0.412829677        0.413879887        0.373184816        0.226120238        0.246350742
          0.383646401        3         2         1         3         2
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687     C13     Sc28    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     21.78502086
        105.7477489     0.107326761     0       0       -6.64332145                                                    0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
688     C14     Sc28    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     28.61131541
        101.4483754     0.140957396     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507       0.268440329
        0.358556204     3       2       1       3       4
689     C15     Sc28    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     76.94530744
        20.48338339     0.379081144     59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
690     C16     Sc28    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      132.8783578
        75.14665628     0.654642649     54.63121188     39.32311405     23.01041848
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
691     C17     Sc28    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     48.74907317     116.9463611
        3.56627786      0.576151579     0       0       -1.91148136                                                    0
        0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592     0.424898731
        0.195078226     0.211045796     0.212449365     3       2       1       4       2
692     C18     Sc28    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     32.71947943     149.1190412
        14.82699307     0.734654505     32.43860895     22.21901297     13.90560646     1       22.21901297
        18.51584414     37.03168829     185.1584414     0.013942102     0.027884205     0.139421023     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.190134611     0.227726379
        0.233220321     3       2       1       4       3
693     C19     Sc28    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     15.52703729     117.0009173
        38.18171179     0.576420357     68.47439068     51.1849573      29.60747804
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
694     C20     Sc28    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     31.51644382     59.96030463
        19.64406076     0.295402301     26.74737871     17.31056311     13.26088315
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
695     C21     Sc28    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395       0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.029325069     63.68161457     89.96292202
        0.313735822     79.75400352     58.45841461     36.47467781                                                    0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
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696     C22     Sc28    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     64.00112666     110.0137174
        96.89993412     0.541997001     0       0       -19.00288766    1       97.78152866     81.48460722
        162.9692144     814.8460722     0.061356464     0.122712929     0.613564643     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.271758123     0.299500727     0.524582877
        3       2       1       5       2
697     C23     Sc28    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     39.76903222     42.68622372
        41.4875192      0.210299277     15.58311099     11.30259806     7.21255982      1       129.7843202
        108.1536002     216.3072004     1081.536002     0.081437743     0.162875486     0.814377431     0.126338191
        0.188706502     0.135993177     0.31838757      0.379056788     0.311830131     0.199912657     0.270966137
        0.563103781     3       2       1       5       3
698     C24     Sc28    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     33.25451259     131.4188135
        38.46617124     0.647452013     19.45536051     13.32935429     10.03885165
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
699     C25     Sc28    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     22.39183764     140.4012386
        14.23314753     0.691705108     54.93115148     33.38990418     24.50163823     1       33.38990418
        27.82492015     55.64984029     278.2492015     0.020951671     0.041903343     0.209516715     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248740571     0.228365852
        0.335062789     2       3       1       5       5
700     C01     Sc29    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451     11.26632609     6.870223806
        22.2596509      0.033847058     65.65109098     51.43704855     32.74395291     1       51.43704855
        42.86420713     85.72841425     428.6420713     0.027107795     0.05421559      0.271077949     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.168825427     0.164826196
        0.267208038     2       3       1       1       1
701     C02     Sc29    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225        0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     25.74805725     34.9928391      3.448308502
        0.172396809     34.05808047     23.05032938     19.17571394                                     0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
702     C03     Sc29    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     27.07795544     85.51575292
        55.36183542     0.421304567     46.36858098     30.68420932     18.92109046     1       90.78426845
        75.65355704     151.3071141     756.5355704     0.04784414      0.095688279     0.478441396     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.230532902     0.246812721
        0.416225455     3       2       1       1       3
703     C04     Sc29    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     2.685184978     3.698785078
        85.97992038     0.01822255      97.67372182     68.1690959      43.4042486
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
704     C05     Sc29    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     17.90360765     25.26080431
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         50.3295197        0.124450664       71.31132816       44.61137973       28.53722046
                 0         0        0        0.286047241       0.291180307       0.19489221        0.44509345        0.451505602
         0.365064068       0.222546725       0.225752801       0.182532034       2        1        3        1        5
705      C06      Sc29     C06      0.988861089       0.748165654       0.280443992       0.789279328       0.103226007
         0.447893526       0.908595503       0.293614148       43.49182041       0.165167411       11.25617792       7.109863301
         57.96001621       0.035027674       76.69792376       48.85187251       32.23564249
                 0         0        0        0.231167154       0.224930393       0.238148451       0.424363564       0.406410035
         0.410044838       0.212181782       0.203205018       0.205022419       1        3        2        2        1
706      C07      Sc29     C07      0.287775339       0.130028572       0.019366958       0.678835533       0.211628116
         0.265546659       0.491573159       0.053362545       43.84426266       0.102324317       33.74358253       36.53268887
         2.665127499       0.179983081       18.33233601       14.46606799       10.10068013
                 0         0        0        0.108835421       0.116048175       0.133699741       0.336205368       0.332993219
         0.339465132       0.168102684       0.166496609       0.169732566       2        3        1        2        2
707      C08      Sc29     C08      0.574117605       0.146728575       0.589305537       0.69975836        0.102334429
         0.414055988       0.694400158       0.41417927        44.82355005       0.309635483       8.390011708       78.84076537
         58.18750434       0.388419366       87.40712142       60.10005914       36.43353834
                 0         0        0        0.195954796       0.182760584       0.225479264       0.378522006       0.365489003
         0.396290772       0.189261003       0.182744501       0.198145386       2        3        1        2        3
708      C09      Sc29     C09      0.049953459       0.535896406       0.663794645       0.514889112       0.944594756
         0.586555041       0.903401915       0.137474704       45.87300595       0.149827337       3.879128793       37.21620286
         111.3518603       0.183350502       96.96133191       62.87738664       41.99387716       1        175.6578623
         146.3815519       292.7631038       1463.815519       0.0925733 0.185146599       0.925732997       0.178780994
         0.232017403       0.229727169       0.392146196       0.44667726        0.432078559       0.242359748       0.315911929
         0.678905778       3        2        1        2        4
709      C10      Sc29     C10      0.139276347       0.807391289       0.397676837       0.165354197       0.92750858
         0.34776586        0.750812103       0.725997985       43.5221926        0.133413638       45.92716747       69.4442434
         100.7044175       0.342126169       0        0        -2.40497487                                                0
         0        0        0.212063257       0.22017735        0.208648434       0.397570841       0.412858391       0.384413237
         0.19878542        0.206429195       0.192206618       2        1        3        2        5
710      C11      Sc29     C11      0.883306091       0.623672207       0.750942434       0.348898342       0.269927892
         0.895886218       0.42809119        0.964840047       43.45649947       0.310566916       27.7047949        9.30900598
         86.56844337       0.045862038       42.7798935        25.99502286       15.75170457       1        112.3632927
         93.63607728       187.2721546       936.3607728       0.059216483       0.118432965       0.592164827       0.316867923
         0.266455347       0.264174875       0.486389832       0.435666719       0.417511021       0.272803157       0.277049842
         0.504837924       3        2        1        3        1
711      C12      Sc29     C12      0.663441498       0.62169572        0.114745973       0.949489259       0.449912133
         0.578389614       0.408136803       0.23702698        45.00772944       0.264571047       4.249414046       102.6475506
         13.89093305       0.505706614       98.80545886       65.74518198       40.75831539       1        65.74518198
         54.78765165       109.5753033       547.8765165       0.034648312       0.069296624       0.346483121       0.220522508
         0.224798251       0.197499161       0.412829677       0.413879887       0.373184816       0.223738995       0.241588256
         0.359833968       3        2        1        3        2
712      C13      Sc29     C13      0.903379521       0.573679487       0.002870327       0.617144914       0.326644902
         0.527058102       0.885942099       0.35726976        43.90154741       0.067289973       35.3814082        16.75770835
         105.7477489       0.082559047       17.79728864       11.67610597       8.52013921
                 0         0        0        0.221712208       0.223609096       0.217157743       0.387200912       0.389670791
         0.373298543       0.193600456       0.194835395       0.186649271       2        1        3        3        3
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713     C14     Sc29    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     8.135060816     22.00870416
        101.4483754     0.108428766     94.76487598     60.77179459     37.83219942     1       60.77179459
        50.64316216     101.2863243     506.4316216     0.032027291     0.064054583     0.320272915     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.235562557       0.26584843
        0.345596707     3       2       1       3       4
714     C15     Sc29    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     12.56976515     59.18869803
        20.48338339     0.29160088      71.76100106     44.28470418     31.27530836
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
715     C16     Sc29    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     14.65631006     102.2141214
        75.14665628     0.503571269     69.54418298     50.05735266     29.29169422
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
716     C17     Sc29    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     34.12435122     89.95873932
        3.56627786      0.443193522     31.83490119     22.00823429     12.71324059
                0       0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592
        0.424898731     0.195078226     0.211045796     0.212449365     3       2       1       4       2
717     C18     Sc29    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     22.9036356      114.7069548
        14.82699307     0.56511885      55.33673428     37.90321646     23.72145029     1       49.57932244
        41.31610203     82.63220406     413.1610203     0.026128756     0.052257513     0.261287563     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.196227938     0.239913033
        0.294153591     3       2       1       4       3
718     C19     Sc29    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     10.86892611     90.00070565
        38.18171179     0.443400275     79.24738946     59.23782899     34.26558922
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
719     C20     Sc29    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     22.06151067     46.12331125
        19.64406076     0.227232539     45.81810536     29.6528947      22.7158163
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
720     C21     Sc29    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395       0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     6.320527548     48.98585736     89.96292202
        0.241335248     85.67694678     62.7998377      39.18347533                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
721     C22     Sc29    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252       44.80078867     84.62593646
        96.89993412     0.41692077      0.403606039     0.253494939     0.19745033      1       135.1189196
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        0.573845087     3       2       1       5       2
722     C23     Sc29    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     27.83832255     32.83555671
        41.4875192      0.161768675     41.36003036     29.99887503     19.14326949     1       189.7500282
        158.1250235     316.2500471     1581.250235     0.1     0.2     1       0.126338191     0.188706502
        0.135993177     0.31838757      0.379056788     0.311830131     0.209193785     0.289528394     0.655915066
