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– a case study in Sydöstra staden, Uppsala, Sweden

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Abstract

Green roofing has emerged as a viable option for developers and planners seeking to integrate ecosystem services into the built environment, while, at the same time, responding to the constraints posed by urban densification. Urban green infrastructure (UGI) has been placed at the core of sustainable urban planning enabling the integration of ecosystem services in urban development. UGI have proven highly useful in mitigating many of the problematic environmental aspects of cities, such as soil pollution, sealing, urban heat island effects and floods. UGIs have also been shown to significantly improve human health and well-being. Five types of green roofs are investigated and compared with one another in this thesis as they provide different ecosystem services: a water roof, an energy roof, a biodiversity roof, a food production roof and a recreation roof.

This study aims to pinpoint what constitutes an optimal location and to develop a spatial methodology to identify how these various types of green roofs can be distributed and placed efficiently to take maximal advantage of the ecosystem services they provide. It also seeks to identify the multifunctionality potential of individual buildings. It uses the upcoming urban area Sydöstra staden in Uppsala, Sweden, as a case study. The district is set to undergo significant urban development and the city of Uppsala is imposing the integration sustainability innovations as a central aspect of the planning and could therefore benefit from an in-depth study on suitability of urban green roofing.

The results are presented in the form of maps ranking the suitability of various buildings for optimal ecosystem service provision on a scale of 1 to 5, 1 being "not particularly effective" to 5 being "necessary". This is done for each green roof type. The finals maps are then compared to showcase areas with the highest overall scores as highly multifunctional, and those with the lowest scores as less multifunctional. The implications of the development of such a model are discussed from an urban planning perspective and suggestions on how to integrate ecosystem services' monetary value are also highlighted.

Keywords: ecosystem services, GIS, green roofs, urban green infrastructure, sustainable development, multifunctionality, urban planning

Preface

Research is a little silly sometimes. One can spend several months (or years) investigating something most people will automatically regard as "useless". Take green roofs for example. Who cares about a roof? Are the people who struggle to make ends meet really going to benefit from a green roof? Probably not. The truth is, they might even be hurt by one if it drives property prices or maintenance costs up. But hopefully the larger scope of this technology will eventually contribute to our common well-being.

This is my rationale: when you look at a satellite or drone picture of a city from above, you'll see roads and parks, and if the resolution is high enough, you might even see people. There's one more thing you may miss but that are always there: roofs. Looking at them from space, they are just empty spaces that sit, unproductive, every day.

Now imagine if all these roofs had small ecosystems on them. Some are parks, some are forests, gardens. Some have literal wetlands on them and other have solar panels. The city as whole would be transformed: more habitats would attract different insect, bird and animal species, which would bring life back to our cities again. We might spot more diverse bird species than just your regular pigeons. Who doesn't get excited at the sight of wild animal?

But there's more. The city as a *system* would be transformed: all this vegetation exposed to the sun would transpire and cool the city in the process, hence reducing the urban heat island effect and keeping those extreme heat events rare. Vegetation also dissipates noise which would lower the overall "sound volume" and make our cities calmer and quieter. The soils, substrates and plants on the rooftops would also retain water and make flooding much less common all while contributing to reducing the load on sewer systems and reusing water for other purposes. They also insulate buildings and reduce the overall energy quantity necessary to warm and cool buildings.
On top of this, there's also an increasing amount of research that's shedding light on the links between our health and green spaces: more exposure to vegetation

seems to significantly improve our mental and physical health. We don't really understand how, but nevertheless it happens.

The city of the future sees waste as an opportunity to improve efficiency somewhere in the chain of consumption. The city of the future works *with* the natural environment, not through, against or despite it.

So, this thesis is but a small piece in a much larger puzzle that our civilization needs to solve quickly if we want to remain who we are. This puzzle is one of integration of ecosystems, circularity and better quality of life for all city dwellers. Remember, if we want to live on other planets, we will inevitably have to understand the full extent of our relationship with a world that provides everything we need.
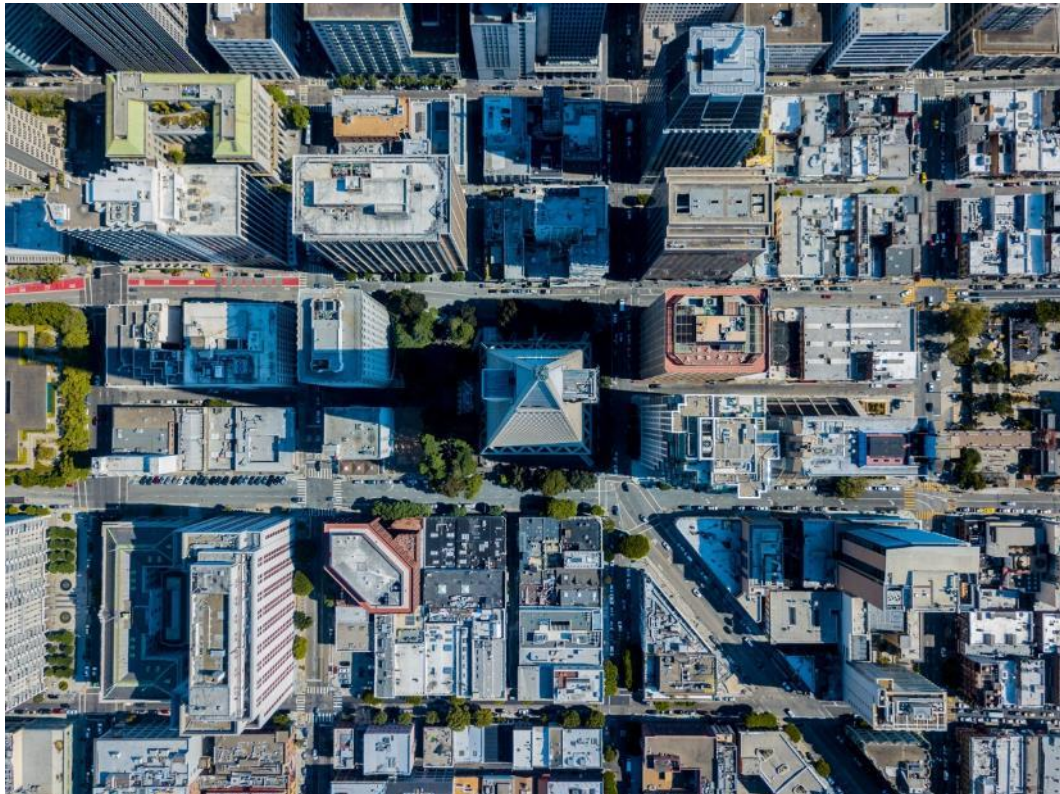
The picture above is of the Transamerica Pyramid in San Francisco, taken by Scott Szarapka. One cannot miss the overwhelming quantity of roofs.

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Abbreviations

CES	Cultural Ecosystem Services
DEM	Digital Elevation Model
EC	European Commission
ES	Ecosystem Services
ESRI	Environmental Systems Research Institute
EU	European Union
FÖP	Förjupad Översiktsplan (Comprehensive Overview Plan)
GI	Green Infrastructure
GIS	Geographic Information System
GROOVES	Green Roofs Verified Ecosystem Services
NBS	Nature-based Solutions
SDG	Sustainable Development Goals
SLU	Swedish University of Agricultural Sciences
UGI	Urban Green Infrastructure
UN	United Nations
WWF	World Wide Fund for Nature

1. Introduction

Nature-based solutions (NBS) and urban green infrastructure (UGI) have been placed at the core of sustainable urban planning (Andersson et al. 2014; Cohen-Shacham et al. 2016), enabling the integration of ecosystem services into urban development. NBS have proven highly useful in mitigating many of the problematic environmental aspects of cities, such as soil pollution, soil sealing and urban heat island effects (Jansson 2013). UGIs have also been shown to significantly improve human health and well-being (see e.g. Tzoulas et al., 2007). Since 2013, the European Commission (EC) has introduced a growing set of policy tools to promote the development of UGIs.

As Uppsala and many other European cities are becoming increasingly dense (OECD 2018), green spaces often come under pressure from urban development and are decreasing in a number of urban areas (Haaland & van den Bosch 2015; Colding et al. 2020). One particular challenge cities face is efficient and systematic integration of green infrastructure – networks of natural and semi-natural elements that provide ecosystem services – into urban planning to ensure that cities remain livable and sustainable. Green roofing has emerged as a viable option for developers and planners seeking to integrate ecosystem services into the built environment, while, at the same time, responding to the constraints posed by densification (Oberndorfer et al. 2007; Gómez-Baggethun et al. 2013).

Individual green roofs can provide many benefits, while occupying space that would otherwise likely go unused, making green roofing a very interesting and incentivizing option for developers and planners alike. Financial advantages are showcased, such as the lowering of energy bills through insulation and food production (Ackerman et al. 2014), as are environmental advantages, such as the delaying of rainwater peaks (Oberndorfer et al., 2007) and the mitigation of CO_2 emissions. According to the needs of the building occupants, tailor made green roofing can allow e.g. restaurants to produce some of their food locally, or offices to save on their energy bills by providing better insulation. The multiple benefits that green roofs can provide can be referred to as their *multifunctionality potential*.

When scaled up to the city level, green infrastructure can potentially also offer benefits beyond their individual and local functions, with both climate mitigation and adaptation potential (Lovell & Taylor 2013). The multifunctionality potential can be used and harnessed for smart urban design to ensure that individual functions are complementary and/or distributed evenly in the city, or even targeted to specific areas that are particularly prone to certain disturbances, such as flooding. In such a scenario, green roofs that provide water retention would be a beneficial alternative. Green roofs can also be designed with biodiversity in mind, for example, by supporting the urban green connectivity for various animal species, e.g. pollinators, through the promotion of green corridors through and around the city (Gilbert-Norton et al. 2010; Orsini et al. 2014).

Finding ways in which different functions of green roofs can be made to work in synergy is a challenge that is unique to each urban area. One way to address this challenge is by using spatial analysis, whereby individual functions can be modeled to be placed in optimal locations from an ecosystem service provision perspective. They can then be combined, and synergies and trade-offs identified, in order to optimize the green roof distribution in the city, while simultaneously taking into account the environmental specificities of each urban area. This study aims to pinpoint what constitutes an optimal location, and to develop a spatial methodology, to identify how various green roofs can be distributed efficiently to take maximal advantage of the ecosystem services they provide. It also seeks to identify the multifunctionality potential of individual buildings. To the author's best knowledge, only one previous study could be related directly to the use of GIS to calculate optimal locations for green roofs based on their ecosystem services (Grunwald et al. 2017).

The neighborhood of Sydöstra staden in Uppsala, Sweden currently under consideration for urban development, provides an ideal setting for research into green roof optimization, as the city has strongly indicated its commitment to sustainable and innovative urban development in future developments (Uppsala Kommun 2018a). The use of green roofs is one that often needs to be integrated into the planning phase of infrastructure development, as building requirements and synergies can be better accounted for and costs lowered (Persson et al. 2020). Persson et al. have created 5 different concept green roofs (water roof, energy roof, biodiversity roof, food production and recreation roof) that were used for the analysis.

Therefore, the guiding research questions of this study is:

i.   What is the ideal location for each of the 5 different green roof types in Sydöstra staden, based on the ecosystem services each provides?

ii.   Which rooftops have the potential to be multifunctional?

2. Background

2.1. Overview on urban development

An important premise for understanding why green roofs are relevant in the first place is to view them as part of a larger paradigm shift in the way that cities are developed and planned. In a 2018 paper, van der Leeuw (2018) argued that "urbanization so far has been the most persistent social evolutionary dynamic known to mankind" (p.3). The ways in which settlements have grown to towns, cities and subsequently even mega-cities today has taken place at a speed that is often difficult to comprehend. Yet it has also been argued that given current urbanization and population growth trends, 60% of the environment that is expected to become urbanized by 2030 has yet to be built (Secretariat of the Convention on Biological Diversity 2012). This means that a large part of the world's urban land has still not been built. This is a source of opportunities for future urban land expansion but will pose important sustainability challenges.

The way we build our cities has an undeniable impact on environmental performance, social cohesion and economic activity (OECD 2018). Since the 20th century, as both populations and wages grew and real costs of transportation decreased, it became easier and more accessible for many to live further from city centers which often resulted in a highly fragmented low-density built environment, known as urban sprawl (*ibid.*).

Urban sprawl manifested itself differently across various countries, but it nevertheless remained a trend among OECD countries. The OECD report also highlights the downstream consequences of urban sprawl that include increased car dependency which result in long commuting times and more greenhouse gas emissions. Because public services are more costly and less efficient to operate in low-density areas, services such as healthcare and public transportation may often be less accessible and combined with housing costs, it has been shown to lead to segregation of certain population groups (*ibid.*).

While urbanization itself is often seen as a leading cause for such problems, it is argued that the form of the urban environment is a strong determinant for many of them. Therefore, building cities with efficient and comprehensive planning that take into account such consequences is of vital importance. Given the amount of urban land that is yet to be built, and the impact of current urban land expansion on the biosphere (Seto et al. 2011), there is a constant need to reassess and improve urbanization practices.

Building for denser cities has therefore been a preferred strategy since it generally enables public services to operate more effectively, limits resource use, restricts the size of housing surface along with a wide range of other environmental, social and economic benefits (Hofstad 2012). Colding et al. (2020) have however stressed some of the important downsides of densification, notably the gradual transfer of public to private property as space becomes more valuable and restricted in the city. In particular, they note that this especially observable in green infrastructure which, over time, tends to decrease due to several reasons

As densification policies are a preferred option for many cities today (Bibri et al. 2020), green roofs – while evidently incapable of restoring "lost" land – can however provide many functions that are seen as essential in urban areas today. Colding et al. (2020) noted economic activity intensification as one driver for urban green decreases as population growth is surpassing planer's capacities to deal with the needs of urbanites. Green roofs have the capacity to provide multifunctional recreative environments that can diminish the effects of UGI losses and overloading in cities. They can also secure essential biodiversity functions in the city that can complement those provided by traditional UGI, as well as key climate adaptation and mitigation functions (Oberndorfer et al. 2007; Engström et al. 2018), which are increasingly viewed as essential in urban planning and even a necessity in many countries.

2.2. What are ES, NbS and GI and why are they relevant in an urban development perspective?

2.2.1. Ecosystem Services (ES)

Ecosystem services are a means to conceptualize and classify functions of the natural environment. They are defined as the multiple benefits that humans obtain from ecosystems (Millennium Ecosystem Assessment 2005). While relatively confined to the research community, the term was popularized by the Millennium

Ecosystem Assessment (MEA) and has since permeated public policy and can even be found increasingly commonly in the business discourse (Houdet et al. 2012). The notion of ecosystem that this definition deals with is wide as they can range from undisturbed natural areas in remote regions, to fully managed green infrastructure in e.g. urban parks.

Generally, ecosystem services are classified into four categories: supporting, provisioning, regulating and cultural (for a detailed overview of each type of ES, see Millennium Ecosystem Assessment (2005, p. 40)). Supporting services are at the core since they generate functioning habitats and include services such as nutrient cycling and soil formation without which other services could not occur. Provisioning services include the direct resources that humans can obtain in the form of e.g. food and energy. Regulating services are the ecosystem functions that maintain the quality in an environment, such as air and soil quality, erosion control or extreme events buffers. Lastly, cultural ecosystem services are understood as the non-material benefits that relate to recreation, mental and physical health, aesthetics and inspirational experiences. Cultural services are considered highly important by being a direct visual means through which most people experience ecosystems (Andersson et al. 2015) – though they encounter challenges, often relating to the difficulty to quantify such subjective experiences (Chan et al. 2012). Figure 1 summarizes the different types of ES.