        3       2       1       5       3
723     C24     Sc29    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     23.27815882     101.091395
        38.46617124     0.49804001      38.78959972     26.57572534     20.01520542
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
724     C25     Sc29    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     15.67428635     108.0009528
        14.23314753     0.532080852     69.99148435     42.54432854     31.21918952     1       42.54432854
        35.45360711     70.90721423     354.5360711     0.02242125      0.0448425 0.224212502       0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.249475361     0.229835431
        0.342410683     2       3       1       5       5
725     C01     Sc30    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451       12.87580124     6.870223806
        22.2596509      0.033847058     62.42411959     48.90874503     31.13447776     1       48.90874503
        40.75728752     81.51457505     407.5728752     0.028731427     0.057462854     0.287314272     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169637243     0.166449828
        0.275326199     2       3       1       1       1
726     C02     Sc30    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225        0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     29.42635114     34.9928391      3.448308502
        0.172396809     27.52504448     18.62880505     15.49742005                                                     0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
727     C03     Sc30    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     30.94623479     85.51575292
        55.36183542     0.421304567     36.88886179     24.41104586     15.05281111     1       82.53396202
        68.77830169     137.5566034     687.7830169     0.048484551     0.096969101     0.484845506     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.230853108     0.247453132
        0.41942751      3       2       1       1       3
728     C04     Sc30    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.068782832     3.698785078
        85.97992038     0.01822255      96.81050148     67.5666314      43.02065075
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
729     C05     Sc30    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     20.46126588     25.26080431
        50.3295197      0.124450664     64.92002577     40.61306943     25.97956223
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
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730       C06       Sc30      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         12.86420333         7.109863301
          57.96001621         0.035027674         72.87196588         46.41497204         30.62761708
                   0          0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
731       C07       Sc30      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         38.56409432         36.53268887
          2.665127499         0.179983081         9.58329726          7.562191182         5.28016834
                   0          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219
          0.339465132         0.168102684         0.166496609         0.169732566         2         3         1         2         2
732       C08       Sc30      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         9.588584809         78.84076537
          58.18750434         0.388419366         84.53164379         58.12291616         35.23496524
                   0          0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
733       C09       Sc30      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         4.433290049         37.21620286
          111.3518603         0.183350502         95.68180696         62.04764159         41.4397159          1         170.2273424
          141.8561187         283.7122374         1418.561187         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
734       C10       Sc30      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         52.4881914          69.4442434
          100.7044175         0.342126169         0         0         -8.9659988                                                            0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
735       C11       Sc30      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         31.66262274         9.30900598
          86.56844337         0.045862038         32.03086931         19.46342339         11.79387673         1         92.06939166
          76.72449305         153.4489861         767.2449305         0.054086136         0.108172272         0.540861358         0.316867923
          0.266455347         0.264174875         0.486389832         0.435666719         0.417511021         0.270237984         0.271919496
          0.47918619          3         2         1         3         1
736       C12       Sc30      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         4.856473196         102.6475506
          13.89093305         0.505706614         97.33383872         64.76596549         40.15125624         1         64.76596549
          53.97163791         107.9432758         539.7163791         0.038046747         0.076093493         0.380467465         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.225438212         0.24498669
          0.376826141         3         2         1         3         2
737       C13       Sc30      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         40.43589509         16.75770835
          105.7477489         0.082559047         7.239226161         4.749373545         3.46565232
                   0          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791
          0.373298543         0.193600456         0.194835395         0.186649271         2         1         3         3         3
738       C14       Sc30      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         9.297212361         22.00870416
          101.4483754         0.108428766         91.8538333          58.9049712          36.67004788         1         58.9049712
          49.087476 98.174952 490.87476 0.034603707         0.069207414         0.346037072         0.254748757         0.280125362
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739     C15     Sc30    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     14.36544588     59.18869803
        20.48338339     0.29160088      67.64082276     41.74208529     29.47962763
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
740     C16     Sc30    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     16.75006864     102.2141214
        75.14665628     0.503571269     64.57319262     46.47927312     27.19793564
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
741     C17     Sc30    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     38.99925854     89.95873932
        3.56627786      0.443193522     19.62777022     13.56915051     7.83833327
                0       0       0       0.154114011     0.183917483     0.218846089     0.390156452     0.422091592
        0.424898731     0.195078226     0.211045796     0.212449365     3       2       1       4       2
742     C18     Sc30    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     26.17558355     114.7069548
        14.82699307     0.56511885      47.70402582     32.67514862     20.44950234     1       37.42452217
        31.18710181     62.37420361     311.8710181     0.021985024     0.043970048     0.21985024      0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.194156072     0.235769301
        0.27343493      3       2       1       4       3
743     C19     Sc30    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     12.42162984     90.00070565
        38.18171179     0.443400275     75.65638985     56.55353842     32.71288549
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
744     C20     Sc30    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     25.21315506     46.12331125
        19.64406076     0.227232539     39.46119646     25.53878416     19.56417191
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
745     C21     Sc30    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     7.223460055     48.98585736     89.96292202
        0.241335248     83.70263236     61.35269667     38.28054283                                             0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
746     C22     Sc30    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252     51.20090133     84.62593646
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        202.3352005     1011.676003     0.071317051     0.142634102     0.713170508     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.276738416     0.309461313     0.57438581
        3       2       1       5       2
747     C23     Sc30    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     31.81522577     32.83555671
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          0.65454665          3         2         1         5         3
748       C24       Sc30      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
          0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         26.60361007         101.091395
          38.46617124         0.49804001          32.34485333         22.16026833         16.68975417
                    0         0         0         0.195074589         0.194999729         0.172101157         0.408593283         0.408513079
          0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
749       C25       Sc30      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
          0.234362086         0.616778357         0.949016321         46.89347587         0.063579986         17.91347011         108.0009528
          14.23314753         0.532080852         64.9713734          39.49285375         28.98000576         1         39.49285375
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          0.234608961         0.294051043         0.476529471         0.414828361         0.460608863         0.249864768         0.230614245
          0.346304756         2         3         1         5         5
750       C01       Sc31      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         14.4852764          6.870223806
          22.2596509          0.033847058         59.19714817         46.38044149         29.5250026          1         46.38044149
          38.65036791         77.30073582         386.5036791         0.028144014         0.056288029         0.281440144         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.169343536         0.165862415
          0.272389135         2         3         1         1         1
751       C02       Sc31      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         33.10464503         34.9928391          3.448308502
          0.172396809         20.99200849         14.20728072         11.81912616                                                         0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
752       C03       Sc31      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         34.81451414         85.51575292
          55.36183542         0.421304567         27.4091426          18.1378824          11.18453176         1         74.28365559
          61.90304633         123.8060927         619.0304633         0.045075903         0.090151806         0.450759028         0.25038454
          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513         0.229148784         0.244044484
          0.402384271         3         2         1         1         3
753       C04       Sc31      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         3.452380686         3.698785078
          85.97992038         0.01822255          95.94728114         66.9641669          42.63705289
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
754       C05       Sc31      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         23.01892412         25.26080431
          50.3295197          0.124450664         58.52872335         36.61475912         23.42190399
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
755       C06       Sc31      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         14.47222875         7.109863301
          57.96001621         0.035027674         69.04600798         43.97807155         29.01959166
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
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756     C07     Sc31    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     43.38460611     36.53268887
        2.665127499     0.179983081     0.834258507     0.658314373     0.45965655
                0       0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219
        0.339465132     0.168102684     0.166496609     0.169732566     2       3       1       2       2
757     C08     Sc31    C08     0.574117605     0.146728575     0.589305537     0.69975836      0.102334429
        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     10.78715791     78.84076537
        58.18750434     0.388419366     81.65616615     56.14577319     34.03639214
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
758     C09     Sc31    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     4.987451305     37.21620286
        111.3518603     0.183350502     94.40228201     61.21789654     40.88555465     1       164.7968226
        137.3306855     274.6613709     1373.306855     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
759     C10     Sc31    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     59.04921532     69.4442434
        100.7044175     0.342126169     0       0       -15.52702272                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
760     C11     Sc31    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     35.62045058     9.30900598
        86.56844337     0.045862038     21.28184512     12.93182392     7.83604889      1       71.77549057
        59.81290881     119.6258176     598.1290881     0.043553929     0.087107857     0.435539287     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.26497188      0.261387288
        0.426525154     2       3       1       3       1
761     C12     Sc31    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     5.463532345     102.6475506
        13.89093305     0.505706614     95.86221858     63.78674901     39.5441971      1       63.78674901
        53.15562418     106.3112484     531.5562418     0.038706298     0.077412596     0.387062979     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.225767988     0.245646242
        0.380123897     3       2       1       3       2
762     C13     Sc31    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     45.49038198     16.75770835
        105.7477489     0.082559047     0       0       -1.58883457                                     0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