This study directly uses the ecosystem services as a basis to understand the different functions that green roofs provide and to determine their optimal location. By being nature-based solutions (see section 3.b.), green roofs actively utilize the benefits of ES to offer functions such as water retention, food production or biodiversity habitats. Therefore, as will be outlined further in the study, the different ES that each green roof provides is estimated based on the work of Persson et al. (2020) at Anthesis Group Sweden. In addition to designing green roofs and identifying their various ES solutions, certain services were also quantified and translated to monetary value to produce a direct estimate of how much green roofs could help save and generate.

Supporting Services

Necessary services for the production of all other ecosystem services

Examples:

Soil formation
Photosynthesis
Primary production
Nutrient cycling
Water cycling

Provisioning Services

Direct products obtained from ecosystems

Examples:

Food
Fiber
Fuels
Biochemicals and pharmaceuticals
Fresh water
Genetic resources
Ornamental resources

Regulating Services

Benefits obtained from regulation of ecosystem processes

Examples:

Air quality regulation
Climate regulation
Water regulation
Water purification
Erosion control
Disease regulation
Pest regulation
Pollination
Natural hazard regulation

Cultural Services

Non-material benefits obtained from ecosystems

Examples:

Physical and mental health
Cultural diversity
Knowledge systems
Religious value
Educational opportunities
Cultural heritage values
Sense of place
Aesthetic values
Social relations

Figure 1. Summary of the four categories of ecosystem services and examples. Own figure, source content from Millennium Ecosystem Assessment (2005).

2.2.2. Nature-based solutions (NbS)

As cities increasingly adopt sustainable strategies to improve their environmental performance and quality of life, nature-based solutions (NBS) utilize natural features that provide ES, particularly in highly urbanized settings (Cohen-Shacham et al. 2016; Nesshöver et al. 2017). This approach provides both adaptation and mitigation potential to address challenges brought forth by issues of climate change, water management, food security, etc. Thus NBS are widely considered essential in sustainable urban development (Leeuwen et al. 2010). The European Commission defines NBS as:

> Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions (European Commission, n.d.).

NBS are also seen as multifunctional because they provide a range of solutions to problems of social, environmental and economic nature, often at the same time. An example of how NBS can address social problems is seen through their provision of Cultural Ecosystem Services (CES), such as health and well-being in recreative, social and aesthetic areas. The benefits of green infrastructure on health for instance

has received significant attention (de Vries et al. 2003; Tzoulas et al. 2007; Hartig et al. 2014) with some even showing potential of urban green to reduce social inequalities (Mitchell 2013; Mitchell et al. 2015).

Similarly, in Stockholm, Barthel et al. (2010) have shown that NBS such as allotment gardens in the city contribute to building social networks of exchange of information and practices. They suggest this generates social-ecological memory whereby experiences and local knowledge of ecosystem services are more readily conserved and dispersed among the population, which builds resilience – particularly in cases of shocks in e.g. the global food chain.

Andersson et al. (2015) also suggest that CES are easily perceptible by urban populations, likely more so than regulating or provisioning services which are often harder to notice. As such, they argue, CES may also be harnessed to more efficiently tackle other types of problems such as environmental ones through increased awareness and engagement of urbanites. Because NBS are multifunctional, the provision of CES are generally accompanied by regulating, supporting and provisioning services.

2.2.3. Green Infrastructure (GI)

Green infrastructure is defined by the EC as follows:

> A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings (European Commission 2013:3, p.2).

GI is used in urban planning and research as a common denomination for the spaces as denoted in the quote above. Green roofs are therefore a type of green infrastructure that provides nature-based Solutions in the form of ecosystem services.

2.2.4. Sustainable Development Goals

The SDGs were introduced in 2015 following the United Nations' resolution known as the 2030 Agenda (United Nations 2015). Together they represent the 17 goals that humanity as a whole should strive for. More practically however, they form a

wider framework aiming to orient the development of national, regional and local policy towards more sustainable and circular outcomes.

Addressing the SDGs should however always be a holistic enterprise, since it is important to consider the various constraining and reinforcing dynamics between different goals. For example Nilsson et al. (2016) explore the interactions between the SDGs and argue that efficiently combining goals is key to reaching them with as few tradeoffs as possible. This effectively means that any solution that addresses multiple goals should be regarded as an appealing option. UGI is interesting in this regard, given that it often contributes to many of the environmental, social and economic goals alike through multifunctional ecosystem services.

Among the 17 goals, five are related to this study, two directly and three indirectly. In seeking to improve the environmental performance and livability of the built environment and of cities in general, this thesis directly addresses goals 9 (*Industry, Innovation and Infrastructure*) and 11 (*Sustainable Cities and Communities*). It is also expected that through the efficient development of green roof technology on a larger scale, goals 3 (*Good Health and Well-Being*), 13 (*Climate Action*) and 15 (*Life on Land*) would be positively impacted.

2.2.5. European Commission and urban development

The EC has since 2013 indicated its commitment to developing GI as part of a wider framework to utilize NBS in both mitigation and adaptation perspectives (European Commission 2013). As part of a strategy for expanding the recognition and use of ecosystem services, providing resilient infrastructure and a general desire to protect European natural capital, UGI is seen as a tool that can respond to many of these challenges. Following this initiative, the EU is actively encouraging the use of GI with policy, legal and financial support.

After a five-year reassessment of the original GI initiative, the EC found that while progress has been seen across Member States and at various scales, "a strategic approach for GI at EU level has not been implemented yet; and a more robust enabling framework for GI should be considered." (European Commission 2019:10). More resources are being introduced as a response as well as more financing mechanisms. This study therefore fits well into the EC's call for more innovative approaches to GI.

2.3. What is the Sydöstra Staden project

2.3.1. Overview

Sydöstra staden is an urban development project in Uppsala, Sweden (figures 2 and 3). It constitutes one of the largest projects of its kind and aims to connect the city of Uppsala with Ultuna in the south to generate up to an estimated 21 000 new housing units and over 10 000 offices (Uppsala Kommun 2018a) in the planned area. The project is an effort led by the city of Uppsala to harness the economic potential of the region given the availability of several research and innovation institutions in the area as well as its close proximity to the economic hub of Stockholm. It also aims to plan ahead for the expected population growth of the region as both Uppsala and the Stockholm regions have experienced strong growth over the past decade, with more growth being anticipated (Uppsala Kommun 2018b; Stockholm Stad 2020).

Public dialogues around the planning started in 2014 and have been ongoing, with two comprehensive overview plans published to this date (*fördjupad översikstplan,* hereafter referred to as FÖP from Uppsala Kommun, 2018). The next steps are expected to include follow ups, further comprehensive plans and ultimately, the issuing of construction permits.

Sustainability and attractiveness have been cited as driving forces behind Södra staden. A strong emphasis has also been directed at the development of green infrastructure and the integration of green corridors to ensure that biodiversity levels are preserved to the maximal extent. Similarly, concerns have been raised over the impact of the project on nearby water quality and risks of ground water contamination (Rydberg & Näslund 2015; Uppsala Kommun 2018a). Hence, water management and biodiversity will be two key areas in which the project will seek to promote innovation and sustainable development.

Important aspects to consider include the construction of a new train station in Bergsbrunna on the existing line between Uppsala and Stockholm, which will render the southern part of the city significantly more accessible to many (Iselidh 2017). To improve connectivity further, tramway lines are planned between the Uppsala and Södra staden and Gottsunda (Uppsala Kommun 2020). This expansion of transport infrastructure means that population, built environment and economic activity are likely to grow significantly in the medium- to long-term thus creating pressure on existing land and natural features.

The development of transports and housing infrastructure at these scale showcases a strong determination by the both the county and city of Uppsala and the government of Sweden to develop this area in anticipation of population and

economic growth trends. It is therefore essential that the development be ambitious and innovative in terms of sustainability given the known impacts of the construction sector and the development of arable land. The expansion of green roofs technology is an example of innovative practices that may reduce the environmental impact of such urban development projects, while simultaneously carrying potential to create new forms of societal and financial value.

Figure 2. Map of Uppsala and Sydöstra staden, the studied area. Base map from OpenStreetMap (CC-BY-SA), outline study area from FÖP (Uppsala Kommun, 2018)

2.3.2. Current highlighted issues

In an opinion communication from researchers at the Swedish University of Agricultural Sciences (Universitetsdirektören SLU 2020) based in Ultuna – which is located within the larger project sister-project Södra staden development area – two interconnected issues were identified. Researchers expressed their concerns over the high degree of urban development that would take place in Södra staden to achieve the project in its current plans. Moreover, they also argued that in its current standing, much of the planned construction would occur on productive arable land. According to Swedish law and environmental regulations *Miljöbalken* enacted in 1999 (MB 4§3), construction on agricultural land should only be undertaken to satisfy essential societal interests and other land types should be prioritized (MB 1998:808).

Concerns over agricultural land losses and water contamination are serious issues facing the development of Södra and Sydöstra staden, though it should be noted that there are many environmental advantages to building more densely and closer to important transport nodes. It may be key to prevent urban sprawl (Bibri et al. 2020) and facilitate the use of more sustainable transport, such as public transport or biking and walking. Similarly, there are increased possibilities for efficient water management in denser area, though space for processing is also needed.

In this regard, it is also worth noting that a significant body of literature has shown that green roofs have strong potential in mitigating stormwater issues and have the capacity to be efficient food production units within urban areas, providing resilience (Czemiel Berndtsson 2010; Whittinghill & Rowe 2012) and innovative urban design.

Therefore, as a response to both concerns of agricultural land and biodiversity losses and stormwater management issues, the present study may serve as a step in the process of reconciling the issues that are facing Sydöstra staden. It should also be stated that this study will work under the assumption that the plan in its current form will be reflective of its end-product, that is important land transformation, for which green roofs can attenuate the negative consequences.

2.4. What role can green roofs play in a sustainable urban development?

2.4.1. Introduction to green roofs

Green roofs (GR) are a type of NBS that can be fitted on rooftops, where their main function is to provide ecosystem services in an urban environment (Oberndorfer et al. 2007). The advantages of GR are especially interesting given their potential to create productive areas and habitats in locations that are generally unused and by doing so, they contribute to increasing a city's resilience (Pelorosso & Gobattoni 2015).

Currently, urbanized areas face many known problems ranging from important losses in biodiversity to water management issues as stormwater runoff has been identified as the most common type of natural disaster (Jha et al. 2012). The lack of green infrastructure in cities is also responsible for causing heat to accumulate known as the heat island effects (Kleerekoper et al. 2012) and studies in the Netherlands and the United Kingdom have highlighted worse health and decreased well-being in communities that do not have access to any green infrastructure (de Vries et al. 2003; Mitchell & Popham 2008; Mitchell et al. 2015). These aspects all threaten the resilience of cities and their capacity to withstand various types of shocks of environmental, social or economic nature (Gómez-Baggethun et al. 2013).

The recent necessity to integrate additional green infrastructure into cities, an effort led by the EC since 2013 (European Commission 2013), has caused a surge in interest over GR. They have been shown to be effective water retention mechanisms (Czemiel Berndtsson 2010; Engström et al. 2018), to have beneficial energy properties in both insulating buildings (Ascione et al. 2013; Besir & Cuce 2018) and optimizing the efficiency of solar panels (Bengtsson & Lind 2017). Moreover, GR can serve as social meeting places if developed as recreational areas and examples exist of significant food production operations taking place on GR (see Ryerson Urban Farm). A more detailed overview of the different specialized functions that green roofs can be developed into can, be found in section 4.c.

GR have been shown to provide all four types of ecosystem services (regulating, provisioning, supporting and cultural) on unoccupied surfaces which makes them very appealing instruments – at least on a theoretical basis. Practically however they often face pushback in the planning and construction sectors due to fears of them being costly to implement and maintain combined with a general lack of

knowledge around both the financial and environmental benefits and spillovers they can potentially translate to (Persson et al. 2020). Being a new technology that answers to emerging needs, green roofs are commonly met with skepticism and resistance as they have yet to demonstrate on a larger scale what benefits they can bring, how they can be financially incentivizing and how they fare with time (*ibid.*).

This section highlights the main functions of green roofs and reasons why green roofs are an attractive option in Uppsala. Key challenges are also identified.

2.4.2. Why build green roofs in Uppsala?

While generally seen as a means for highly urbanized and densely settled populations to access UGI (Langemeyer et al. 2020), there are other circumstances in which planning for GR may be relevant. In a location such as Södra staden in Uppsala, future urban development and rigorous sustainability objectives, as well as innovation may be incentivizing reasons to develop GR.

The city has been experiencing sharp growth in population over the past decade and it has been recorded to be increasingly difficult for inhabitants to find housing (Länsstyrelsen Uppsala 2019). Therefore, the pace of construction is expected to accelerate which points to future challenges in housing a rapidly growing population while planning for sustainable urban development – two elements that can often clash.

In anticipation of these future development trends and in the context of a strong sustainability policy, green roofs provide the possibility for developers, property owners and residents alike to reduce direct and indirect and costs associated with stormwater runoff, noise, heating and cooling among others while contributing to providing a better living environment on the city level. Having won the WWF sustainability awards in 2018 and being on track to meet the Agenda 2030 goals, Uppsala has demonstrated through both action and policy that it is actively seeking to establish itself as a leader in sustainable urban planning and design (WWF 2018). Södra staden is one example of a serious attempt at innovating in sustainability and promoting the development of a strong industry anchored in the export of green and clean technology (Uppsala Kommun 2018a).

 It may be of strategic importance to the project and those involved to include emerging technologies. Building more efficiently and with less climate impact has been a significant trend in Europe and the world in general as minimum requirements have grown (Laustsen 2008). For planners and construction firms

alike, the successful integration of green roofs could represent an edge over their competition and enable to further develop export the practices.

2.4.3. What are the different types and functions of green roofs?

The term green roof is often employed as an umbrella to designate rooftops that provide a set of ecosystem services. As a basis for study, this thesis uses the five green roofs designed by Anthesis Group Sweden in collaboration with the University of Gävle and Ekologigruppen (Persson et al. 2020) delivered as a mission to Future Position X. Those five green roofs were developed to showcase how urban ecosystem services can be developed from a market-driven perspective and demonstrate the financial savings and incentives that emerge when integrating green roofs and their ecosystem services to buildings. Each rooftop design is created to address one main function while also providing a range of other ES. Below the different types of green roofs are introduced, their basic functions are summarized, and their ES are listed. Further details about the roof concepts can be found in the report (see Persson et al., 2020).

Water Roof

The main ES provided by the water roof is stormwater management by retaining rainwater and thus delaying its peak flow (Graceson et al. 2013; Persson et al. 2020). This is particularly relevant in the event of a cloudburst whereby extreme amounts of rainfall can suddenly occur in a short period of time. Depending on a city's stormwater management infrastructure, this can generate massive floods and cause significant property damage as well as pose safety risks. As the predictability of cloudbursts is difficult to ascertain and likely to increase in frequency due to the effects of climate change, efficient stormwater management is extremely important to consider in urban planning (Rosenzweig et al. 2019). Green roofs with water retention functions are therefore an easier and cheaper solution to deal with stormwater retention issues than expanding the processing capacity of local wastewater systems (Bengtsson & Lind 2017). They should be considered as one of the components of a larger urban network that deals with stormwater management because they cannot fulfill the function alone, other forms are infrastructure such as canals and basins are also necessary. It is worth noting that "local climate regulation" ES incorporates both regulating of surrounding urban microclimate as well as regulating of energy inside of the building, mainly through

insulation. The ES lists that follow are adapted from Swedish. For more extensive details about the type of water production roof, see Persson et al. (2020).