763     C14     Sc31    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     10.45936391     22.00870416
        101.4483754     0.108428766     88.94279062     57.0381478      35.50789633     1       57.0381478
        47.53178983     95.06357966     475.3178983     0.034611194     0.069222388     0.346111939     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236854508       0.268432332
        0.35851622      3       2       1       3       4
764     C15     Sc31    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     16.16112662     59.18869803
        20.48338339     0.29160088      63.52064444     39.19946638     27.68394689
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          0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
         0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
765      C16       Sc31      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
         0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         18.84382722         102.2141214
         75.14665628         0.503571269         59.60220225         42.90119359         25.10417706
          0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
         0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
766      C17       Sc31      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
         0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         43.87416586         89.95873932
         3.56627786          0.443193522         7.420639264         5.130066733         2.96342595
          0         0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592
         0.424898731         0.195078226         0.211045796         0.212449365         3         2         1         4         2
767      C18       Sc31      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
         0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         29.44753149         114.7069548
         14.82699307         0.56511885          40.07131739         27.4470808          17.1775544          1         27.4470808
         22.87256733         45.74513466         228.7256733         0.016655103         0.033310206         0.166551032         0.168545737
         0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.191491112         0.23043938
         0.246785326         3         2         1         4         3
768      C19       Sc31      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
         0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         13.97433357         90.00070565
         38.18171179         0.443400275         72.06539025         53.86924785         31.16018176
          0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
         0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
769      C20       Sc31      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
         0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         28.36479944         46.12331125
         19.64406076         0.227232539         33.10428759         21.42467364         16.41252753
          0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
         0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
770      C21       Sc31      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
         0.070022144         0.486345111         45.50400288         0.252623045         8.126392562         48.98585736         89.96292202
         0.241335248         81.72831794         59.90555564         37.37761032                                                   0
         0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
         0.184443254         0.17732464          0.165746932         1         2         3         5         1
771      C22       Sc31      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
         0.380141173         0.550948219         0.745334431         44.998239 0.032643252         57.601014 84.62593646         96.89993412
         0.41692077          0         0         -12.602775          1         107.936816          89.94734663         179.8946933
         899.4734663         0.065496904         0.130993807         0.654969036         0.273632139         0.256849416         0.255171744
         0.482159781         0.476288524         0.435601111         0.273828342         0.303641166         0.545285074         3         2
         1         5         2
772      C23       Sc31      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
         0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         35.792129 32.83555671
         41.4875192          0.161768675         24.17541744         17.53469038         11.18946304         1         149.7728896
         124.8107413         249.6214826         1248.107413         0.09088336          0.18176672          0.9088336 0.126338191
         0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.204635465         0.280411754
         0.610331866         3         2         1         5         3
773      C24       Sc31      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
         0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         29.92906133         101.091395
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        38.46617124     0.49804001      25.90010692     17.74481131     13.36430291
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        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
774     C25     Sc31    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     20.15265387     108.0009528
        14.23314753     0.532080852     59.95126245     36.44137897     26.740822 1     36.44137897     30.36781581
        60.73563162     303.6781581     0.022112914     0.044225827     0.221129136     0.297089204     0.234608961
        0.294051043     0.476529471     0.414828361     0.460608863     0.249321192     0.229527094     0.340869  2
        3       1       5       5
775     C01     Sc32    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451       16.09475155     6.870223806
        22.2596509      0.033847058     55.97017677     43.85213797     27.91552745     1       43.85213797
        36.54344831     73.08689662     365.4344831     0.027516569     0.055033137     0.275165686     0.125908042
        0.105685808     0.089720661     0.310543058     0.275436802     0.263338126     0.169029813     0.165234969
        0.269251906     2       3       1       1       1
776     C02     Sc32    C02     0.396767474     0.538816734     0.419194514     0.6852195 0.20445225        0.878117436
        0.027387593     0.67046751      44.92377119     0.012963116     36.78293892     34.9928391      3.448308502
        0.172396809     14.4589725      9.78575639      8.14083227                                              0
        0       0       0.257404041     0.194814404     0.208494062     0.445364891     0.378338276     0.386777277
        0.222682445     0.189169138     0.193388639     1       3       2       1       2
777     C03     Sc32    C03     0.417304802     0.558689828     0.140386939     0.198101489     0.800744569
        0.968261576     0.313424178     0.692322616     45.9990459      0.274831239     38.68279349     85.51575292
        55.36183542     0.421304567     17.92942341     11.86471894     7.31625241      1       66.03334916
        55.02779097     110.0555819     550.2779097     0.041434951     0.082869902     0.414349508     0.25038454
        0.237553697     0.192031501     0.413221665     0.397937162     0.354009513     0.227328308     0.240403532
        0.384179511     3       2       1       1       3
778     C04     Sc32    C04     0.876389152     0.894606664     0.085044211     0.039054783     0.16983042
        0.878142503     0.098346834     0.421107625     46.08943358     0.217661196     3.83597854      3.698785078
        85.97992038     0.01822255      95.08406081     66.3617024      42.25345504
                0       0       0       0.214732899     0.18442312      0.126095549     0.407884499     0.379289941
        0.3266149 0.203942249   0.189644971     0.16330745      1       2       3       1       4
779     C05     Sc32    C05     0.95788953      0.533165285     0.691877114     0.315515631     0.686500928
        0.834625672     0.018288277     0.750144315     46.44082811     0.210183901     25.57658235     25.26080431
        50.3295197      0.124450664     52.13742096     32.61644881     20.86424576
                0       0       0       0.286047241     0.291180307     0.19489221      0.44509345      0.451505602
        0.365064068     0.222546725     0.225752801     0.182532034     2       1       3       1       5
780     C06     Sc32    C06     0.988861089     0.748165654     0.280443992     0.789279328     0.103226007
        0.447893526     0.908595503     0.293614148     43.49182041     0.165167411     16.08025417     7.109863301
        57.96001621     0.035027674     65.22005008     41.54117107     27.41156624
                0       0       0       0.231167154     0.224930393     0.238148451     0.424363564     0.406410035
        0.410044838     0.212181782     0.203205018     0.205022419     1       3       2       2       1
781     C07     Sc32    C07     0.287775339     0.130028572     0.019366958     0.678835533     0.211628116
        0.265546659     0.491573159     0.053362545     43.84426266     0.102324317     48.2051179      36.53268887
        2.665127499     0.179983081     0       0       -4.36085524                                             0
        0       0       0.108835421     0.116048175     0.133699741     0.336205368     0.332993219     0.339465132
        0.168102684     0.166496609     0.169732566     2       3       1       2       2
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        0.414055988     0.694400158     0.41417927      44.82355005     0.309635483     11.98573101     78.84076537
        58.18750434     0.388419366     78.78068852     54.16863022     32.83781904
                0       0       0       0.195954796     0.182760584     0.225479264     0.378522006     0.365489003
        0.396290772     0.189261003     0.182744501     0.198145386     2       3       1       2       3
783     C09     Sc32    C09     0.049953459     0.535896406     0.663794645     0.514889112     0.944594756
        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     5.541612561     37.21620286
        111.3518603     0.183350502     93.12275706     60.3881515      40.33139339     1       159.3663027
        132.8052523     265.6105045     1328.052523     0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
784     C10     Sc32    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     65.61023925     69.4442434
        100.7044175     0.342126169     0       0       -22.08804665                                    0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
785     C11     Sc32    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     39.57827842     9.30900598
        86.56844337     0.045862038     10.53282093     6.400224457     3.87822105      1       57.72715192
        48.10595993     96.21191986     481.0595993     0.036222935     0.07244587      0.362229348     0.316867923
        0.266455347     0.264174875     0.486389832     0.435666719     0.417511021     0.261306383     0.254056294
        0.389870185     2       3       1       3       1
786     C12     Sc32    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.070591495     102.6475506
        13.89093305     0.505706614     94.39059844     62.80753253     38.93713794     1       62.80753253
        52.33961044     104.6792209     523.3961044     0.039410799     0.078821597     0.394107986     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226120238     0.246350742
        0.383646401     3       2       1       3       2
787     C13     Sc32    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     50.54486886     16.75770835
        105.7477489     0.082559047     0       0       -6.64332145                                     0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
788     C14     Sc32    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     11.62151545     22.00870416
        101.4483754     0.108428766     86.03174795     55.17132441     34.34574479     1       55.17132441
        45.97610368     91.95220735     459.7610368     0.034619191     0.069238382     0.346191908     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236858507     0.268440329
        0.358556204     3       2       1       3       4
789     C15     Sc32    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     17.95680735     59.18869803
        20.48338339     0.29160088      59.40046614     36.65684749     25.88826616
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
790     C16     Sc32    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     20.9375858      102.2141214
        75.14665628     0.503571269     54.63121188     39.32311405     23.01041848
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791     C17       Sc32      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
        0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         48.74907317         89.95873932
        3.56627786          0.443193522         0         0         -1.91148136                                                     0
        0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
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792     C18       Sc32      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
        0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         32.71947943         114.7069548
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        18.51584414         37.03168829         185.1584414         0.013942102         0.027884205         0.139421023         0.168545737
        0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.190134611         0.227726379
        0.233220321         3         2         1         4         3
793     C19       Sc32      C19       0.044551879         0.107494129         0.225709339         0.71298898          0.559716982
        0.01255598          0.07197428          0.96727633          45.13451533         0.423280743         15.52703729         90.00070565
        38.18171179         0.443400275         68.47439068         51.1849573          29.60747804
                 0         0         0         0.19335296          0.154863434         0.16721044          0.416396653         0.388253269
        0.385127801         0.208198327         0.194126634         0.192563901         1         2         3         4         4
794     C20       Sc32      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
        0.581358927         0.970019989         0.846828801         44.77732697         0.039822739         31.51644382         46.12331125
        19.64406076         0.227232539         26.74737871         17.31056311         13.26088315
                 0         0         0         0.266503103         0.213730709         0.290225506         0.462800059         0.417820608
        0.473734591         0.23140003          0.208910304         0.236867296         2         3         1         4         5
795     C21       Sc32      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
        0.070022144         0.486345111         45.50400288         0.252623045         9.029325069         48.98585736         89.96292202
        0.241335248         79.75400352         58.45841461         36.47467781                                                     0
        0         0         0.167087112         0.139838178         0.158385453         0.368886507         0.35464928          0.331493863
        0.184443254         0.17732464          0.165746932         1         2         3         5         1
796     C22       Sc32      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
        0.380141173         0.550948219         0.745334431         44.998239 0.032643252         64.00112666         84.62593646
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        0.255171744         0.482159781         0.476288524         0.435601111         0.271758123         0.299500727         0.524582877
        3         2         1         5         2
797     C23       Sc32      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
        0.21017401          0.752755554         0.066536481         46.98159204         0.214061164         39.76903222         32.83555671
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        0.188706502         0.135993177         0.31838757          0.379056788         0.311830131         0.199912657         0.270966137
        0.563103781         3         2         1         5         3
798     C24       Sc32      C24       0.260315099         0.804754564         0.193434283         0.639460881         0.524670309
        0.92480797          0.26329677          0.065961091         43.29336424         0.048265458         33.25451259         101.091395
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        0.377206528         0.204296641         0.204256539         0.188603264         1         2         3         5         4
799     C25       Sc32      C25       0.735065963         0.77217803          0.907815853         0.931972069         0.013951573
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         22.2596509        0.033847058       52.74320535       41.32383444       26.30605229       1        41.32383444
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801      C02      Sc33     C02      0.396767474       0.538816734       0.419194514       0.6852195 0.20445225        0.878117436
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         0        0        0.257404041       0.194814404       0.208494062       0.445364891       0.378338276       0.386777277
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         0.968261576       0.313424178       0.692322616       45.9990459        0.274831239       42.55107284       85.51575292
         55.36183542       0.421304567       8.449704227       5.591555482       3.44797306        1        57.78304274
         48.15253561       96.30507123       481.5253561       0.037537109       0.075074218       0.375371091       0.25038454
         0.237553697       0.192031501       0.413221665       0.397937162       0.354009513       0.225379387       0.23650569
         0.364690302       3        2        1        1        3
803      C04      Sc33     C04      0.876389152       0.894606664       0.085044211       0.039054783       0.16983042
         0.878142503       0.098346834       0.421107625       46.08943358       0.217661196       4.219576394       3.698785078
         85.97992038       0.01822255        94.22084047       65.7592379        41.86985719
                  0        0        0        0.214732899       0.18442312        0.126095549       0.407884499       0.379289941
         0.3266149 0.203942249       0.189644971       0.16330745        1        2        3        1        4
804      C05      Sc33     C05      0.95788953        0.533165285       0.691877114       0.315515631       0.686500928
         0.834625672       0.018288277       0.750144315       46.44082811       0.210183901       28.13424059       25.26080431
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         0.365064068       0.222546725       0.225752801       0.182532034       2        1        3        1        5
805      C06      Sc33     C06      0.988861089       0.748165654       0.280443992       0.789279328       0.103226007
         0.447893526       0.908595503       0.293614148       43.49182041       0.165167411       17.68827958       7.109863301
         57.96001621       0.035027674       61.3940922        39.1042706        25.80354083
                  0        0        0        0.231167154       0.224930393       0.238148451       0.424363564       0.406410035
         0.410044838       0.212181782       0.203205018       0.205022419       1        3        2        2        1
806      C07      Sc33     C07      0.287775339       0.130028572       0.019366958       0.678835533       0.211628116
         0.265546659       0.491573159       0.053362545       43.84426266       0.102324317       53.02562969       36.53268887
         2.665127499       0.179983081       0        0        -9.18136703                                                 0
         0        0        0.108835421       0.116048175       0.133699741       0.336205368       0.332993219       0.339465132
         0.168102684       0.166496609       0.169732566       2        3        1        2        2
807      C08      Sc33     C08      0.574117605       0.146728575       0.589305537       0.69975836        0.102334429
         0.414055988       0.694400158       0.41417927        44.82355005       0.309635483       13.18430411       78.84076537
         58.18750434       0.388419366       75.90521089       52.19148725       31.63924594
                  0        0        0        0.195954796       0.182760584       0.225479264       0.378522006       0.365489003
         0.396290772       0.189261003       0.182744501       0.198145386       2        3        1        2        3
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        0.586555041     0.903401915     0.137474704     45.87300595     0.149827337     6.095773817     37.21620286
        111.3518603     0.183350502     91.84323212     59.55840645     39.77723213     1       153.9357828
        128.279819      256.5596381     1282.79819      0.1     0.2     1       0.178780994     0.232017403
        0.229727169     0.392146196     0.44667726      0.432078559     0.246073098     0.32333863      0.716039279
        3       2       1       2       4
809     C10     Sc33    C10     0.139276347     0.807391289     0.397676837     0.165354197     0.92750858
        0.34776586      0.750812103     0.725997985     43.5221926      0.133413638     72.17126317     69.4442434
        100.7044175     0.342126169     0       0       -28.64907057                                            0
        0       0       0.212063257     0.22017735      0.208648434     0.397570841     0.412858391     0.384413237
        0.19878542      0.206429195     0.192206618     2       1       3       2       5
810     C11     Sc33    C11     0.883306091     0.623672207     0.750942434     0.348898342     0.269927892
        0.895886218     0.42809119      0.964840047     43.45649947     0.310566916     43.53610626     9.30900598
        86.56844337     0.045862038     0       0       -0.07960679     1       44.46850265     37.05708554
        74.11417108     370.5708554     0.028887697     0.057775394     0.288876971     0.316867923     0.266455347
        0.264174875     0.486389832     0.435666719     0.417511021     0.257638765     0.246721057     0.353193996
        2       3       1       3       1
811     C12     Sc33    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      45.00772944     0.264571047     6.677650644     102.6475506
        13.89093305     0.505706614     92.9189783      61.82831605     38.3300788      1       61.82831605
        51.5235967      103.0471934     515.235967      0.040165006     0.080330012     0.401650058     0.220522508
        0.224798251     0.197499161     0.412829677     0.413879887     0.373184816     0.226497342     0.247104949
        0.387417437     3       2       1       3       2
812     C13     Sc33    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      43.90154741     0.067289973     55.59935575     16.75770835
        105.7477489     0.082559047     0       0       -11.69780834                                            0
        0       0       0.221712208     0.223609096     0.217157743     0.387200912     0.389670791     0.373298543
        0.193600456     0.194835395     0.186649271     2       1       3       3       3
813     C14     Sc33    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      45.96726024     0.256789061     12.783667 22.00870416
        101.4483754     0.108428766     83.12070527     53.30450101     33.18359324     1       53.30450101
        44.42041751     88.84083501     444.2041751     0.034627752     0.069255504     0.346277519     0.254748757
        0.280125362     0.188733628     0.439097823     0.467642276     0.3709205 0.236862787       0.26844889
        0.35859901      3       2       1       3       4
814     C15     Sc33    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     43.84507351     0.092219933     19.75248809     59.18869803
        20.48338339     0.29160088      55.28028782     34.11422858     24.09258542
                0       0       0       0.251517278     0.292575574     0.225051384     0.421654228     0.461972982
        0.38826343      0.210827114     0.230986491     0.194131715     2       1       3       3       5
815     C16     Sc33    C16     0.019880134     0.026210987     0.028306488     0.246211068     0.860027949
        0.538831064     0.552821979     0.842030892     43.94800428     0.392667574     23.03134438     102.2141214
        75.14665628     0.503571269     49.66022151     35.74503452     20.9166599
                0       0       0       0.198021052     0.185581091     0.191572754     0.409469615     0.400700715
        0.376351488     0.204734808     0.200350357     0.188175744     1       2       3       4       1
816     C17     Sc33    C17     0.124173315     0.279183679     0.585759271     0.969595748     0.561030219
        0.018647289     0.800632673     0.232974274     46.83759181     0.426987646     53.62398049     89.95873932
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817     C18     Sc33    C18     0.807105196     0.387860644     0.863541855     0.747121643     0.556240234
        0.136455226     0.05991769      0.121343456     46.62508589     0.247118419     35.99142738     114.7069548
        14.82699307     0.56511885      24.80590049     16.99094513     10.63365851     1       16.99094513
        14.15912094     28.31824188     141.5912094     0.011037684     0.022075368     0.110376839     0.168545737
        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.188682402     0.224821961
        0.218698229     3       1       2       4       3
818     C19     Sc33    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     17.07974102     90.00070565
        38.18171179     0.443400275     64.88339108     48.50066673     28.05477431
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
819     C20     Sc33    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     34.6680882      46.12331125
        19.64406076     0.227232539     20.39046984     13.19645259     10.10923877
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
820     C21     Sc33    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395     0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     9.932257576     48.98585736     89.96292202
        0.241335248     77.7796891      57.01127357     35.5717453                                              0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
821     C22     Sc33    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252       70.40123933     84.62593646
        96.89993412     0.41692077      0       0       -25.40300033    1       92.75630809     77.29692341
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        0.255171744     0.482159781     0.476288524     0.435601111     0.271208138     0.298400758     0.519083033
        3       2       1       5       2
822     C23     Sc33    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     43.74593544     32.83555671
        41.4875192      0.161768675     6.990804538     5.070505748     3.2356566 1     109.7957509     91.49645909
        182.9929182     914.9645909     0.071325685     0.142651369     0.713256846     0.126338191     0.188706502
        0.135993177     0.31838757      0.379056788     0.311830131     0.194856627     0.260854078     0.512543489
        3       2       1       5       3
823     C24     Sc33    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     36.57996385     101.091395
        38.46617124     0.49804001      13.0106141      8.913897266     6.71340039
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
824     C25     Sc33    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     24.6310214      108.0009528
        14.23314753     0.532080852     49.91104053     30.33842939     22.26245447     1       30.33842939
        25.28202449     50.56404899     252.8202449     0.019708497     0.039416994     0.197084972     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.248118984     0.227122678
        0.328846918     2       3       1       5       5
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825       C01       Sc34      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         44.010279 0.217997451         19.31370186         6.870223806
          22.2596509          0.033847058         49.51623395         38.79553091         24.69657714         1         38.79553091
          32.3296091          64.65921819         323.296091          0.026124011         0.052248022         0.261240108         0.125908042
          0.105685808         0.089720661         0.310543058         0.275436802         0.263338126         0.168333535         0.163842412
          0.262289117         2         3         1         1         1
826       C02       Sc34      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         44.13952671         34.9928391          3.448308502
          0.172396809         1.392900504         0.94270772          0.78424448                                                            0
          0         0         0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277