Figure 3. Illustration of the concept water roof, by Marita Wallhagen. From Persson et al. (2020). Figure reprinted with permission from publisher.

Table 1. Summary of the ecosystem services provided by the water roof.

Ecosystem Service		Effect
Supporting	Biodiversity	Medium-high
	Nutrient cycling	-
Provisioning	Food production	-
Regulating	Local climate regulation	High
	Air regulation	Medium (if presence of shrubs and smaller trees)
	Noise regulation	High
	Water regulation	High
	Pollination	Medium to High
Cultural	Mental well-being / aesthetics	Low
	Knowledge and inspiration	Low
	Social interaction	-

Energy Roof

The main function of the energy roof is to provide improved, local and renewable energy production. By using vegetation as a layer under solar panels which cools the panels, their efficiency can be improved since efficiency decreases with 0,35% to 0,5% for every increase in degree (Bengtsson & Lind 2017). The roof provides a means to avoid rises in electricity prices, which are expected to increase. Energy production is not considered an ecosystem service and therefore not listed in the table. For more extensive details about the energy roof, see Persson et al. (2020).

Figure 4. Illustration of the concept energy roof, by Marita Wallhagen. From Persson et al. (2020). Figure reprinted with permission from publisher.

Table 2. Summary of the ecosystem services provided by the energy roof.

Ecosystem Service		Effect
Supporting	Biodiversity	Low
	Nutrient cycling	-
Provisioning	Food production	-
Regulating	Local climate regulation	Medium
	Air regulation	-
	Noise regulation	Low
	Water regulation	Low
	Pollination	Low
Cultural	Mental well-being / aesthetics	Low
	Knowledge and inspiration	Low
	Social interaction	-

Biodiversity Roof

The main function of the biodiversity roof is to contribute to the strengthening of biodiversity in urban areas by providing space, habitats and interactions grounds for various species (vegetation, insects, birds, small mammals, etc.). Its design intends to reproduce a natural environment. It is designed to have low to zero maintenance and can have a substrate depth variating between 120mm and 800mm depending on the vegetation types desired and strength of the roof. For more extensive details about the type of biodiversity production roof, see Persson et al. (2020).
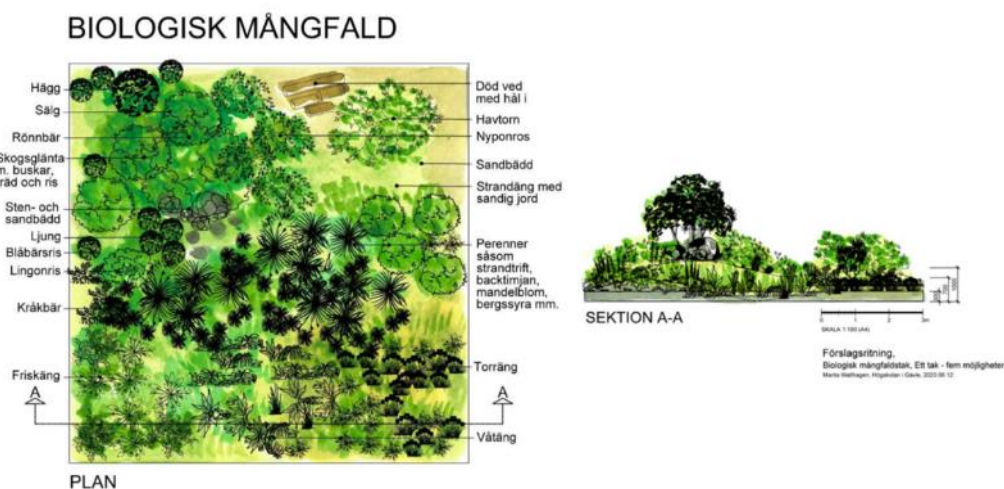
Figure 5. Illustration of the concept biodiversity roof, by Marita Wallhagen. From Persson et al. (2020). Figure reprinted with permission from publisher.

Table 3. Summary of the ecosystem services provided by the biodiversity roof.

Ecosystem Service		Effect
Supporting	Biodiversity	High
	Nutrient cycling	-
Provisioning	Food production	-
Regulating	Local climate regulation	High
	Air regulation	Medium
	Noise regulation	High
	Water regulation	High
	Pollination	High
Cultural	Mental well-being / aesthetics	Low
	Knowledge and inspiration	Low
	Social interaction	-

Food Production Roof

The food production roof is primarily designed to be fitted on the roof of a business that uses food on a daily basis such as a restaurant or a hotel. This is partly due to it being one of the two roofs together with the recreation roof that may require the most active form of management, thus having a higher potential operational cost. The advantages of a food production roof are plentiful though they largely depend on the design and the implementation. A properly designed food production roof offers nutrient cycling functions with thicker substrates as well as high potential for composting existing food waste, hence its ideal placement on the roof of a facility that serves food. Through thicker soil and presence of vegetation, it provides high noise reduction, regulation of local temperature, building insulation and air filtration ecosystem services. For more extensive details about the type of food production roof, see Persson et al. (2020).
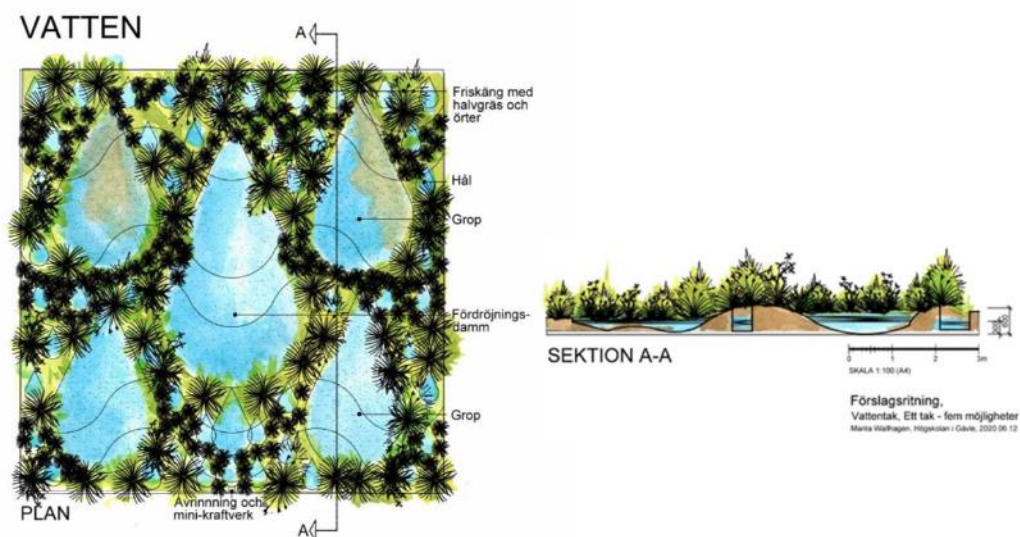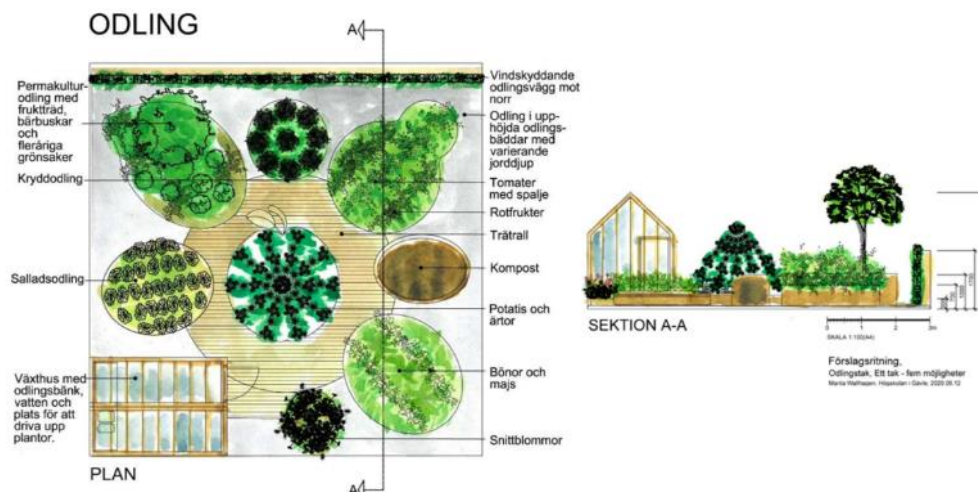

Figure 6. Illustration of the concept food production roof, by Marita Wallhagen. From Persson et al. (2020). Figure reprinted with permission from publisher.

Table 4. Summary of the ecosystem services provided by the food production roof.

Ecosystem Service		Effect
Supporting	Biodiversity	Low
	Nutrient cycling	Medium
Provisioning	Food production	High
Regulating	Local climate regulation	High
	Air regulation	-
	Noise regulation	High
	Water regulation	High
	Pollination	Medium
Cultural	Mental well-being / aesthetics	Low

	Knowledge and inspiration	Low
	Social interaction	-

Recreation Roof

The main purpose of the recreation roof is to provide green spaces that can as further primarily cultural ecosystem services. It is designed to be social and resting area with optional space for physical activity while offering this in an aesthetically pleasing green area. Buildings such as offices can for example use these types of roofs as a break area for workers. For more extensive details about the recreation roof, see Persson et al. (2020).
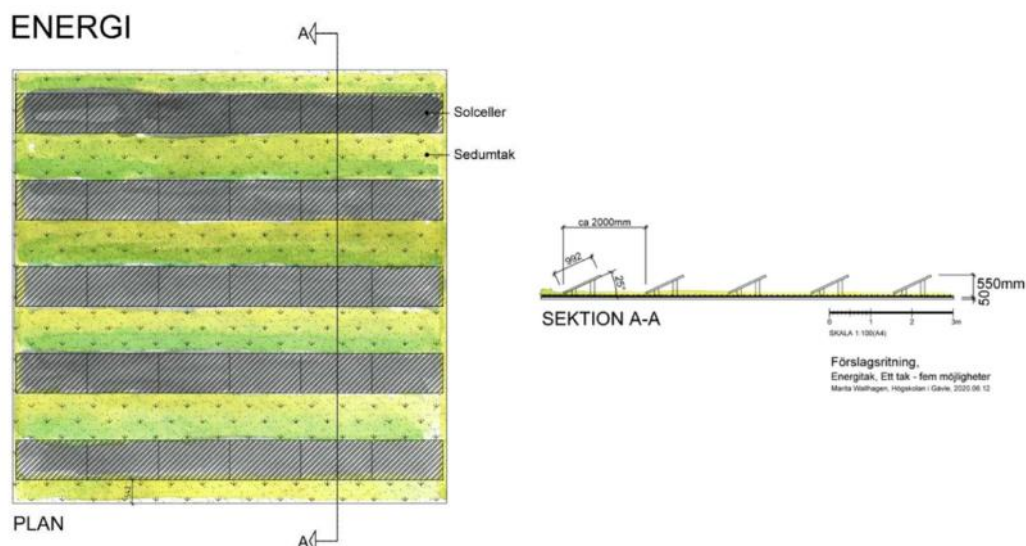

Figure 7. Illustration of the concept recreation roof, by Marita Wallhagen. From Persson et al. (2020). Figure reprinted with permission from publisher.

Table 5. Summary of the ecosystem services provided by the recreation roof.

Ecosystem Service		Effect
Supporting	Biodiversity	Medium
	Nutrient cycling	-
Provisioning	Food production	-
Regulating	Local climate regulation	Low-Medium
	Air regulation	Low-Medium
	Noise regulation	Low-Medium
	Water regulation	Low-Medium
	Pollination	Low-Medium
Cultural	Mental well-being / aesthetics	High
	Knowledge and inspiration	Medium-High
	Social interaction	High

2.4.4. Where to build green roofs?

While seemingly a straightforward question, this has received little attention in the academic literature on green roofs. Much of the published content is either focused primarily on individual functions of specific types of green roofs for e.g. enhanced energy production, or on the composition of green roofs (i.e. how should a specific green roof be built).

This study attempts to answer the question of optimal placement using Södra staden as an example. Given the limited quantity of information available on the subject, this question posed a significant challenge. Determining where a specific type of green roof should be located ultimately comes down to the geographical specificities of each location, given of course that the buildings are planned with green roofs in mind. In Södra staden, a development area of relatively small size yet large enough to contain enough variables to render certain areas more adapted than others.

To the author's best knowledge, only one previous study could be related directly to the use of GIS to calculate optimal locations for green roofs based on their ecosystem services. Grunwald et al. (2017) use GIS to map the suitability of rooftops in Braunschweig, Germany, based on datasets similar to the ones used in this study, namely a digital elevation model, land use map, building data, traffic flows data but use an additional climate dataset. They define four urban ecosystem services as main criteria: urban climate regulation, air quality regulation, water retention and biodiversity. In their model, approximately 1% of the existing buildings in the city are considered as highly suitable for green roofing, with 3,5% as moderately suitable and another 4,2% classified as low suitability. Their study demonstrates the applicability of the spatial approach in urban ES and green roofs mapping, and that the accuracy and wider deployment is mostly hindered by absent, insufficient or low-quality data as well as a lack of research on the effects of green roofs at the scale of a city. One of the main differences with this approach is the focus on new, unbuilt buildings for analysis.

2.4.5. The disruptive capacity of green roofs

Green roofs are a technology that can be traced back several hundreds of years. Former Viking settlements in the 11th century have been shown to use of such practices for insulation purposes, while some records even date back to ancient Syria and Egypt (Oberndorfer et al. 2007; Jim 2017). For most of history and to some extent still today, the greening of roofs was often practiced by the wealthiest in society, though they were always exceptions when green roofs were necessary (e.g. insulation in cold climates or fire hazards in Germany, see Jim, 2017). The recent re-emergence of green roof technology can be traced back to Germany in the 1960s, particularly with the standardization of concrete buildings for mass housing which permitted the use of flat roofs (*ibid.*). These were waterproofed with tar which is highly flammable and as a response, a sand and gravel mixture was used as an upper layer which also proved to be very hospitable to vegetation. The ES were then quickly understood and harnessed to provide services ranging from water retention, insulation and food production (*ibid.*).

Today, there are new contexts that are inseparable from the acceleration of green roof technology. The local benefits in climate adaptation and mitigation and the increasingly stringent regulatory environments in the EU and beyond have pushed many in the construction sector to rethink what can be done to reduce its environmental impact in both at the source (e.g. materials) as well as its impact during the lifetime of the buildings (e.g. lowered energy impact). With cities such as San Francisco and Toronto having legally mandated the construction of solar and green roofs on new buildings, as well as the global objectives as set out by the Agenda 2030's SDGs, there is significant evidence suggesting that green roofs are likely to grow significantly this coming century.

In the event of lockdowns, as was the case in many countries during the Covid-19 pandemic, greenspace proved to be an essential resilience tool in many urban areas as residents turned to natural environments for their health and well-being properties (Samuelsson et al. 2020). If green roofs are more readily available in the future, urban dwellers may be given an opportunity to enjoy greenspace while confined to their buildings.