          0.222682445         0.189169138         0.193388639         1         3         2         1         2
827       C03       Sc34      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         46.41935219         85.51575292
          55.36183542         0.421304567         0         0         -0.42030629         1         50.21434428         41.8452869
          83.69057381         418.452869          0.033813175         0.06762635          0.338131749         0.25038454          0.237553697
          0.192031501         0.413221665         0.397937162         0.354009513         0.22351742          0.232781756         0.346070631
          3         2         1         1         3
828       C04       Sc34      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         4.603174248         3.698785078
          85.97992038         0.01822255          93.35762014         65.1567734          41.48625933
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
829       C05       Sc34      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         30.69189882         25.26080431
          50.3295197          0.124450664         39.35481615         24.6198282          15.74892929
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
830       C06       Sc34      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         19.296305 7.109863301
          57.96001621         0.035027674         57.5681343          36.66737012         24.19551541
                    0         0         0         0.231167154         0.224930393         0.238148451         0.424363564         0.406410035
          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
831       C07       Sc34      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         57.84614148         36.53268887
          2.665127499         0.179983081         0         0         -14.00187882                                                          0
          0         0         0.108835421         0.116048175         0.133699741         0.336205368         0.332993219         0.339465132
          0.168102684         0.166496609         0.169732566         2         3         1         2         2
832       C08       Sc34      C08       0.574117605         0.146728575         0.589305537         0.69975836          0.102334429
          0.414055988         0.694400158         0.41417927          44.82355005         0.309635483         14.38287721         78.84076537
          58.18750434         0.388419366         73.02973326         50.21434428         30.44067284
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
833       C09       Sc34      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         6.649935073         37.21620286
          111.3518603         0.183350502         90.56370717         58.7286614          39.22307088         1         148.505263
          123.7543858         247.5087717         1237.543858         0.1       0.2       1         0.178780994         0.232017403
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          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
834       C10       Sc34      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         78.7322871          69.4442434
          100.7044175         0.342126169         0         0         -35.2100945                                                           0
          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
835       C11       Sc34      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         47.49393411         9.30900598
          86.56844337         0.045862038         0         0         -4.03743464         1         37.61007784         31.34173153
          62.68346306         313.4173153         0.025325754         0.050651508         0.253257542         0.316867923         0.266455347
          0.264174875         0.486389832         0.435666719         0.417511021         0.255857793         0.243159114         0.335384281
          2         3         1         3         1
836       C12       Sc34      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         7.284709793         102.6475506
          13.89093305         0.505706614         91.44735816         60.84909956         37.72301965         1         60.84909956
          50.70758297         101.4151659         507.0758297         0.040974372         0.081948745         0.409743724         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.226902025         0.247914316
          0.39146427          3         2         1         3         2
837       C13       Sc34      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         60.65384264         16.75770835
          105.7477489         0.082559047         0         0         -16.75229523                                                          0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
838       C14       Sc34      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         13.94581854         22.00870416
          101.4483754         0.108428766         80.2096626          51.43767762         32.0214417          1         51.43767762
          42.86473135         85.7294627          428.6473135         0.034636939         0.069273878         0.346369392         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236867381         0.268458077
          0.358644946         3         2         1         3         4
839       C15       Sc34      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         21.54816882         59.18869803
          20.48338339         0.29160088          51.16010952         31.57160969         22.29690469
                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
840       C16       Sc34      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         25.12510296         102.2141214
          75.14665628         0.503571269         44.68923115         32.16695499         18.82290132
                    0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
841       C17       Sc34      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         58.49888781         89.95873932
          3.56627786          0.443193522         0         0         -11.661296                                                            0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
842       C18       Sc34      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
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        0.230647918     0.139241534     0.36632712      0.427568554     0.327019619     0.187123984     0.221705126
        0.203114054     3       1       2       4       3
843     C19     Sc34    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     18.63244475     90.00070565
        38.18171179     0.443400275     61.29239148     45.81637616     26.50207058
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
844     C20     Sc34    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     37.81973259     46.12331125
        19.64406076     0.227232539     14.03356094     9.082342047     6.95759438
                0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
845     C21     Sc34    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395   0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     10.83519008     48.98585736     89.96292202
        0.241335248     75.80537469     55.56413255     34.6688128                                              0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
846     C22     Sc34    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252   76.801352 84.62593646    96.89993412
        0.41692077      0       0       -31.803113      1       87.73108753     73.10923961     146.2184792
        731.0923961     0.05907608      0.118152159     0.590760797     0.273632139     0.256849416     0.255171744
        0.482159781     0.476288524     0.435601111     0.27061793      0.297220342     0.513180954     3       2
        1       5       2
847     C23     Sc34    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     47.72283866     32.83555671
        41.4875192      0.161768675     0       0       -0.74124662     1       90.96876813     75.80730678
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        0.135993177     0.31838757      0.379056788     0.311830131     0.189821914     0.250784653     0.462196359
        3       2       1       5       3
848     C24     Sc34    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     39.90541511     101.091395
        38.46617124     0.49804001      6.565867693     4.498440244     3.38794913
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
849     C25     Sc34    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     26.87020516     108.0009528
        14.23314753     0.532080852     44.89092959     27.28695461     20.02327071     1       27.28695461
        22.73912884     45.47825769     227.3912884     0.018374402     0.036748805     0.183744024     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.247451937     0.225788583
        0.322176444     2       3       1       5       5
850     C01     Sc35    C01     0.417022005     0.720324493     0.000114375     0.302332573     0.146755891
        0.092338595     0.186260211     0.345560727     44.010279 0.217997451   20.92317702     6.870223806
        22.2596509      0.033847058     46.28926253     36.26722738     23.08710198     1       36.26722738
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851       C02       Sc35      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          44.92377119         0.012963116         47.8178206          34.9928391          3.448308502
          0.172396809         0         0         -2.89404941                                                   0         0         0
          0.257404041         0.194814404         0.208494062         0.445364891         0.378338276         0.386777277         0.222682445
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852       C03       Sc35      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         45.9990459          0.274831239         50.28763154         85.51575292
          55.36183542         0.421304567         0         0         -4.28858564         1         48.23720131         40.19766776
          80.39533552         401.9766776         0.033714687         0.067429373         0.337146866         0.25038454          0.237553697
          0.192031501         0.413221665         0.397937162         0.354009513         0.223468176         0.232683268         0.34557819
          3         2         1         1         3
853       C04       Sc35      C04       0.876389152         0.894606664         0.085044211         0.039054783         0.16983042
          0.878142503         0.098346834         0.421107625         46.08943358         0.217661196         4.986772102         3.698785078
          85.97992038         0.01822255          92.4943998          64.5543089          41.10266148
                    0         0         0         0.214732899         0.18442312          0.126095549         0.407884499         0.379289941
          0.3266149 0.203942249         0.189644971         0.16330745          1         2         3         1         4
854       C05       Sc35      C05       0.95788953          0.533165285         0.691877114         0.315515631         0.686500928
          0.834625672         0.018288277         0.750144315         46.44082811         0.210183901         33.24955706         25.26080431
          50.3295197          0.124450664         32.96351374         20.62151788         13.19127105
                    0         0         0         0.286047241         0.291180307         0.19489221          0.44509345          0.451505602
          0.365064068         0.222546725         0.225752801         0.182532034         2         1         3         1         5
855       C06       Sc35      C06       0.988861089         0.748165654         0.280443992         0.789279328         0.103226007
          0.447893526         0.908595503         0.293614148         43.49182041         0.165167411         20.90433042         7.109863301
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          0.410044838         0.212181782         0.203205018         0.205022419         1         3         2         2         1
856       C07       Sc35      C07       0.287775339         0.130028572         0.019366958         0.678835533         0.211628116
          0.265546659         0.491573159         0.053362545         43.84426266         0.102324317         62.66665327         36.53268887
          2.665127499         0.179983081         0         0         -18.82239061                                                            0
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          58.18750434         0.388419366         70.15425563         48.23720131         29.24209974
                    0         0         0         0.195954796         0.182760584         0.225479264         0.378522006         0.365489003
          0.396290772         0.189261003         0.182744501         0.198145386         2         3         1         2         3
858       C09       Sc35      C09       0.049953459         0.535896406         0.663794645         0.514889112         0.944594756
          0.586555041         0.903401915         0.137474704         45.87300595         0.149827337         7.204096329         37.21620286
          111.3518603         0.183350502         89.28418222         57.89891636         38.66890962         1         143.0747431
          119.2289526         238.4579052         1192.289526         0.1       0.2       1         0.178780994         0.232017403
          0.229727169         0.392146196         0.44667726          0.432078559         0.246073098         0.32333863          0.716039279
          3         2         1         2         4
859       C10       Sc35      C10       0.139276347         0.807391289         0.397676837         0.165354197         0.92750858
          0.34776586          0.750812103         0.725997985         43.5221926          0.133413638         85.29331103         69.4442434
          100.7044175         0.342126169         0         0         -41.77111843                                                            0
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          0         0         0.212063257         0.22017735          0.208648434         0.397570841         0.412858391         0.384413237
          0.19878542          0.206429195         0.192206618         2         1         3         2         5
860       C11       Sc35      C11       0.883306091         0.623672207         0.750942434         0.348898342         0.269927892
          0.895886218         0.42809119          0.964840047         43.45649947         0.310566916         51.45176195         9.30900598
          86.56844337         0.045862038         0         0         -7.99526248         1         34.23046963         28.52539136