Green roofs thus exemplify a form of technological innovation that – in addition to providing financial, health and environmental benefits in the form of ES – would allow many developers and building owners alike to stay ahead of regulation, while seizing what represents a new market of unused space in some of the most crowded and expensive areas in the world. Innovation and regulation can both potentially benefit from a practice known in the business literature as *first-mover advantage,* though this concept has some limitations (see Suarez and Lanzolla, 2005).

Therefore, green roofs can be seen as granting a competitive advantage to those implementing and perfecting them early, which may in turn translate to better *savoir-faire* and edge in an industry that has come under pressure for its high carbon footprint.

3. Methods and Analysis

The purpose of this study is to model the best suited location for each green roof type and thereby contribute to using the surrounding environment and ecosystem services as a means to optimize the outputs of green roofs. In other words, this analysis creates maps that will reveal – for each given rooftop in the construction area – which type of green roof is best suited for it. This is relevant because it will enable developers and planners to better integrate green roofs into the city and harness the environmental specificities of a location so ES can be optimized. Similar to how solar power companies provide visualization of where solar panels are effective to install, this study essentially aims to achieve a similar result with ES of green roofs.

Furthermore, it will allow to visualize areas with potential for high multifunctionality, that is, were multiple types of green roofs can be built. Conversely, areas with low multifunctionality potential can be seen as places where individual or low-combinations roofs may more relevant, ensuring efficient but single functions. Essentially, this study is a site suitability model for green roofs and their multifunctionality based on the ecosystem services they provide.

See appendix A for in-depth information on the models developed and used in the study.

3.1. Site Suitability

In order to perform a site suitability analysis, a GIS analysis will usually seek to break down the process in multiple steps (full description detailed on ESRI website). The first step is problem definition, which seeks to lay out a clear question that can then be further broken down into smaller spatial questions. In this case, the simplest and broadest question asked is: where should a green roof be placed? As mentioned in the background section 2.4.3, there are 5 different types of green roofs that are covered in this study, thus 5 separate versions of the same question are asked for each roof type (e.g. where should a water roof be placed?).

Once the problem is defined, a site suitability requires the definition of criteria that serve as proxies to help locate the output – the second step. This can be attained by identifying what elements constitute a desirable location. This can be a distance from something, or a terrain specificity. A common example when trying to locate an optimal location for e.g. a mine is to consider where the ore is located, where there are road connections and where the closest water stream is located. In short, the key elements which will make up an ideal location need to be thought out and modeled. When applied to this case, one of the criteria definition steps for e.g. a water roof – whose function is primarily aimed at retaining and delaying stormwater runoff – should ideally be placed in a location where it will help to avoid overflows, and not in a dry area where there is little rain and no risk for property damage in case of a storm. A summary of all the criteria used for each roof suitability is summarized in table 6. Some of the criteria are similar between roof types but the underlying models may differ from one suitability model to the other. For a more detailed overview of how the criteria are modeled, see the individual roof model descriptions (see section 3.2).

Criteria are therefore processed version of the raw datasets. To reflect reality more effectively, since certain criteria are often more significant than others, they were weighted in each subsequently explained model and detailed in table 6. The main rationale behind these weights is that the dataset which is most relevant to the main ES of a roof – for example the flood risk criteria in the case of the water roof – should receive the largest weight. The other criteria – such as the biodiversity map in the case of the water roof – received a weight of either 10%, 15% or 20% depending of if its ecosystem provided in section 2.4.3 was considered low, medium or high respectively. These sub criteria (that are not the main criteria, that is) were then summed and the remaining weight out of 100% was granted to the main criteria. This is all summarized in table 6.

3.2. Data

A joint step together with criteria definition of site suitability is deriving the data. This means finding data, not necessarily spatial, from which the criteria can be translated. The criteria are processed versions of the original dataset that extract the relevant information, an example of this can be found in section 3.3.1. The datasets used in this study are summarized in the section below along with brief descriptions. A total of 4 distinct datasets were used: a digital elevation model (DEM), a planned land use map, a street and flows map and a map of planned buildings. The number of datasets used reflect the time constraints of the thesis as well as the limitations

in obtaining precise data for a relatively small area that has not yet been developed, hence lacking a lot of information. Below, each dataset that was used is explained, shown in the form of map and its source is given.

3.2.1. Digital Elevation Model (DEM)

The DEM (figure 8) is a representation of the terrain and highlights variations in altitude. Multiple elements can be derived from a DEM, such as slope, aspect, radiation, etc. The results depend on its resolution. The DEM used in this study is obtained from the Swedish Mapping, Cadastral and Land Registration Authority (*Lantmäteriet*). It is of relatively high quality with 2 meters cell size resolution, meaning one cell in the map is the average elevation of a 2x2 meters square. All the rasters extracted in this study were based on the same cell size as the DEM.
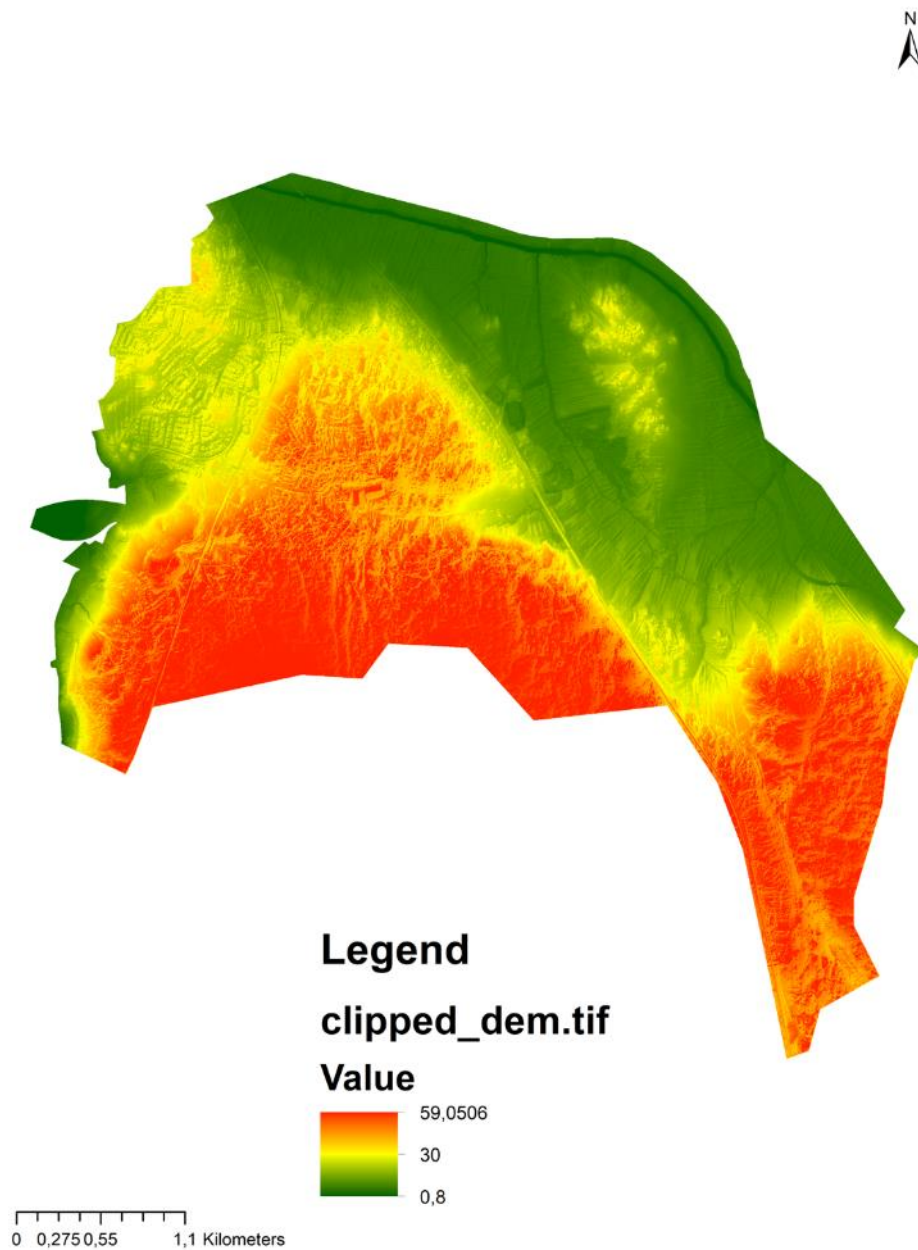
Figure 8. Digital Elevation Model of Sydöstra staden, with altitude ranging from 0.8 meters to 59 meters. Data from Lantmäteriet.

3.2.2. Planned Land Use

This dataset was georeferenced from the FÖP and contains the city's latest, preliminary plans for how the land will be developed, used and distributed in the new neighborhood. It incorporates elements such as built environment (buildings,

urban land cover) and green areas (forests, parks, urban agriculture, biodiversity corridors) as well as other land uses, see figure 8.

Figure 9. Map of existing and planned land use in Sydöstra staden. Data georeferenced from FÖP.

3.2.3. Streets and Flows

This dataset was georeferenced from the FÖP and contains the city's latest, preliminary plans for how various streets and flows will be incorporated into the landscape. It details e.g. where main roads will be located for various vehicles (cars, bicycles, public transport), where biodiversity corridors are planned etc. See figure 9 for overview.
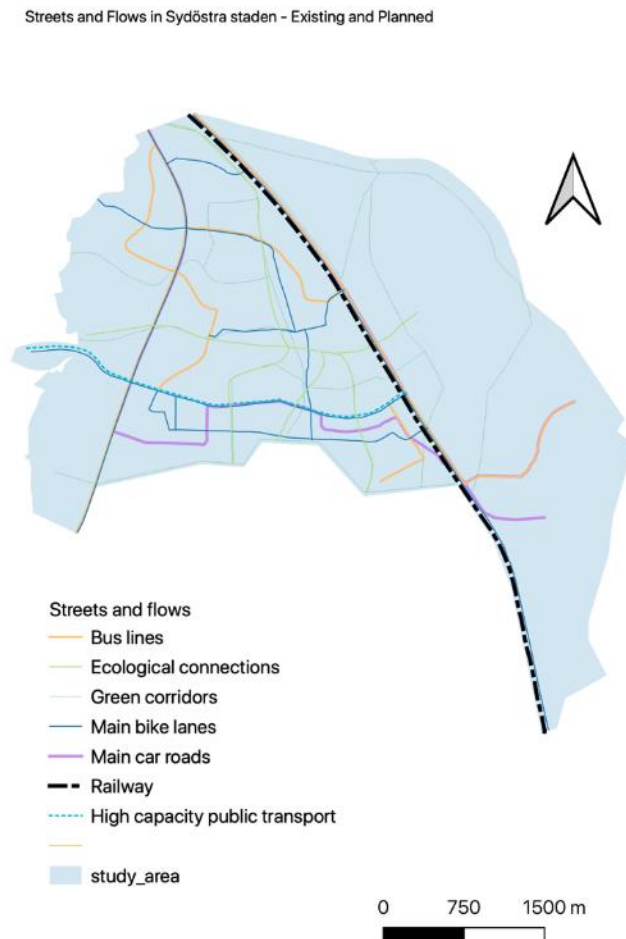
Figure 10. Map of existing and planned streets and flows in Sydöstra staden. Data georeferenced from FÖP.

3.2.4. Planned Buildings

Uppsala Kommun provided the planned buildings map, which details the shape and the locations of all new buildings in the area. This dataset was enriched with information extracted from the FÖP relating to building functions, such as which ones will be schools, hospitals, offices, etc. (see Uppsala Kommun 2020:27). These functions where added as new attributes to each shape. See figure 11 for overview.
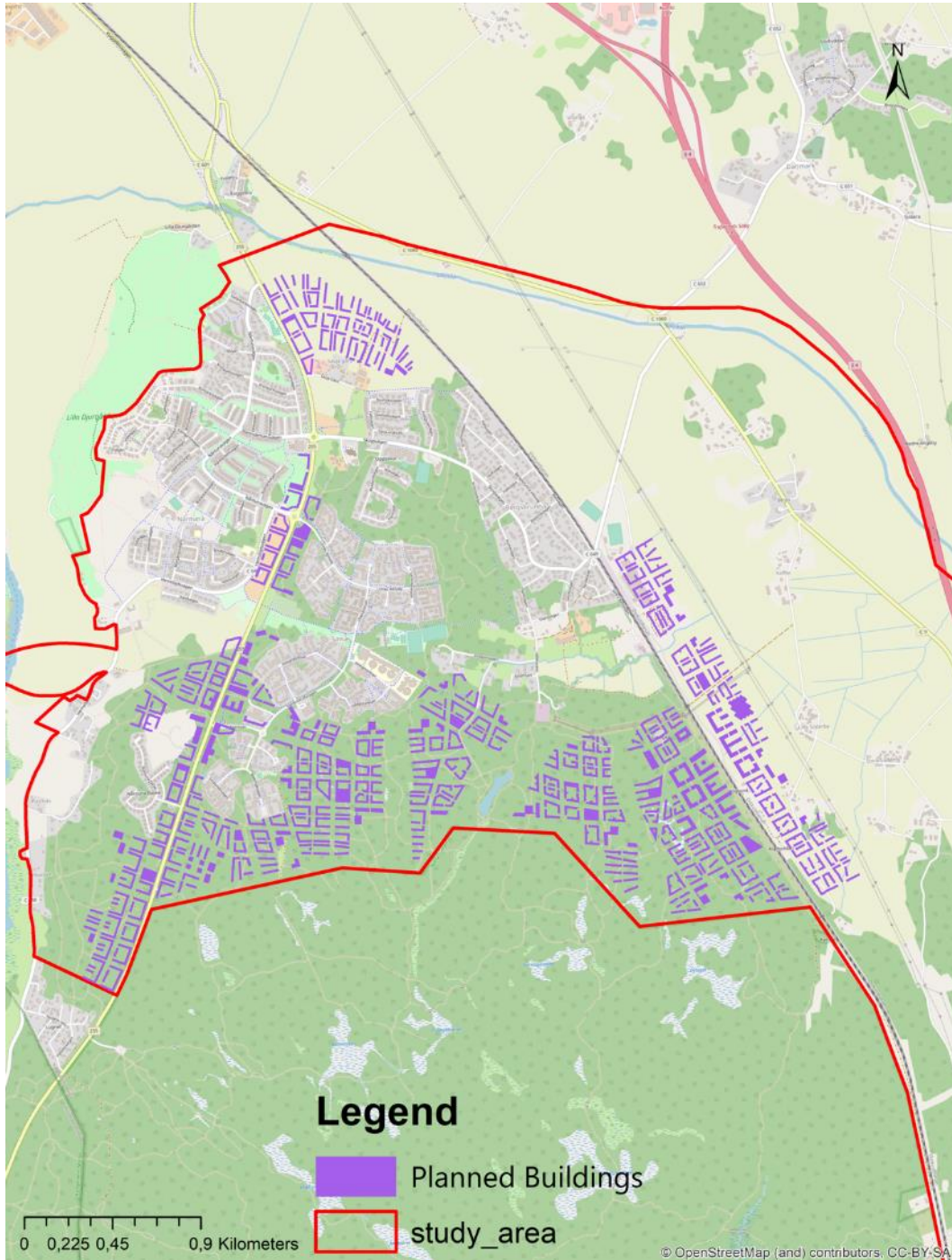
Figure 11. Map of planned buildings in Sydöstra staden. Base map from OpenStreetMap (CC-BY-SA).

Table 6. Summary of the parameters, criteria and data used for the GIS analysis

Roof type	Primary ecosystem service function	Criteria and weight	Datasets
Water roof	Retaining and delaying stormwater runoff	Flood risk (60%) Noise pollution (20%) Biodiversity support (20%)	Elevation map (DEM) Streets and flows map Planned land cover Planned buildings
Biodiversity roof	Supporting biodiversity	Biodiversity support (60%) Flood risk (20%) Noise pollution (20%)	Elevation map (DEM) Streets and flows map Planned land cover Planned buildings
Food production roof	Local food production	Proximity to biodiversity rich areas and habitats (20%) Close proximity to biodiversity (20%) Function of the building (e.g. restaurant, hotel, schools) (20%) Flood risk (20%) Noise pollution (20%)	Elevation map (DEM) Streets and flows map Planned land cover Planned buildings
Recreational / social roof	Cultural ecosystem services: meeting and social place, learning, resting	Function of the building (20%) Feature of building: size, surface. (20%) Biodiversity support (20%) Flood risk (20%) Noise pollution (20%)	Elevation map (DEM) Streets and flows map Planned land cover Planned buildings
Energy roof	Energy production and solar panel output optimization	Solar radiation (70%) Flood risk (10%) Noise pollution (10%) Biodiversity support (10%)	Elevation map (DEM) Streets and flows map Planned land cover Planned buildings

3.3. Suitability Models

3.3.1. Water Roof Model

The water roof model is intended to display optimal locations for water roofs. In Persson et al. (2020), the concept water roof provides high ES for stormwater management, biodiversity, noise pollution reduction and local temperature regulation. The site suitability for the water roof was therefore conducted on the basis of the main ES that it provides and where these services would be the most needed.

All ES were included in the water roof model except local temperature regulation. This could have been integrated in two ways, either through data on temperature variations or urban heat island effect in Uppsala. A temperature map was found but since it was at a national scale, its resolution was deemed too low to have any impact since all average temperatures were the same. Readily available data on e.g. urban heat island was not found and difficult to estimate in an area not yet constructed. One potential way of including a rough estimate for locations with higher than average temperatures would be to use urban land cover as a proxy and/or Uppsala's local temperature variation as proxy, though this would require high resolution data which is often accessible only through paywalls.

The resulting layers from the sections that are described below are weighted together (figure 12). The biodiversity, noise and flood risk models are merged using the weighted overlay tool in ArcGIS. The biodiversity and noise models are attributed a weight of 20% each while the main function of the roof which is preventing flooding is attributed a weight of 60%. The rationale used in this study to weigh the criteria is the following: out of the incorporated ES, a *high* ES was always given 20% weight, a *medium* ES was given 15% and a *low* ES was given 10%. The main ES of the roof was attributed the rest of the weight (on 100% basis).

The resulting layer is then processed in the zonal statistics tool as an input value raster together with the planned buildings layer which us used as the feature zone data. By choosing majority as the statistics type, the tool selects the most common cell value in a given building which is used to determine what value each building obtains.
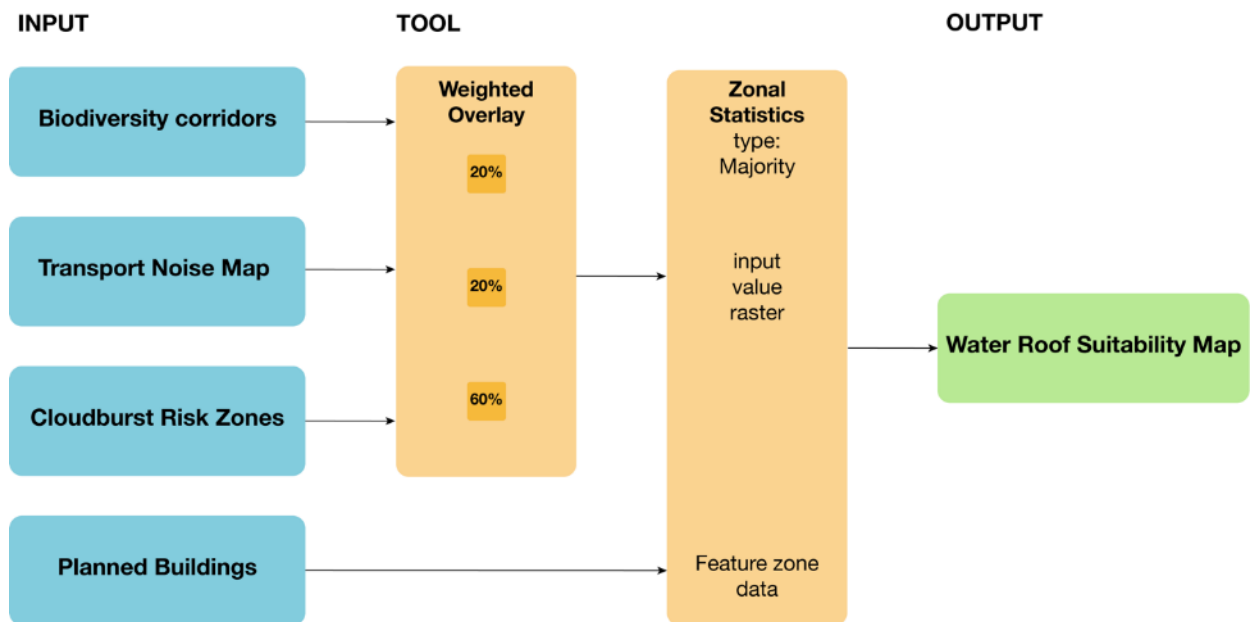
Figure 12. Simplified GIS model of the water roof suitability analysis. Own figure. The full model can be found in the appendix in python format.

Flood Risk sub-model

The main function of the model is firstly to use the elevation data of the study area to locate sinks that are susceptible to being filled in the event of a cloudburst. These are also known as bluespots. Once the bluespots are found, they are combined together with the planned buildings to determine how large each bluespot is and much of each building is located in a bluespots risk zone. These two are then merged together using the weighted sum tool and given equal weight to generate a cloudburst risk zone map, also referred to as the flood risk sub-model. This map is then used in the final water roof model weighted at 60% (see previous section). Figure 3 and 4 provide a simplified overview of the steps developed for flood risk sub models.

This sub-model is in part based on the Environmental Systems Research Institute's (ESRI) cloudburst model developed as a case study for Copenhagen in response to its cloudburst catastrophe in 2011. The ArcGIS license accessed through the Swedish University of Agricultural Sciences enables access to the model description and content. By using the fill tool which finds cells with have undefined drainage location, that is, lower value than their surrounding cells (figure 13). With this, the pourpoint is calculated and areas that are likely to fill up first in the event of a cloudburst are highlighted. These areas are then transformed to polygons so that each bluespot can be defined by attributes, such as areas size.
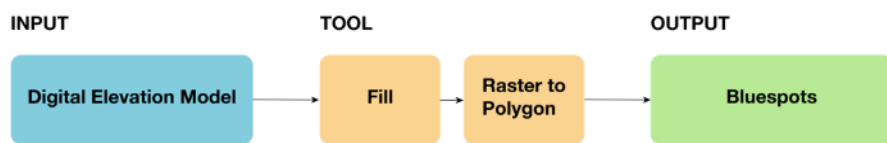
Figure 13. Simplified GIS model of the bluespots sub-model. Own figure. The full water roof suitability model can be found in the appendix in python format.

The bluespots are used as input component to the cloudburst risk zones layer which is the main flood risk input of the water roof suitability. This layer is obtained by first calculating the area of each building and bluespot and then identifying all the locations in which these intersect and how much percentage of each building is located in a bluespot (figure 14). Both bluespots and the relative bluespot cover of each building are then reclassified to a 1-5 where 5 is most exposed and largest bluespot. These layers are then weighted together with equal influence to generate the cloudburst risk zones, or flood risk layer.
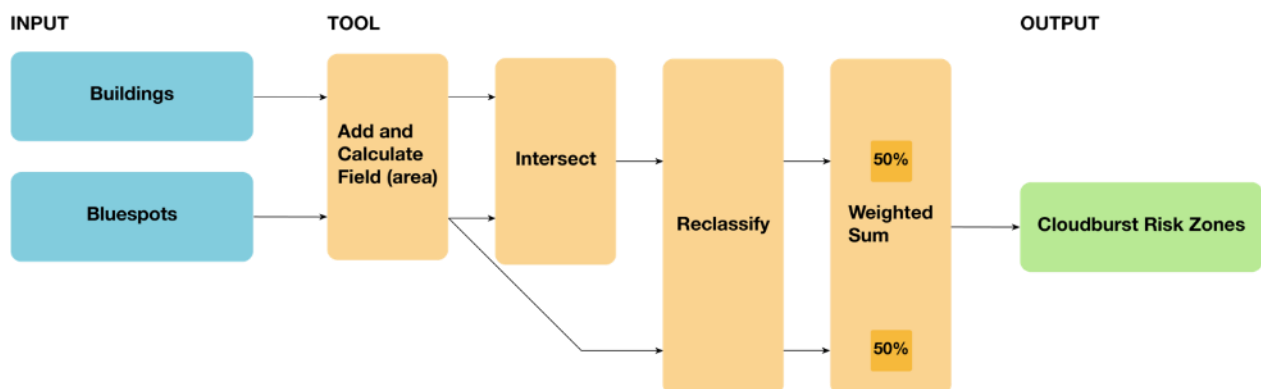
Figure 14. Simplified GIS model of the cloudburst risk zones. Own figure.

Biodiversity sub-model

The biodiversity sub-model is developed in such a way that it is intended to provide a suitability map of locations in proximity to high biodiversity areas which may enhance the biodiversity potential of the biodiversity roofs. It is used both as a sub-model in the for the green roofs that have biodiversity listed as a main ES (e.g. water roof), and as a main component in the biodiversity roof model.

This is based on the assumption that green roofs which provide biodiversity ES are doing it mainly through habitats and/or feeding grounds for various species (arthropods, insects, birds, various pollinators, small mammals, etc.). This has been documented by Madre et al. (2013) who have investigated arthropod communities on green roofs and found that green roofs such as the biodiversity roof could host many and diverse arthropod communities. They also stress that this is an area that significantly lacks research. An important element to take into account in the green roof planning process is habitat redundancy as it can minimize the distance between habitats and facilitate the mobility of species, particularly for those with low dispersal capacity (Mayrand & Clergeau 2018).

While green roofs vary in size, even large ones may be considered unsuitable for hosting a high and diverse fauna and flora, unless they are connected with their surrounding environment (Braaker et al. 2014). In such a scenario, biodiversity roofs may even act as enhancers of local biodiversity, by enlarging the total areas size on which animals, insects and plants can interact, move about and reproduce.

Through the overview plans of the city (FÖP), there are in the study area multiple areas that have been designed to promote the circulation of biodiversity, such as green corridors which favor the active circulation of fauna through the city by leaving space for them to cross and be less exposed to residents and vehicles (Uppsala Kommun 2020). There is also geographical data about where new parks and were e.g. urban farming lots will be located (see figure 9). All these elements factor into the overall suitability for biodiversity roof.

There are of course several limitations that ensue from moving certain habitats from the ground up to roofs. One of them is that it has been documented that pollinators may not always have the capacity to move in altitude between buildings. Another one is that for a biodiversity roofs to reach its full potential, it may need to be integrated in an existing network of green roofs that together provide a large enough habitat size at the roof level in a given city. It may be easier for some species to move between roofs rather than between the ground and roofs.
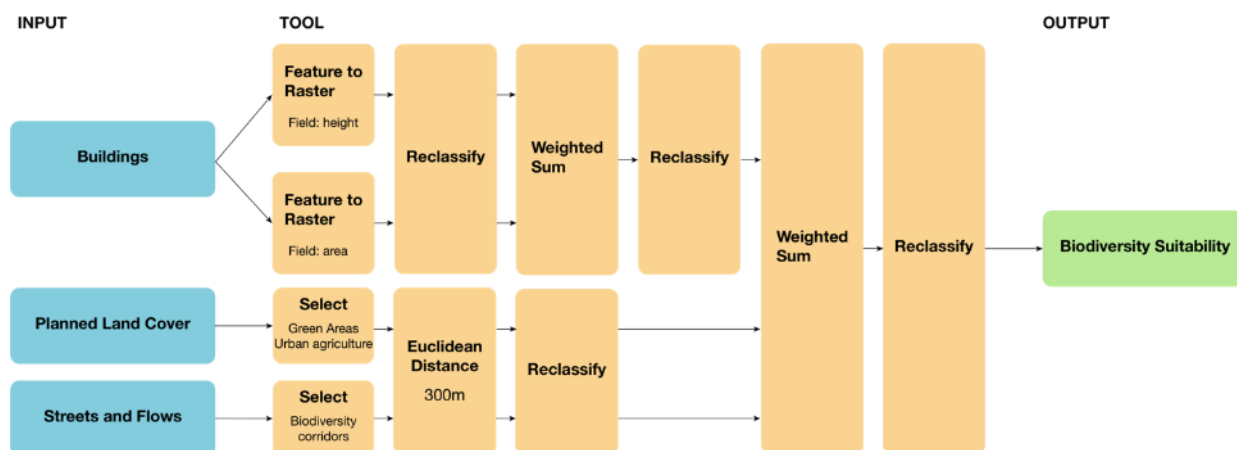
Figure 15. Simplified GIS model of the biodiversity suitability layer. It is synonymous with the biodiversity corridors layer in figure 12 (erratum). Own figure.

In other words, this model aims to showcase which areas would benefit most from infrastructure that promotes biodiversity. It draws on 3 datasets: planned buildings, planned landcover of the final study area and the streets and flows. From the buildings are extracted both height and surface area features on which these features are rasterized and reclassified using the Jenks natural breaks classification method. They are then weighted together at similar weights (50% each) and added to the other two datasets. Based on the planned land cover (biodiversity rich) and streets and flows (biodiversity promoter) datasets a buffer area of 300 meters is created around them and reclassified to a gradual buffer in 5 categories with equal intervals as classification method. The buffers around biodiversity rich and promotion areas is then added to the buildings with equal weights each and subsequently reclassified to generate the biodiversity suitability layer which is then used in the final calculation of the biodiversity roof as the main criteria.

Noise Pollution sub-model

Noise pollution is a main concern in urban areas. This is due to the presence of multiple noise-emitting sources (traffic, construction sites, etc.) and the proximity of people's housing and workplaces. In most countries, there are regulations that limit the average sustained noise levels to ensure that their impact on public health is minimized.

Because noise pollution has been a concern for a significant amount of time and at the center of many infrastructural projects such as the construction of new railways, highways and airports, the health damages that elevated noise contributes to has been widely documented and quantified and even subject to monetary valuations

for compensation. However, it is generally difficult to provide off-the-bat values as many physical attributes of an environment can change the propagation of noise. For example, hard surfaces such as concrete and asphalt relay sound much more efficiently than "softer" surfaces such as unpaved ground or vegetation. This is also one of the reasons that many green roofs have efficient noise reduction potential, since they are covered with little to extensive vegetation (Connelly & Hodgson 2008). However, their placement on roofs and not on facades may limit the efficacy of the noise reduction. It is estimated that a green roof can provide a reduction in noise levels from 2 to 8 dB (Connelly & Hodgson 2008; Persson et al. 2020).