          57.05078272         285.2539136         0.023924886         0.047849773         0.239248863         0.316867923         0.266455347
          0.264174875         0.486389832         0.435666719         0.417511021         0.255157359         0.241758246         0.328379942
          2         3         1         3         1
861       C12       Sc35      C12       0.663441498         0.62169572          0.114745973         0.949489259         0.449912133
          0.578389614         0.408136803         0.23702698          45.00772944         0.264571047         7.891768944         102.6475506
          13.89093305         0.505706614         89.97573802         59.86988308         37.1159605          1         59.86988308
          49.89156923         99.78313846         498.9156923         0.041845179         0.083690359         0.418451795         0.220522508
          0.224798251         0.197499161         0.412829677         0.413879887         0.373184816         0.227337428         0.248785123
          0.395818305         3         2         1         3         2
862       C13       Sc35      C13       0.903379521         0.573679487         0.002870327         0.617144914         0.326644902
          0.527058102         0.885942099         0.35726976          43.90154741         0.067289973         65.70832952         16.75770835
          105.7477489         0.082559047         0         0         -21.80678211                                                          0
          0         0         0.221712208         0.223609096         0.217157743         0.387200912         0.389670791         0.373298543
          0.193600456         0.194835395         0.186649271         2         1         3         3         3
863       C14       Sc35      C14       0.908535151         0.623360116         0.015821243         0.929437234         0.690896918
          0.99732285          0.172340508         0.13713575          45.96726024         0.256789061         15.10797009         22.00870416
          101.4483754         0.108428766         77.29861992         49.57085422         30.85929015         1         49.57085422
          41.30904518         82.61809036         413.0904518         0.034646824         0.069293648         0.346468238         0.254748757
          0.280125362         0.188733628         0.439097823         0.467642276         0.3709205 0.236872323         0.268467962
          0.358694369         3         2         1         3         4
864       C15       Sc35      C15       0.932595463         0.696818161         0.066000173         0.755463053         0.753876188
          0.923024536         0.711524759         0.124270962         43.84507351         0.092219933         23.34384956         59.18869803
          20.48338339         0.29160088          47.0399312          29.02899078         20.50122395
                    0         0         0         0.251517278         0.292575574         0.225051384         0.421654228         0.461972982
          0.38826343          0.210827114         0.230986491         0.194131715         2         1         3         3         5
865       C16       Sc35      C16       0.019880134         0.026210987         0.028306488         0.246211068         0.860027949
          0.538831064         0.552821979         0.842030892         43.94800428         0.392667574         27.21886154         102.2141214
          75.14665628         0.503571269         39.71824078         28.58887545         16.72914274
                    0         0         0         0.198021052         0.185581091         0.191572754         0.409469615         0.400700715
          0.376351488         0.204734808         0.200350357         0.188175744         1         2         3         4         1
866       C17       Sc35      C17       0.124173315         0.279183679         0.585759271         0.969595748         0.561030219
          0.018647289         0.800632673         0.232974274         46.83759181         0.426987646         63.37379512         89.95873932
          3.56627786          0.443193522         0         0         -16.53620331                                                          0
          0         0         0.154114011         0.183917483         0.218846089         0.390156452         0.422091592         0.424898731
          0.195078226         0.211045796         0.212449365         3         2         1         4         2
867       C18       Sc35      C18       0.807105196         0.387860644         0.863541855         0.747121643         0.556240234
          0.136455226         0.05991769          0.121343456         46.62508589         0.247118419         42.53532326         114.7069548
          14.82699307         0.56511885          9.54048362          6.534809481         4.08976263          1         6.534809481
          5.445674567         10.89134913         54.45674567         0.00456741          0.009134819         0.045674095         0.168545737
          0.230647918         0.139241534         0.36632712          0.427568554         0.327019619         0.185447265         0.218351687
          0.186346857         3         1         2         4         3
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868     C19     Sc35    C19     0.044551879     0.107494129     0.225709339     0.71298898      0.559716982
        0.01255598      0.07197428      0.96727633      45.13451533     0.423280743     20.18514848     90.00070565
        38.18171179     0.443400275     57.70139188     43.13208559     24.94936685
                0       0       0       0.19335296      0.154863434     0.16721044      0.416396653     0.388253269
        0.385127801     0.208198327     0.194126634     0.192563901     1       2       3       4       4
869     C20     Sc35    C20     0.568100462     0.203293235     0.252325745     0.743825854     0.195429481
        0.581358927     0.970019989     0.846828801     44.77732697     0.039822739     40.97137697     46.12331125
        19.64406076     0.227232539     7.676652064     4.968231522     3.80595
        0       0       0       0.266503103     0.213730709     0.290225506     0.462800059     0.417820608
        0.473734591     0.23140003      0.208910304     0.236867296     2       3       1       4       5
870     C21     Sc35    C21     0.239847759     0.493769714     0.619955718     0.8289809 0.156791395   0.018576202
        0.070022144     0.486345111     45.50400288     0.252623045     11.73812259     48.98585736     89.96292202
        0.241335248     73.83106026     54.11699151     33.76588029                                     0
        0       0       0.167087112     0.139838178     0.158385453     0.368886507     0.35464928      0.331493863
        0.184443254     0.17732464      0.165746932     1       2       3       5       1
871     C22     Sc35    C22     0.606329462     0.568851437     0.317362409     0.988616154     0.579745219
        0.380141173     0.550948219     0.745334431     44.998239 0.032643252   83.20146466     84.62593646
        96.89993412     0.41692077      0       0       -38.20322566    1       82.70586696     68.9215558
        137.8431116     689.215558      0.057806057     0.115612113     0.578060566     0.273632139     0.256849416
        0.255171744     0.482159781     0.476288524     0.435601111     0.269982919     0.295950319     0.506830839
        3       2       1       5       2
872     C23     Sc35    C23     0.669232893     0.264919558     0.066334834     0.370084198     0.629717507
        0.21017401      0.752755554     0.066536481     46.98159204     0.214061164     51.69974189     32.83555671
        41.4875192      0.161768675     0       0       -4.71814985     1       77.21229111     64.34357592
        128.6871518     643.4357592     0.053966402     0.107932804     0.53966402      0.126338191     0.188706502
        0.135993177     0.31838757      0.379056788     0.311830131     0.186176986     0.243494796     0.425747076
        3       2       1       5       3
873     C24     Sc35    C24     0.260315099     0.804754564     0.193434283     0.639460881     0.524670309
        0.92480797      0.26329677      0.065961091     43.29336424     0.048265458     43.23086637     101.091395
        38.46617124     0.49804001      0.121121283     0.082983222     0.06249787
                0       0       0       0.195074589     0.194999729     0.172101157     0.408593283     0.408513079
        0.377206528     0.204296641     0.204256539     0.188603264     1       2       3       5       4
874     C25     Sc35    C25     0.735065963     0.77217803      0.907815853     0.931972069     0.013951573
        0.234362086     0.616778357     0.949016321     46.89347587     0.063579986     29.10938893     108.0009528
        14.23314753     0.532080852     39.87081862     24.23547982     17.78408694     1       24.23547982
        20.19623318     40.39246636     201.9623318     0.016939034     0.033878069     0.169390343     0.297089204
        0.234608961     0.294051043     0.476529471     0.414828361     0.460608863     0.246734253     0.224353215
        0.314999603     2       3       1       5       5
```

2. Sensitivity analysis of HSE to the weights

```
          Unnamed: 0          sc_id     cell_id   se1       se2       se3       se4       se5       se6       se7       se8       rainfall  slope
          ks        dg        dr        slope_n   rainfall_n          ks_n      dg_n      dr_n      hhi       runoff    feasible  hhi_catch
          hhci_lid1 hhci_lid2 hhci_lid3 hhci_norm1          hhci_norm2          hhci_norm3          sei1      sei2      sei3      sei_nei_1
          sei_nei_2 sei_nei_3 hse_lid1w1          hse_lid2w1          hse_lid3w1          hse_lid1w1          hse_lid2w1          hse_lid3w1
          hse_lid1w2          hse_lid2w2          hse_lid3w2          hse_lid1w2          hse_lid2w2          hse_lid3w2          hse_lid1w3
          hse_lid2w3          hse_lid3w3          hse_lid1w3          hse_lid2w3          hse_lid3w3          hse_lid1w4          hse_lid2w4
          hse_lid3w4          hse_lid1w4          hse_lid2w4          hse_lid3w4          hse_lid1w5          hse_lid2w5          hse_lid3w5
          hse_lid1w5          hse_lid2w5          hse_lid3w5          hse_lid1w6          hse_lid2w6          hse_lid3w6          hse_lid1w6
          hse_lid2w6          hse_lid3w6          hse_lid1w7          hse_lid2w7          hse_lid3w7          hse_lid1w7          hse_lid2w7
          hse_lid3w7          hse_lid1w8          hse_lid2w8          hse_lid3w8          hse_lid1w8          hse_lid2w8          hse_lid3w8
          hse_lid1w9          hse_lid2w9          hse_lid3w9          hse_lid1w9          hse_lid2w9          hse_lid3w9          hse_lid1w10
          hse_lid2w10         hse_lid3w10         hse_lid1w10         hse_lid2w10         hse_lid3w10         x         y
0         C01       sc01      C01       0.417022005         0.720324493         0.000114375         0.302332573         0.146755891
          0.092338595         0.186260211         0.345560727         33.010279 0.217997451         16.09475155         6.870223806
          22.2596509          0.435994902         0.307934953         0.233291079         0.058724881         0.190269689         26.57238144
          16.91552745         1         26.57238144         22.1436512          44.28730241         221.436512          0.024507874
          0.049015747         0.245078737         0.125908042         0.105685808         0.089720661         0.310543058         0.275436802
          0.263338126         0.28193954          0.252794696         0.261512187         1         3         2         0.253336021
          0.230152591         0.259686248         2         3         1         0.224732503         0.207510486         0.25786031          2
          3         1         0.196128984         0.18486838          0.256034371         2         3         1         0.167525466
          0.162226275         0.254208432         2         3         1         0.138921948         0.139584169         0.252382493         3
          2         1         0.110318429         0.116942064         0.250556554         3         2         1         0.081714911
          0.094299958         0.248730615         3         2         1         0.053111392         0.071657853         0.246904676         3
          2         1         0.024507874         0.049015747         0.245078737         3         2         1         1         1
1         C02       sc01      C02       0.396767474         0.538816734         0.419194514         0.6852195 0.20445225          0.878117436
          0.027387593         0.67046751          33.92377119         0.012963116         36.78293892         34.9928391          3.448308502
          0.025926232         0.519391479         0.533163341         0.29910966          0.029475241         0         -2.85916773
                    0         0         0         0         0         0         0.257404041         0.194814404         0.208494062
          0.445364891         0.378338276         0.386777277         0.400828402         0.340504448         0.348099549         1         3
          2         0.356291913         0.302670621         0.309421822         1         3         2         0.311755424         0.264836793
          0.270744094         1         3         2         0.267218934         0.227002966         0.232066366         1         3         2
          0.222682445         0.189169138         0.193388639         1         3         2         0.178145956         0.15133531
          0.154710911         1         3         2         0.133609467         0.113501483         0.116033183         1         3         2
          0.089072978         0.075667655         0.077355455         1         3         2         0.044536489         0.037833828
          0.038677728         1         3         2         0         0         0         1         2         3         1         2
2         C03       sc01      C03       0.417304802         0.558689828         0.140386939         0.198101489         0.800744569
          0.968261576         0.313424178         0.692322616         34.9990459          0.274831239         38.68279349         85.51575292
          55.36183542         0.549662478         0.768297662         0.560701457         0.730966347         0.473218526         0         -
3.68374759          1         36.02324329         30.01936941         60.03873882         300.1936941         0.033224463         0.066448926
          0.332244628         0.25038454          0.237553697         0.192031501         0.413221665         0.397937162         0.354009513
          0.375221945         0.364788339         0.351833025         1         2         3         0.337222224         0.331639515
          0.349656536         2         3         1         0.299222504         0.298490691         0.347480048         2         3         1