The variations in noise propagation and the specificities of each individual environment require in-depth analysis and specific case modeling. Many cities have conducted assessments into noise pollution, though reports and modeling often require expertise in both noise and software. Simplification is therefore complicated and to interpret with caution. Nevertheless, and in order to gain the most accurate picture of a site suitability for various types of green roofs with noise reduction potential, this thesis attempts to provide a simplification of a noise model. To do so, a literature review on previous noise and acoustical assessments in Sweden was conducted.

Noise under 50dB can be considered as acceptable and livable without major complications, according to the Swedish Public Health Agency (*Hälsoeffekter av buller och höga ljudnivåer — Folkhälsomyndigheten*) . This is also because estimations of monetary compensation for noise exposition generally begin at levels over 50dB (Persson et al. 2020). Based on this lower limit of 50dB, inverse square law was used to determine the distance from the noise source where sound would reach acceptable levels again. An important element to consider here is that this was conducted assuming that there are no sounded barriers along the way of the noise spread. This is of course not the case in reality, there are different ground types, buildings, trees, infrastructure on the path that reflect noise, thus amplifying it in some locations and dampening it in others. Ideally, data from an in-depth noise study would be used for this type of estimations. However, by using inverse square law it is still possible to perform a rough but meaningful simulation of which areas are most likely to be subject to noise pollution and which ones are less likely.

Inverse square law can be written in the following way:
$$\frac{I_2}{I_1} = \left[\frac{d_1}{d_2}\right]^2$$

Where I_1 is the sound level in dB measured at distance d_1 and I_2 the sound level in dB measured at distance d_2.

To calculate the distance d_2 at which road traffic sound levels enter the acceptable threshold of 50dB (I_2) and in this case assuming I_1 of 80dB is measured at a distance d_1 of 15 meters, we find:

$$d_2 \approx 472 \text{ meters}$$

This number was rounded to 500 meters and thus used as a sound buffer zone, with values decreasing in natural breaks from the source.

To calculate the distance d_2 at which railway traffic sound levels enter the acceptable threshold of 50dB (I_2) and in this case assuming I_1 of 90dB is measured at a distance d_1 of 15 meters, we find:

$$d_2 = 1500 \text{ meters}$$

The same sound value was used for public transport as for road traffic hence their buffer distances are the same. Below an illustration of the propagation of sound can be found.
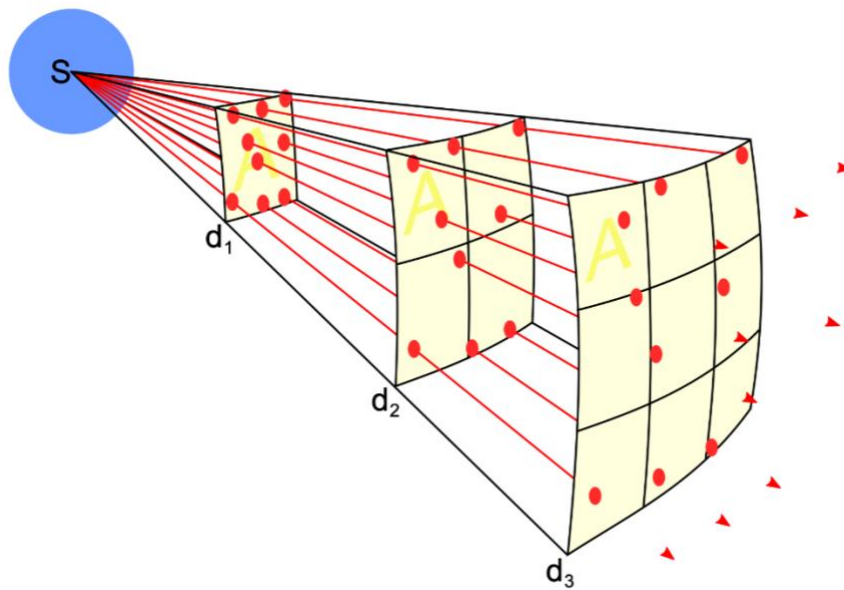
Figure 16. Representation of inverse square law. S is the source emission of noise in this case and d1 is the distance of measure from the source, d2 distance measured from d1 at a given point. Illustration by Borb, Wikimedia Commons licensed under CC

The resulting layer from the noise pollution mapping was integrated in the models of the roofs that have noise reduction listed as an ecosystem service. The given weight of the layer was determined by three criteria, namely relative importance to the main function, the importance given to this function in the urban planning process and how effective the noise reduction potential of a roof is in its ecosystem services.
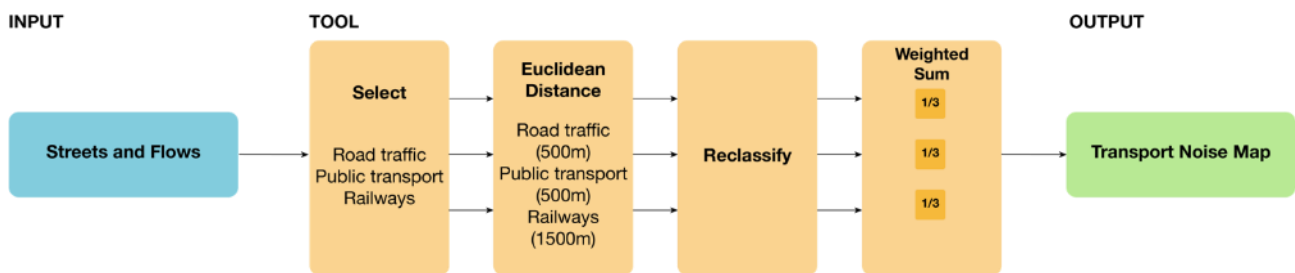
Figure 17. Simplified GIS model of the transport noise map, also referred to as the noise-pollution sub-model. Own Figure.

The main steps of the noise-pollution sub-model include the selection of the correct attributes and the attribution of the buffer area of each of them through the Euclidean distance tool. This generates a raster layer for each attribute which is then reclassified on 1-5 scale from noisiest to least noisy. All of the three reclassified attribute buffers are then merged in the weighted sum tool and each given the same weight. This generates the transport noise map, also referred to as the noise-pollution sub-model.

3.3.2. Energy Roof Model

In order to get the most accurate modeling of the solar potential of buildings, it is essential to take into account elements that may disturb solar panels, through e.g. shading. Shade may be caused by natural features such as large trees but also by nearby taller buildings. Because the buildings that are investigated in this study are not yet built, a 3D model of the buildings was created to simulate what the landscape would look like in their presence. The parameters used to model the buildings in 3D are outlined below.

The FÖP provided by Uppsala Kommun provides information into the different buildings and their estimated heights in floors. As such, smaller houses (småhus) will have between 2 to 3 floors and larger buildings will vary between 5 to 8 floors. In a report on noise pollution, Thorén et al. (2017) used building heights to simulate the propagation of noise in the city. They estimated the average floor in Uppsala to

be around 2,8m. This value was subsequently used in this study together with the city's estimates of building floors to obtain an approximate building height value in meters. Average floor values were used (2,5 for small houses, 6,5 for larger buildings). Following this process, the number of average floors and the average height in meters were multiplied to obtain a rough estimation of a given buildings height. For simplification purposes, the building data was sorted through manually to derive what surface area separates small houses from large buildings. By approximation, 175m^2 was found to generate an accurate picture of this separation. Buildings features were then selected by attribute, with surface areas less or equal to 175m for small houses and greater than 175m for buildings. Small houses were given an average height of 7m and remaining buildings 19m. A summary of the values in available in table 7.

Table 7. Height attributes of the two buildings types and rationale for the reasons behind attribution.

	Floors in overview plan	Floors in model	Average floor height (in meters)	Surface requirement (in m^2)	Average building height (in meters)
Small houses (småhus)	2-3	2,5	2,8	≤175	7
Larger buildings	5-8	6,5	2,8	>175	19

This table details the values that were given as attributes to the various buildings. This data is partly based on the information provided in the FÖP, which details that small buildings will have a number of floors comprised between 2-3 and larger buildings between 5-8 floors. Based on these values, a simplification was made by taking the average number of floors in each buildings type (assuming there will be only 2 different types of buildings) which amounts to an average floor height of 2,5 for small houses and 6,5 floors for larger buildings. To determine the height in meters, an estimate made in Thorén et al. (2017) about the average floor height in Uppsala of 2,8 meters was used to subsequently determine the height of each building type. Lastly, to differentiate the buildings type, the map was examined visually, and features selected manually to encompass small houses. Using this method, it was determined that buildings with a surface area larger than 175m^2 could be considered small houses while those with a superior surface could be categorized as larger buildings. This step was critical to simulating the buildings in 3D for the subsequent solar radiation analysis.

Based on the heights of each building, they were simulated in 3D to calculate the solar potential of each roof. The benefit of this process is that height differences between buildings become apparent when they rest on uneven ground. Though their real height will likely vary, this provides insights into how close by buildings could affect each other's solar potential through changes in ground elevation, especially between small houses and larger buildings.

This step was done by rasterizing the buildings layer based on the 'height' attribute. This generated a raster layer containing two values, 7 and 19 where each building was located. The layer was reclassified to assign 0 as a value to each 'NoData' entry in the dataset within the study area processing environment so that it could subsequently be added to the DEM raster. Using the reclassified height, the plus function was used to generate a DEM layer with extruded buildings. To perform the Area Solar Radiation method was then used to determine the incident solar radiation that would occur on each cell and generate a layer with information in the received energy of a surface in Wh/m^2 (see explanation of formula on ESRI). For the purpose of this study, the solar radiation was calculated over the course of 1 year, with 14 days as day interval and 30min hour intervals between measure times hence resulting in long processing times for the entire area. Further parameters of the calculations used can be found in the model script in appendix. Zonal statistics was used with 'average' as statistics type to determine the average Wh/m^2 that each building receives. This layer was then converted to integer with the *Int* tools which truncates cell values (see here). These steps are illustrated in the simplified models in figures 18 and 19. The Wh/m^2 layer was used an intermediary layer, meaning it was immediately reclassified.
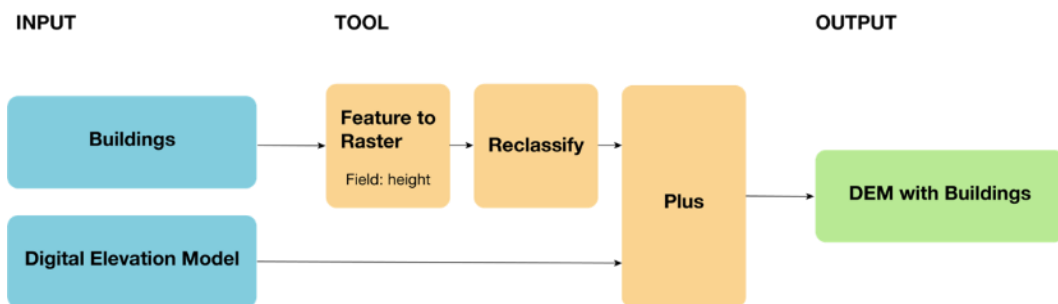
Figure 18. Simplified GIS model of the sub-model designed to simulate buildings on the elevation map. Own figure.

The solar potential model uses the previously created DEM with the added buildings to run the area solar radiation tool, which serves to calculate the insolation across a landscape by simulating the solar radiation over a defined time window.

Here a period of one year was used to simulate the exposure as it was deemed the most representative for the use of solar panels. The resulting map was then reclassified using Jenks natural breaks as classification method (figure 19) (see details on data classification here).
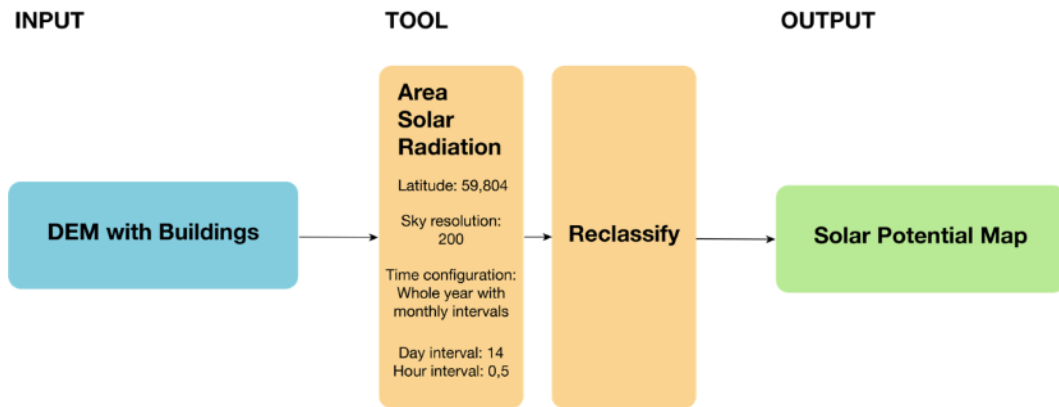
Figure 19. Simplified GIS model of the sub-model used to generate the solar potential map. Own Figure.

The solar potential map is then joined together with the other layers shown in figure 20 to form the solar roof suitability map. The transport noise map is used to model the location for noise pollution reduction ecosystem service and the biodiversity corridors to model the habitat creation potential (see pages 47,48). Finally, the cloudburst risk zones data is also used to model the water retention capability of the energy roof. These maps are added together with the weighted overlay tool. Since noise reduction, biodiversity and water retention are ranked as 'low' in the provided ecosystem services of the energy roof, they were each given a weight of 10% thus slightly influencing the placement of energy roofs, but significantly less so than the most important criterion: solar radiation. The resulting layer is then processed in the zonal statistics tool as an input value raster together with the planned buildings layer which is used as the feature zone data. By choosing mean as the statistics type, the zonal statistics tool (details here) selects the average cell value in a given building which is used to determine what value each building obtains in this energy roof model. The details on all the other layers used in the energy roof model can be found in the previous section of the water roof model.
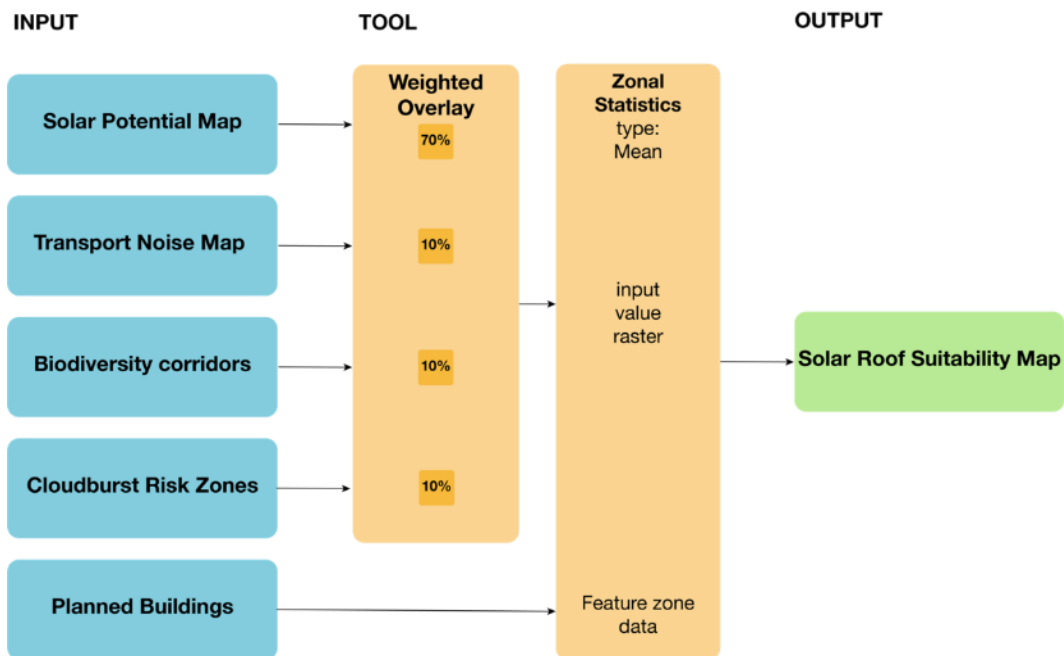
Figure 20. Simplified GIS model of the solar roof suitability map. Own figure.

3.3.3. Biodiversity Roof Model

The biodiversity roof consists of very similar ecosystem service provision to the water roof, meaning it provides high biodiversity, regulation of local climate, noise and stormwater management as well as pollination services. The model used for the site suitability of the biodiversity roofs thus closely resembles that of the water roof in many ways. However, since stormwater management and retention are not the main functions of the roof, but rather to support the development of urban biodiversity, the weight of the criteria is assigned differently to prioritize the functions that the biodiversity roof can perform best.

This includes among other, the strengthening of biodiversity in the urban area mainly by providing an extended corridor network along existing corridors and connecting any biodiversity rich area in the study area, as well as providing access to areas that may benefit from enhanced biodiversity. This includes urban gardens, parks, green corridors and surrounding ecosystems such as forests and meadows.

While the flood risk and noise pollution models are the same as in the water roof, the biodiversity models has been slightly upgraded to fit the more specific functions of this roof. The details that are added in this model are building surface area as well as building height. While studies on biodiversity of green roofs are rather rare, early results from the GROOVES-project (Green Roofs Verified Ecosystem Services) in Paris have documented relevant spatial findings for the application in this context. An example of this is that buildings heights under 12 meters seem to be more favorable towards promoting biodiversity on a roof, partly because these may be more accessible than higher buildings. In the model this translates to buildings under 12 meters being assigned a ranking score of 5 while those over 12 meters a score of 3.

A similar process was used for building surface. Another relevant finding of the GROOVES project indicates that biodiversity gains do not seem positively correlated with building surface. In other words, as the surface of a green roof increases, the biodiversity seems to decrease meaning that large buildings may be less suitable for biodiversity roofs. This is of course highly dependent on factors such as local climate, type of biodiversity roof, the type of vegetation that is present on the roof and likely a multitude of other factors too. However, properties such as exposition to winds may be an example of why large roofs are less suitable. Following this assumption, the buildings map was rasterized based on building surface and reclassified in 5 groups using Jenks natural breaks as classification method, with the smallest roofs receiving the highest ranking.

The biodiversity suitability map aims to showcase which areas would benefit most from infrastructure that promotes biodiversity. It draws on 3 datasets: planned buildings, planned landcover of the final study area and the streets and flows. From the buildings are extracted both height and surface area features on which these features are rasterized and reclassified using the Jenks natural breaks classification method. They are then weighted together at similar weights (50% each) and added to the other two datasets. Based on the planned land cover (biodiversity rich) and streets and flows (biodiversity promoter) datasets a buffer area of 300 meters is created around them and reclassified to a gradual buffer in 5 categories with equal intervals as classification method. The buffers around biodiversity rich and promotion areas is then added to the buildings with equal weights each and subsequently reclassified to generate the biodiversity suitability layer which is then used in the final calculation of the biodiversity roof as the main criteria. See figure 15.

The biodiversity suitability layer explained above is combined with the transport noise map and the cloudburst risks zones map with the weighted overlay tool. A

weight was given to each of the layer based on the ecosystem services they provide and the main function of the roof. With both high stormwater management and noise pollution reduction, each layer was granted a 20% weight. The biodiversity suitability layer, which is the most important layer in this roof model was given the remainder of the weight, at 60%. The output was then processed in the zonal statistics tools with majority as statistics type as input value raster together with the planned building map which was used as the feature zone data to determine the area in which the majority of in cell values should be determined. This generates the biodiversity roof suitability map which showcases which rooftops are best suited for biodiversity roofs on a scale of 1 to 5, 5 being the most suitable (figure 21).
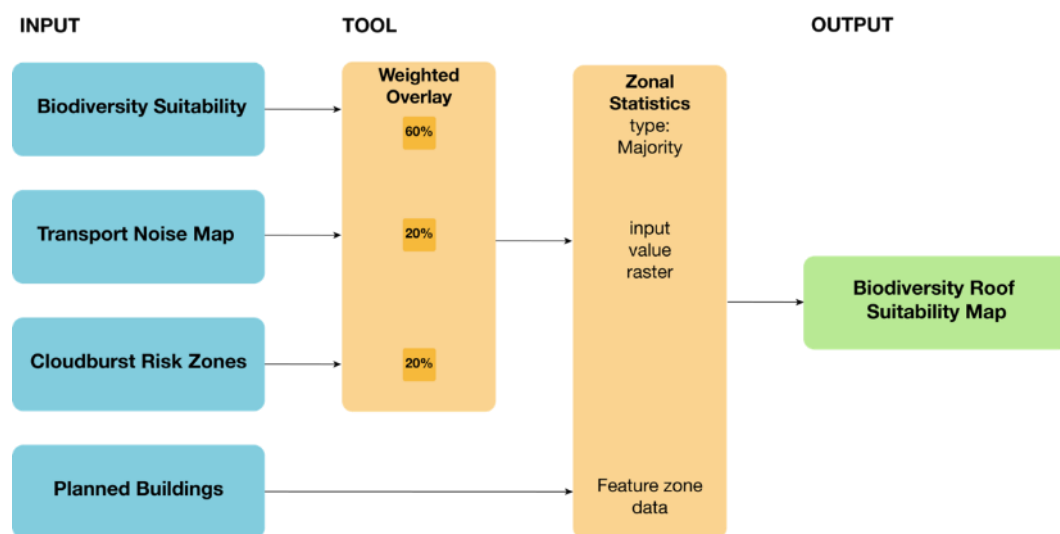
Figure 21. Simplified GIS model of the biodiversity roof suitability map. Own figure.

3.3.4. Food Production Roof Model

According to Persson et al. (2020), the food production roof is primarily designed to be fitted on the roof of a business that uses food on a daily basis such as a restaurant or a hotel. This is partly due to it being one of the two roofs together with the recreation roof that may require the most active form of management, thus having a higher potential operational cost. The advantages of a food production roof are plentiful though they largely depend on the design and the implementation (*ibid.*). A properly designed food production roof offers nutrient cycling functions with thicker substrates as well as high potential for composting existing food waste, hence its ideal placement on the roof of a facility that serves food. Through thicker soil and presence of vegetation, it provides high noise reduction, regulation of local temperature, building insulation and air filtration ecosystem services. For more extensive details about the type of food production roof, see Persson et al. (2020).

Buildings such as hotels, restaurants and educational facilities are locations that could benefit from having local production to reduce food miles and providing educational opportunities in agricultural practices. The former enables a reduction in emissions related to transport of food, and the latter responds to a growing observation in the research community about reconnecting people with the biosphere through interaction with natural environments (see e.g. Andersson et al., 2014; Colding and Barthel, 2013). The simplified models for the food production roof are shown in figures 22 and 23.

The suitable roofs for food production (figure 22) are based on two criteria which could be extracted from the existing datasets. Highly suitable locations for biodiversity roofs are used to create 75 meters buffers to simulate ease of accessibility by pollinators, since they are required for fully functioning cultivation. Included are also the functions of buildings which may benefit from food production on rooftops for both food production and learning purposes. Thus schools, restaurants and hotels are included as suitable rooftops. These two criteria are weighted together equally to produce the suitable roofs for food production layer, which is the main component of the food roof suitability map (figure 23).
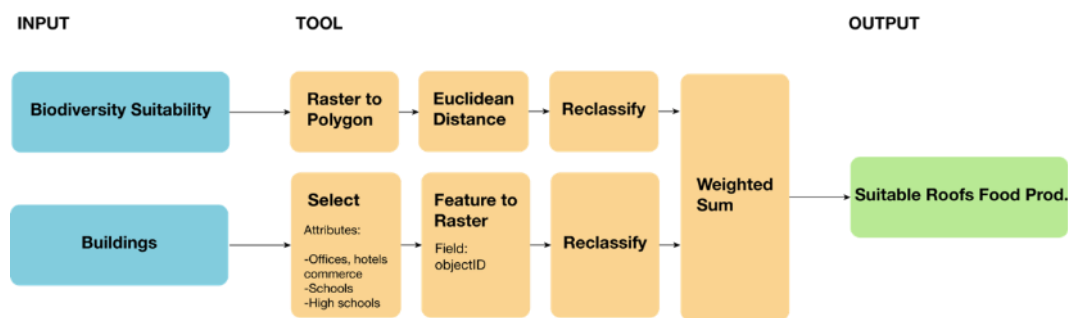
Figure 22. Simplified GIS model of the map for suitable roofs for food production.

The food roof suitability map shows optimal locations for food roofs. The model combines the previously obtained layers relating to transport noise, biodiversity corridors and cloudburst risk. Because of the food production roof's ecosystem services, each of these layers in weighted at 20%. The layer with suitable roofs for food production is the main layer in this model at 40% of the influence. A more detailed overview of how it is obtained is available in figure 10. When the layers are combined, they are processed in the zonal statistics tool, which selects the majority cell value present in a defined feature – in this case the buildings. This allows to determine the ranking in suitability of rooftops of food production.
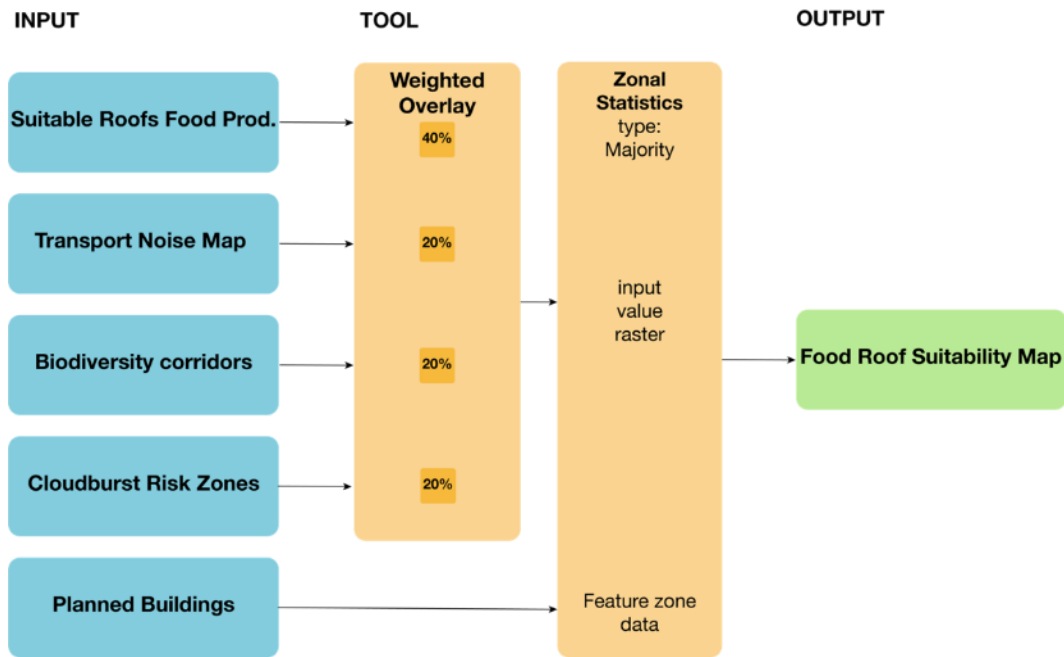
Figure 23. Simplified GIS model of the food roof suitability map. Own figure.

3.3.5. Recreation Roof Model

The recreation roof is the last roof for which a site suitability model was developed. The recreation roof is one that draws mostly on cultural ES and therefore is a roof type that is significantly more subject to variations in personal preferences of e.g. buildings occupants, investors and urban planners. Spatial characteristics of a roof suited to recreational uses include elements such a roof size (not too small) and use of the building (e.g. offices, workplace, hospitals). Given that it provides low to medium ES in e.g. regulating and supporting ES, the recreation roof suitability model includes a small part relating to those ES though the majority of the influence is made up by the size and function. A simplified representation of the GIS model is detailed below in figure 24.
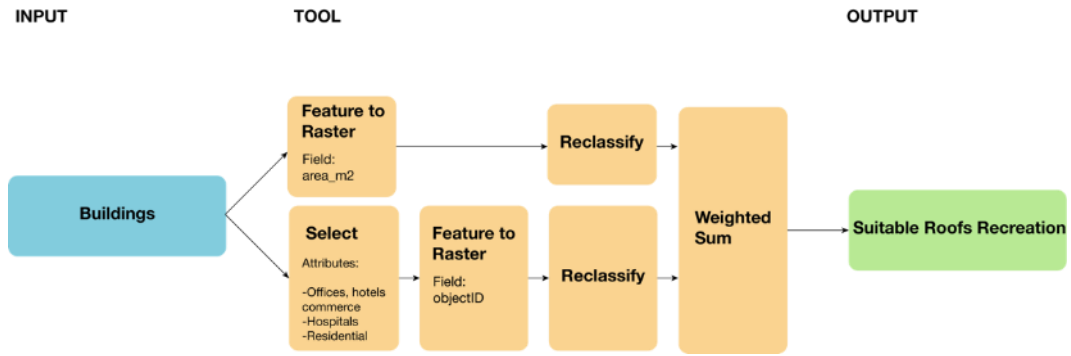
Figure 24. Simplified GIS model of the suitable roofs for recreation roofs (component of final model). Own figure.

To generate the suitable roofs for recreation layers, which is a component of the final model (see figure 25), the building polygons are rasterized based on function of the building, as well as based on their surface area. The smaller the building, the less suitable it is for recreative purposes, using the whole area sample classified with natural breaks (Jenks). For the functions, only selected buildings are attributed a score of 5 while the rests receives 0 (null). These two factors are summed. In the final model (fig. 25), all the other ES functions, are considered low-medium for this roof type and therefore were given a weight of 15% each. Thus 55% of the weight is occupied by the suitability of the building.
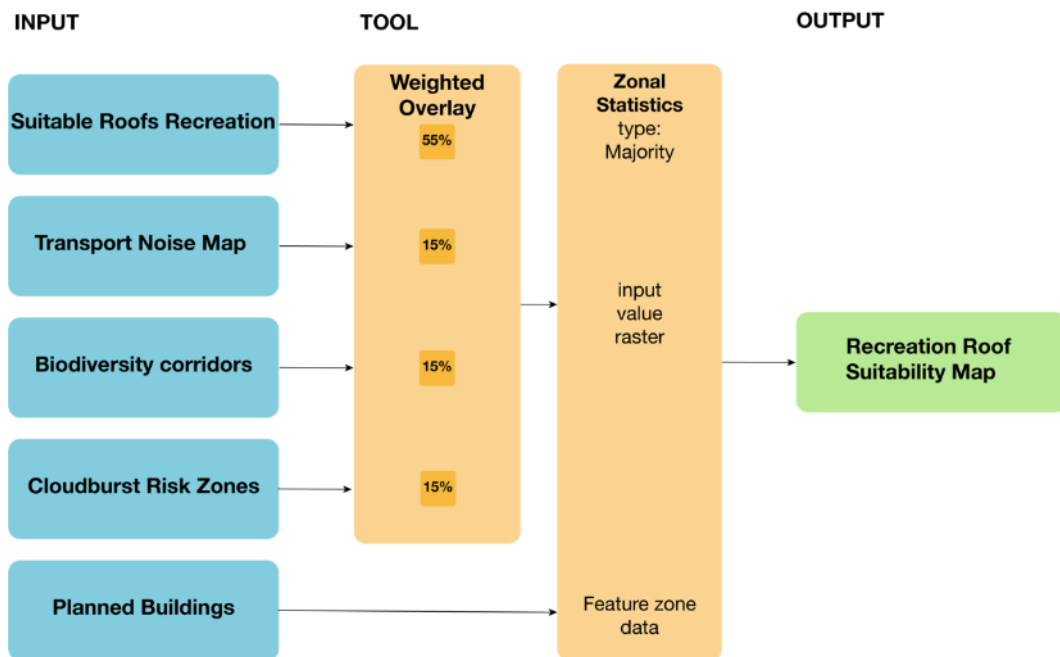
Figure 25. Simplified GIS model of the recreation roof suitability model. Own figure.