          0.261222784         0.265341868         0.345303559         3         2         1         0.223223064         0.232193044
          0.343127071         3         2         1         0.185223344         0.19904422          0.340950582         3         2         1
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         0.147223623        0.165895397        0.338774094        3        2        1        0.109223903        0.132746573
         0.336597605        3        2        1        0.071224183        0.099597749        0.334421116        3        2        1
         0.033224463        0.066448926        0.332244628        3        2        1        1        3
3        C04      sc01     C04      0.876389152        0.894606664        0.085044211        0.039054783        0.16983042
         0.878142503        0.098346834        0.421107625        35.08943358        0.217661196        3.83597854         3.698785078
         85.97992038        0.435322393        0.789220736        0.05560195         0.03161625         0.734933929        49.08551219
         31.25345504                           0        0        0        0        0        0        0.214732899        0.18442312
         0.126095549        0.407884499        0.379289941        0.3266149 0.367096049        0.341360947        0.29395341         1
         2        3        0.326307599        0.303431953        0.26129192         1        2        3        0.285519149
         0.265502959        0.22863043         1        2        3        0.244730699        0.227573965        0.19596894         1
         2        3        0.203942249        0.189644971        0.16330745         1        2        3        0.1631538 0.151715977
         0.13064596         1        2        3        0.12236535         0.113786982        0.09798447         1        2        3
         0.0815769 0.075857988        0.06532298         1        2        3        0.04078845         0.037928994        0.03266149
         1        2        3        0        0        0        1        2        3        1        4
4        C05      sc01     C05      0.95788953         0.533165285        0.691877114        0.315515631        0.686500928
         0.834625672        0.018288277        0.750144315        35.44082811        0.210183901        25.57658235        25.26080431
         50.3295197         0.420367802        0.870562062        0.370728835        0.215922765        0.430203605        15.42047916
         9.86424576                            0        0        0        0        0        0        0.286047241        0.291180307
         0.19489221         0.44509345         0.451505602        0.365064068        0.400584105        0.406355042        0.328557661
         2        1        3        0.35607476         0.361204481        0.292051254        2        1        3        0.311565415
         0.316053921        0.255544848        2        1        3        0.26705607         0.270903361        0.219038441        2
         1        3        0.222546725        0.225752801        0.182532034        2        1        3        0.17803738
         0.180602241        0.146025627        2        1        3        0.133528035        0.135451681        0.10951922         2
         1        3        0.08901869         0.09030112         0.073012814        2        1        3        0.044509345
         0.04515056         0.036506407        2        1        3        0        0        0        1        2        3        1
         5
5        C06      sc01     C06      0.988861089        0.748165654        0.280443992        0.789279328        0.103226007
         0.447893526        0.908595503        0.293614148        32.49182041        0.165167411        16.08025417        7.109863301
         57.96001621        0.330334821        0.187921392        0.233080942        0.060773257        0.495427098        24.87109546
         16.41156624                           0        0        0        0        0        0        0.231167154        0.224930393
         0.238148451        0.424363564        0.406410035        0.410044838        0.381927208        0.365769032        0.369040354
         1        3        2        0.339490851        0.325128028        0.32803587         1        3        2        0.297054495
         0.284487025        0.287031387        1        3        2        0.254618139        0.243846021        0.246026903        1
         3        2        0.212181782        0.203205018        0.205022419        1        3        2        0.169745426
         0.162564014        0.164017935        1        3        2        0.127309069        0.121923011        0.123013451        1
         3        2        0.084872713        0.081282007        0.082008968        1        3        2        0.042436356
         0.040641004        0.041004484        1        3        2        0        0        0        1        2        3        2
         1
6        C07      sc01     C07      0.287775339        0.130028572        0.019366958        0.678835533        0.211628116
         0.265546659        0.491573159        0.053362545        32.84426266        0.102324317        48.2051179         36.53268887
         2.665127499        0.204648634        0.269505246        0.698726162        0.312271894        0.022780815        0        -
15.36085524                  0        0        0        0        0        0        0.108835421        0.116048175
         0.133699741        0.336205368        0.332993219        0.339465132        0.302584831        0.299693897        0.305518619
         2        3        1        0.268964294        0.266394575        0.271572106        2        3        1        0.235343757
         0.233095253        0.237625592        2        3        1        0.201723221        0.199795931        0.203679079        2
         3        1        0.168102684        0.166496609        0.169732566        2        3        1        0.134482147
         0.133197288        0.135786053        2        3        1        0.10086161         0.099897966        0.10183954         2
```

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         3         1         0.067241074        0.066598644        0.067893026        2         3         1         0.033620537
         0.033299322         0.033946513        2         3         1         0         0         0         1         2         3         2
         2
7        C08       sc01      C08       0.574117605        0.146728575        0.589305537        0.69975836         0.102334429
         0.414055988         0.694400158        0.41417927         33.82355005        0.309635483        11.98573101        78.84076537
         58.18750434         0.619270966        0.496192141        0.173731425        0.673910295        0.497371607        36.02324329
         21.83781904                            0         0         0         0         0         0         0.195954796        0.182760584
         0.225479264         0.378522006        0.365489003        0.396290772        0.340669805        0.328940102        0.356661695
         2         3         1         0.302817605        0.292391202        0.317032617        2         3         1         0.264965404
         0.255842302         0.27740354         2         3         1         0.227113203        0.219293402        0.237774463        2
         3         1         0.189261003        0.182744501        0.198145386        2         3         1         0.151408802
         0.146195601         0.158516309        2         3         1         0.113556602        0.109646701        0.118887232        2
         3         1         0.075704401        0.073097801        0.079258154        2         3         1         0.037852201
         0.0365489 0.039629077          2         3         1         0         0         0         1         2         3         2         3
8        C09       sc01      C09       0.049953459        0.535896406        0.663794645        0.514889112        0.944594756
         0.586555041         0.903401915        0.137474704        34.87300595        0.149827337        5.541612561        37.21620286
         111.3518603         0.299654674        0.739121747        0.080324867        0.318114393        0.951806652        43.91786345
         29.33139339         1         108.4238548        90.35321233        180.7064247        903.5321233        0.1       0.2       1
         0.178780994         0.232017403        0.229727169        0.392146196        0.44667726         0.432078559        0.362931577
         0.422009534         0.488870703        3         2         1         0.333716957        0.397341808        0.545662847        3
         2         1         0.304502338        0.372674082        0.602454991        3         2         1         0.275287718
         0.348006356         0.659247135        3         2         1         0.246073098        0.32333863         0.716039279        3
         2         1         0.216858479        0.298670904        0.772831424        3         2         1         0.187643859
         0.274003178         0.829623568        3         2         1         0.158429239        0.249335452        0.886415712        3
         2         1         0.12921462         0.224667726        0.943207856        3         2         1         0.1       0.2       1
         3         2         1         2         4
9        C10       sc01      C10       0.139276347        0.807391289        0.397676837        0.165354197        0.92750858
         0.34776586          0.750812103        0.725997985        32.5221926         0.133413638        65.61023925        69.4442434
         100.7044175         0.266827275        0.194951992        0.95101086         0.593591276        0.860795089        0         -
33.08804665                        0         0         0         0         0         0         0.212063257        0.22017735
         0.208648434         0.397570841        0.412858391        0.384413237        0.357813757        0.371572552        0.345971913
         2         1         3         0.318056672        0.330286713        0.307530589        2         1         3         0.278299588
         0.289000874         0.269089266        2         1         3         0.238542504        0.247715034        0.230647942        2
         1         3         0.19878542         0.206429195        0.192206618        2         1         3         0.159028336
         0.165143356         0.153765295        2         1         3         0.119271252        0.123857517        0.115323971        2
         1         3         0.079514168        0.082571678        0.076882647        2         1         3         0.039757084
         0.041285839         0.038441324        2         1         3         0         0         0         1         2         3         2
         5
10       C11       sc01      C11       0.883306091        0.623672207        0.750942434        0.348898342        0.269927892
         0.895886218         0.42809119         0.964840047        32.45649947        0.310566916        39.57827842        9.30900598
         86.56844337         0.621133833        0.179745247        0.57368138         0.079570955        0.73996447         0         -
7.12177895         1         24.87109546        20.72591288        41.45182577        207.2591288        0.022938767        0.045877534
         0.22938767          0.316867923        0.266455347        0.264174875        0.486389832        0.435666719        0.417511021
         0.440044726         0.396687801        0.398698686        1         3         2         0.393699619        0.357708882
         0.379886351         1         3         2         0.347354513        0.318729964        0.361074016        2         3         1
         0.301009406         0.279751045        0.342261681        2         3         1         0.2546643 0.240772127        0.323449346
         2         3         1         0.208319193        0.201793208        0.304637011        2         3         1         0.161974087
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        0.16281429      0.285824676     3       2       1       0.11562898      0.123835371     0.26701234      3
        2       1       0.069283874     0.084856453     0.248200005     3       2       1       0.022938767
        0.045877534     0.22938767      3       2       1       3       1
11      C12     sc01    C12     0.663441498     0.62169572      0.114745973     0.949489259     0.449912133
        0.578389614     0.408136803     0.23702698      34.00772944     0.264571047     6.070591495     102.6475506
        13.89093305     0.529142094     0.538826259     0.087992339     0.877404484     0.118736072     45.06398757
        27.93713794     1       45.06398757     37.55332297     75.10664594     375.5332297     0.041562798
        0.083125596     0.415627978     0.220522508     0.224798251     0.197499161     0.412829677     0.413879887
        0.373184816     0.375702989     0.380804458     0.377429132     3       1       2       0.338576301
        0.347729029     0.381673448     3       2       1       0.301449614     0.3146536 0.385917765   3       2
        1       0.264322926     0.281578171     0.390162081     3       2       1       0.227196238     0.248502742
        0.394406397     3       2       1       0.19006955      0.215427312     0.398650713     3       2       1
        0.152942862     0.182351883     0.40289503      3       2       1       0.115816174     0.149276454
        0.407139346     3       2       1       0.078689486     0.116201025     0.411383662     3       2       1
        0.041562798     0.083125596     0.415627978     3       2       1       3       2
12      C13     sc01    C13     0.903379521     0.573679487     0.002870327     0.617144914     0.326644902
        0.527058102     0.885942099     0.35726976      32.90154741     0.067289973     50.54486886     16.75770835
        105.7477489     0.134579945     0.282765605     0.732640511     0.143240519     0.90390417      0       -
17.64332145                     0       0       0       0       0       0       0.221712208     0.223609096
        0.217157743     0.387200912     0.389670791     0.373298543     0.348480821     0.350703712     0.335968689
        2       1       3       0.309760729     0.311736633     0.298638834     2       1       3       0.271040638
        0.272769554     0.26130898      2       1       3       0.232320547     0.233802474     0.223979126     2
        1       3       0.193600456     0.194835395     0.186649271     2       1       3       0.154880365
        0.155868316     0.149319417     2       1       3       0.116160274     0.116901237     0.111989563     2
        1       3       0.077440182     0.077934158     0.074659709     2       1       3       0.038720091
        0.038967079     0.037329854     2       1       3       0       0       0       1       2       3       3
        3
13      C14     sc01    C14     0.908535151     0.623360116     0.015821243     0.929437234     0.690896918
        0.99732285      0.172340508     0.13713575      34.96726024     0.256789061     11.62151545     22.00870416
        101.4483754     0.513578121     0.760939869     0.168452174     0.188124662     0.867154247     37.50146247
        23.34574479     1       37.50146247     31.25121873     62.50243746     312.5121873     0.034587834
        0.069175667     0.345878336     0.254748757     0.280125362     0.188733628     0.439097823     0.467642276
        0.3709205 0.398646824   0.427795615     0.368416284     2       1       3       0.358195825     0.387948954
        0.365912067     3       1       2       0.317744826     0.348102294     0.363407851     3       2       1
        0.277293827     0.308255633     0.360903634     3       2       1       0.236842828     0.268408972
        0.358399418     3       2       1       0.196391829     0.228562311     0.355895202     3       2       1
        0.15594083      0.18871565      0.353390985     3       2       1       0.115489831     0.148868989
        0.350886769     3       2       1       0.075038832     0.109022328     0.348382552     3       2       1
        0.034587834     0.069175667     0.345878336     3       2       1       3       4
14      C15     sc01    C15     0.932595463     0.696818161     0.066000173     0.755463053     0.753876188
        0.923024536     0.711524759     0.124270962     32.84507351     0.092219933     17.95680735     59.18869803
        20.48338339     0.184439866     0.269692942     0.260281307     0.50592955      0.175086618     21.08124579
        14.88826616                     0       0       0       0       0       0       0.251517278     0.292575574
        0.225051384     0.421654228     0.461972982     0.38826343      0.379488805     0.415775684     0.349437087
        2       1       3       0.337323382     0.369578386     0.310610744     2       1       3       0.295157959
        0.323381088     0.271784401     2       1       3       0.252992537     0.277183789     0.232958058     2
        1       3       0.210827114     0.230986491     0.194131715     2       1       3       0.168661691
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	0.046197298	0.038826343	2	1	3	0	0	0	1	2	3	3
	5
15	C16	sc01	C16	0.019880134	0.026210987	0.028306488	0.246211068	0.860027949
	0.538831064	0.552821979	0.842030892	32.94800428	0.392667574	20.9375858	102.2141214
	75.14665628	0.785335148	0.293519509	0.303487256	0.873699645	0.642334014	20.52492249
	12.01041848		0	0	0	0	0	0	0.198021052	0.185581091
	0.191572754	0.409469615	0.400700715	0.376351488	0.368522654	0.360630643	0.338716339
	1	2	3	0.327575692	0.320560572	0.30108119	1	2	3	0.286628731
	0.2804905	0.263446041	1	2	3	0.245681769	0.240420429	0.225810893	1	2
	3	0.204734808	0.200350357	0.188175744	1	2	3	0.163787846	0.160280286
	0.150540595	1	2	3	0.122840885	0.120210214	0.112905446	1	2	3
	0.081893923	0.080140143	0.075270298	1	2	3	0.040946962	0.040070071
	0.037635149	1	2	3	0	0	0	1	2	3	4	1
16	C17	sc01	C17	0.124173315	0.279183679	0.585759271	0.969595748	0.561030219
	0.018647289	0.800632673	0.232974274	35.83759181	0.426987646	48.74907317	89.95873932
	3.56627786	0.853975293	0.962405512	0.706610714	0.768943836	0.030483613	0	-
12.91148136		0	0	0	0	0	0	0.154114011	0.183917483
	0.218846089	0.390156452	0.422091592	0.424898731	0.351140806	0.379882433	0.382408858
	3	2	1	0.312125161	0.337673273	0.339918985	3	2	1	0.273109516
	0.295464114	0.297429112	3	2	1	0.234093871	0.253254955	0.254939239	3
	2	1	0.195078226	0.211045796	0.212449365	3	2	1	0.156062581
	0.168836637	0.169959492	3	2	1	0.117046935	0.126627478	0.127469619	3
	2	1	0.07803129	0.084418318	0.084979746	3	2	1	0.039015645
	0.042209159	0.042489873	3	2	1	0	0	0	1	2	3	4
	2
17	C18	sc01	C18	0.807105196	0.387860644	0.863541855	0.747121643	0.556240234
	0.136455226	0.05991769	0.121343456	35.62508589	0.247118419	32.71947943	114.7069548
	14.82699307	0.494236837	0.913214326	0.474264088	0.980485125	0.126737269	4.64271068
	2.90560646	1	4.64271068	3.868925567	7.737851134	38.68925567	0.004282001
	0.008564002	0.042820011	0.168545737	0.230647918	0.139241534	0.36632712	0.427568554
	0.327019619	0.330122608	0.385668099	0.298599659	2	1	3	0.293918096
	0.343767644	0.270179698	2	1	3	0.257713584	0.301867188	0.241759737	2
	1	3	0.221509072	0.259966733	0.213339776	2	1	3	0.185304561
	0.218066278	0.184919815	2	1	3	0.149100049	0.176165823	0.156499855	3
	1	2	0.112895537	0.134265368	0.128079894	3	1	2	0.076691025
	0.092364913	0.099659933	3	2	1	0.040486513	0.050464457	0.071239972	3
	2	1	0.004282001	0.008564002	0.042820011	3	2	1	4	3
18	C19	sc01	C19	0.044551879	0.107494129	0.225709339	0.71298898	0.559716982
	0.01255598	0.07197428	0.96727633	34.13451533	0.423280743	15.52703729	90.00070565
	38.18171179	0.846561485	0.568174845	0.225062144	0.769302553	0.326367312	32.16832476
	18.60747804		0	0	0	0	0	0	0.19335296	0.154863434
	0.16721044	0.416396653	0.388253269	0.385127801	0.374756988	0.349427942	0.346615021
	1	2	3	0.333117323	0.310602615	0.308102241	1	2	3	0.291477657
	0.271777288	0.269589461	1	2	3	0.249837992	0.232951961	0.231076681	1
	2	3	0.208198327	0.194126634	0.192563901	1	2	3	0.166558661
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          0.038825327         0.03851278          1         2         3         0         0         0         1         2         3         4
          4
19        C20       sc01      C20       0.568100462         0.203293235         0.252325745         0.743825854         0.195429481
          0.581358927         0.970019989         0.846828801         33.77732697         0.039822739         31.51644382         46.12331125
          19.64406076         0.079645477         0.485492354         0.456826262         0.394250032         0.167912307         2.951323831
          2.26088315                              0         0         0         0         0         0         0.266503103         0.213730709
          0.290225506         0.462800059         0.417820608         0.473734591         0.416520053         0.376038547         0.426361132
          2         3         1         0.370240047         0.334256486         0.378987673         2         3         1         0.323960041
          0.292474425         0.331614214         2         3         1         0.277680035         0.250692365         0.284240755         2
          3         1         0.23140003          0.208910304         0.236867296         2         3         1         0.185120024
          0.167128243         0.189493836         2         3         1         0.138840018         0.125346182         0.142120377         2
          3         1         0.092560012         0.083564122         0.094746918         2         3         1         0.046280006
          0.041782061         0.047373459         2         3         1         0         0         0         1         2         3         4
          5
20        C21       sc01      C21       0.239847759         0.493769714         0.619955718         0.8289809 0.156791395         0.018576202
          0.070022144         0.486345111         34.50400288         0.252623045         9.029325069         48.98585736         89.96292202
          0.50524609          0.653704371         0.130878752         0.418718329         0.768979588         40.82857935         25.47467781
                              0         0         0         0         0         0         0.167087112         0.139838178         0.158385453
          0.368886507         0.35464928          0.331493863         0.331997857         0.319184352         0.298344477         1         2
          3         0.295109206         0.283719424         0.265195091         1         2         3         0.258220555         0.248254496
          0.232045704         1         2         3         0.221331904         0.212789568         0.198896318         1         2         3
          0.184443254         0.17732464          0.165746932         1         2         3         0.147554603         0.141859712
          0.132597545         1         2         3         0.110665952         0.106394784         0.099448159         1         2         3
          0.073777301         0.070929856         0.066298773         1         2         3         0.036888651         0.035464928
          0.033149386         1         2         3         0         0         0         1         2         3         5         1
21        C22       sc01      C22       0.606329462         0.568851437         0.317362409         0.988616154         0.579745219
          0.380141173         0.550948219         0.745334431         33.998239 0.032643252         64.00112666         84.62593646
          96.89993412         0.065286504         0.536629399         0.927687008         0.723360428         0.828275358         0         -
30.00288766         1         61.35350184         51.1279182          102.2558364         511.279182          0.056586719         0.113173438
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          0.439602475         0.439977016         0.448627719         3         2         1         0.397045168         0.403665507
          0.461654327         3         2         1         0.354487862         0.367353998         0.474680934         3         2         1
          0.311930556         0.33104249          0.487707542         3         2         1         0.26937325          0.294730981
          0.50073415          3         2         1         0.226815944         0.258419472         0.513760757         3         2         1
          0.184258637         0.222107964         0.526787365         3         2         1         0.141701331         0.185796455
          0.539813973         3         2         1         0.099144025         0.149484946         0.55284058          3         2         1
          0.056586719         0.113173438         0.565867188         3         2         1         5         2
22        C23       sc01      C23       0.669232893         0.264919558         0.066334834         0.370084198         0.629717507
          0.21017401          0.752755554         0.066536481         35.98159204         0.214061164         39.76903222         32.83555671
          41.4875192          0.428122328         0.995738897         0.576446329         0.280669773         0.354624491         0         -
3.78744018          1         56.20089438         46.83407865         93.6681573          468.3407865         0.051834437         0.103668873
          0.518344367         0.126338191         0.188706502         0.135993177         0.31838757          0.379056788         0.311830131
          0.291732257         0.351517996         0.332481555         3         1         2         0.265076943         0.323979205
          0.353132978         3         2         1         0.23842163          0.296440413         0.373784402         3         2         1
          0.211766317         0.268901622         0.394435826         3         2         1         0.185111003         0.24136283
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         0.47704152     3         2         1         0.07848975     0.131207665    0.497692943    3         2         1
         0.051834437    0.103668873    0.518344367    3         2         1         5         3
23       C24       sc01      C24       0.260315099    0.804754564    0.193434283    0.639460881    0.524670309
         0.92480797     0.26329677     0.065961091    32.29336424    0.048265458    33.25451259    101.091395
         38.46617124    0.096530916    0.141982464    0.482019316    0.864102872    0.328798797    0         -
0.96114835                    0         0         0         0         0         0         0.195074589    0.194999729
         0.172101157    0.408593283    0.408513079    0.377206528    0.367733954    0.367661771    0.339485876
         1         2         3         0.326874626    0.326810463    0.301765223    1         2         3         0.286015298
         0.285959155    0.26404457     1         2         3         0.24515597     0.245107847    0.226323917    1
         2         3         0.204296641    0.204256539    0.188603264    1         2         3         0.163437313
         0.163405231    0.150882611    1         2         3         0.122577985    0.122553924    0.113161959    1
         2         3         0.081718657    0.081702616    0.075441306    1         2         3         0.040859328
         0.040851308    0.037720653    1         2         3         0         0         0         1         2         3         5
         4
24       C25       sc01      C25       0.735065963    0.77217803     0.907815853    0.931972069    0.013951573
         0.234362086    0.616778357    0.949016321    35.89347587    0.063579986    22.39183764    108.0009528
         14.23314753    0.127159972    0.975341637    0.324566425    0.92316397     0.121661232    18.39952098
         13.50163823    1         18.39952098    15.33293415    30.6658683     153.3293415    0.016969993
         0.033939987    0.169699934    0.297089204    0.234608961    0.294051043    0.476529471    0.414828361
         0.460608863    0.430573523    0.376739524    0.43151797     2         3         1         0.384617575
         0.338650686    0.402427077    2         3         1         0.338661628    0.300561849    0.373336185    2
         3         1         0.29270568     0.262473011    0.344245292    2         3         1         0.246749732
         0.224384174    0.315154399    2         3         1         0.200793784    0.186295337    0.286063506    2
         3         1         0.154837837    0.148206499    0.256972613    2         3         1         0.108881889
         0.110117662    0.22788172     3         2         1         0.062925941    0.072028824    0.198790827    3
         2         1         0.016969993    0.033939987    0.169699934    3         2         1         5         5
```

3. The three selected LID data

	sc_id	lid_id	lid_bnf1	lid_bnf2	lid_bnf3	lid_bnf4	lid_bnf5	lid_bnf6	lid_bnf7	lid_bnf8	cost
lid01	sc01	lid01	0.417022	0.302333	0.18626	0.538817	0.204452	0.670468	0.140387	0.968262	1.2
lid02	sc01	lid02	0.720324	0.146756	0.345561	0.419195	0.878117	0.417305	0.198101	0.313424	0.6
lid03	sc01	lid03	0.000114	0.092339	0.396767	0.68522	0.027388	0.55869	0.800745	0.692323	0.12

APPENDIX F: IT DESIGN PARAMETERS USED IN CHAPTER 4

Table F 1. Design parameters for IT (used in PCSWMM)

	Parameters				
SURFACE	Berm height (mm)	Vegetative Cover (fraction)	Surface roughness (Manning's n)	Surface slope (percent)	
	150	0	0.013	5	
STORAGE	Storage Height (mm)	Storage Void Ratio (voids / solids)	Seepage Rate (mm/hr)	Storage Clogging Factor	
	750	0.4	210	0	
DRAIN	Drain coefficient (mm/hr)	Drain exponent	Drain offset height (mm)	Open level (mm)	Closed level (mm)
	0	0.5	0	0	0