3.3.6. Multifunctionality Model

The multifunctionality model is the final step of the analysis in this study. It is a relatively simple and straightforward process in that it is the sum of the suitability maps combined. Each rooftop suitability map is added to the others since they are based on the same scale of 1-5, where 1 is considered low and 5 highest. By summing the layers together, the final map evidences all locations from lowest multifunctionality (lowest on the scale) to highest multifunctionality. The minimum score is 5 and the largest possible score is 25. A higher score (e.g. over 15) symbolizes that a roof is suitable for multiple types of green roofs and showcases where additional investigations could be conducted given that satisfying results can be expected from several roof types.

4. Results

In this section, the final maps from the analysis are presented. To facilitate the visualization, only the buildings are shown on each map along with the study area perimeter and the railroad track for orientation purposes. This evidently creates a difficult to visualize the roofs when they are embedded in their environment, though for simplification purposes and ease of visualization, only the rooftops and their scores are displayed. The scores are ranked on a 1 to 5 suitability scale, where 1 is the least suitable and 5 the most suitable. The proposed qualitative descriptive scale is suggested the as follows where roof type is understood as the respective type of green roof in each model:

1. Other roof type recommended (ecosystem services not compatible)
2. Roof type may have certain positive effects
3. Roof type will likely benefit the building and the surrounding environment
4. Roof type highly recommended
5. Roof type necessary

Score 1 on the scale indicates that none of the ecosystem services that the roof provides serves any specific synergetic function in that given area. Score 2 values shows that some of the ES provided by the roof can be used in synergy with the surrounding environment, but that the most of them are not particularly useful. Score 3 is attributed when roughly half of the ES of a roof provide synergetic functions, which is considered here as starting to significantly be benefitting the city in ES provision. Score 4 is attribute when the need of the surroundings match those provided by the roof up to about 80% compatibility and finally, a score of 5 displays full match and compatibility with needed ES and provided ES, that is, there is no better green roof suited for an given roof.

4.1. Water Roof

The water roof suitability map showcases 5 degrees of suitability (figure 26). There is a higher concentration of less suitable buildings in the southwestern part than in the south-east. Few buildings demonstrate a necessity to incorporate water roofs though they are highly recommended in some areas along the major transportation

axis and areas at risk of flooding from cloudburst events. The map clearly evidences an important piece of information: some roofs are clearly more suited to retain stormwater runoff than others.
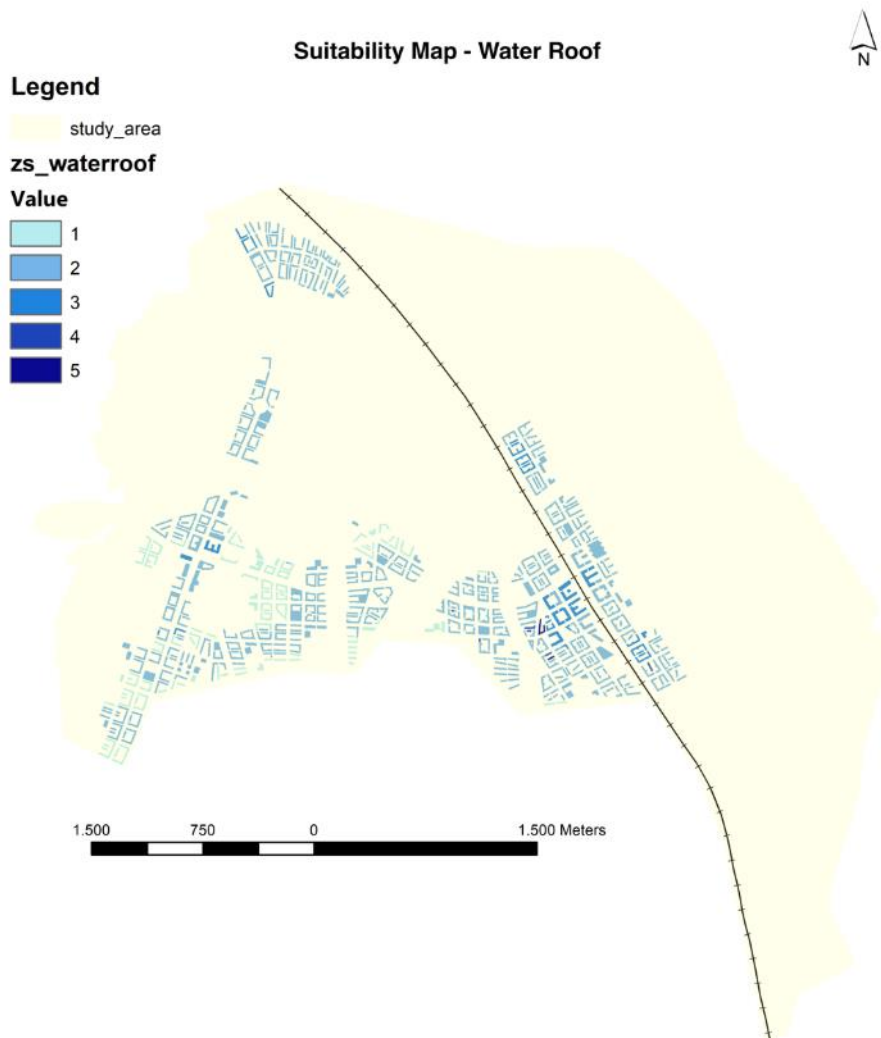
Figure 26. Water roof suitability map

4.2. Energy Roof

The energy roof resulting map is quite different from the others in that the values are mostly related to the solar exposition to roofs. On the suitability scale, this is displayed through 3,8 to 4,7 divided in 5 categories (still on a scale of 1 to 5) that is, considered both beneficial and highly recommended. Practically, this implies

firstly that there are no roofs where an energy roof is unsuitable and that they can be rather effective wherever they are placed. Secondly, the variation between roofs appear mostly related to the building use and the other ecosystem services that factor into the overall energy roof model.
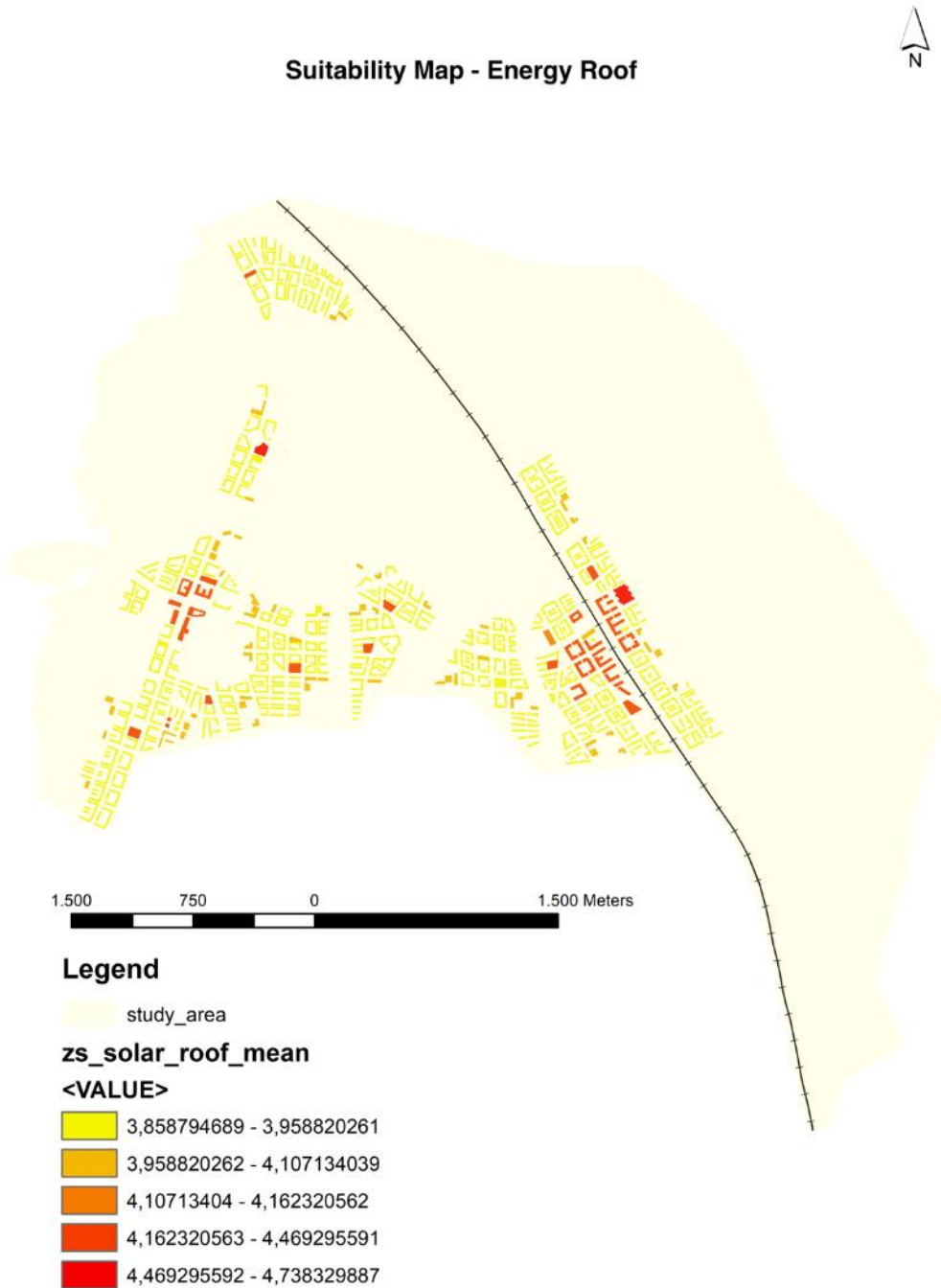
Figure 27. Energy roof suitability map

4.3. Biodiversity Roof

The biodiversity roof also points to a full variation in the suitability of roofs, since its values cover the full range from 1 to 5, that is, from another type of roof being recommended to the biodiversity roof being necessary in some locations. The suitability of these roofs is mostly located along the green corridors in the area (see figure 10) and along various axes with higher-than-usual noise levels (e.g. railroad), likely due to the weight of biodiversity support and noise reduction in the model.
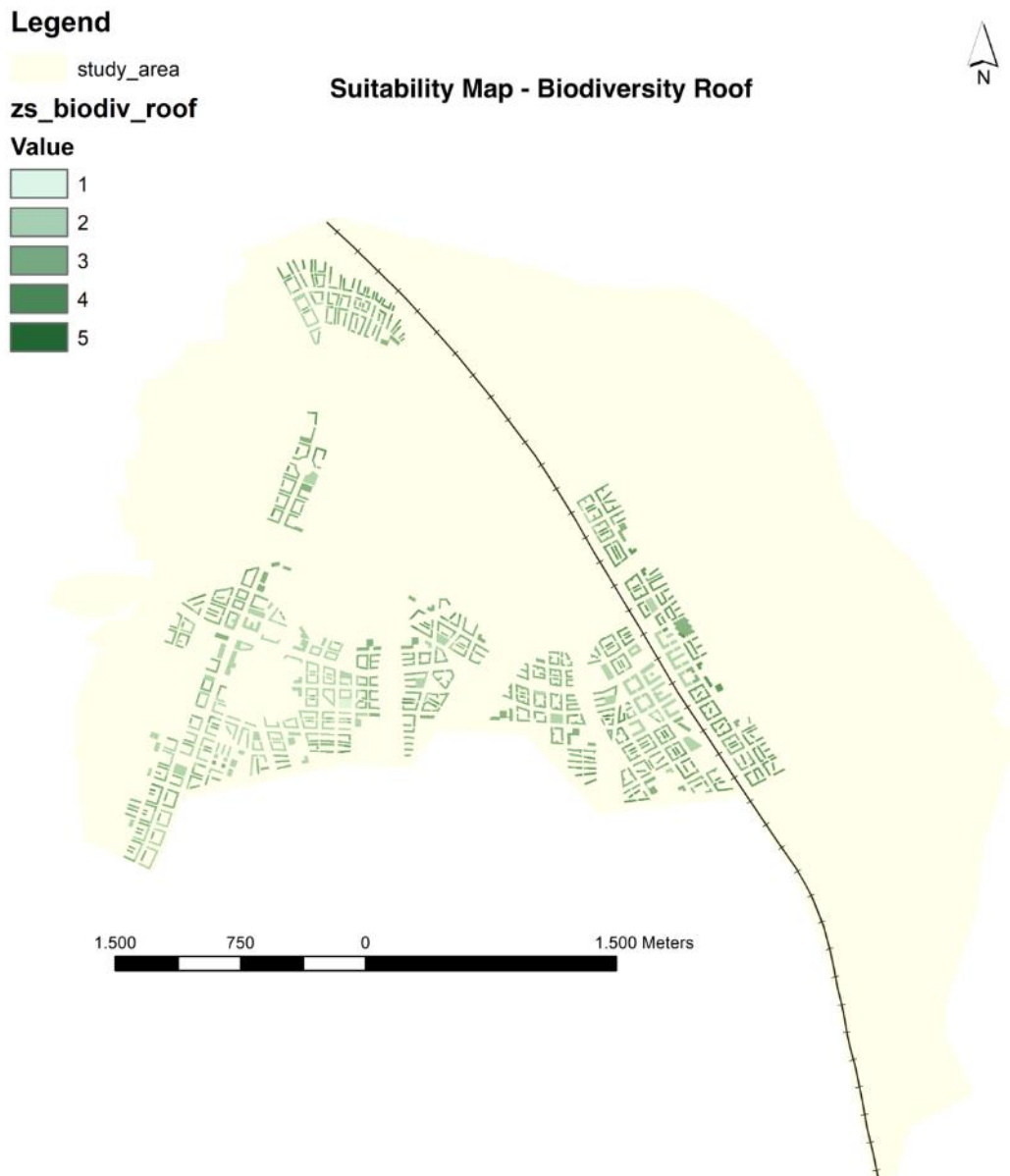
Figure 28. Biodiversity roof suitability map

4.4. Food Production Roof

The food production roof model yields a suitability scale that ranges from 1 to 4 with no roof indicating a necessity to harbor a food production roof based on the aggregated criteria in the model. A few roofs are considered highly recommended for utilization in food production and based on the FÖP, these are mostly due to the extra attribute of function being either schools or restaurants. The rest of the more suitable roofs are yet again distributed mostly along major axes that are likely to emit noise and in proximity to where biodiversity roofs would be highly suitable. Again, a concentration of significantly less suitable roofs is located in the southwestern part of the city.
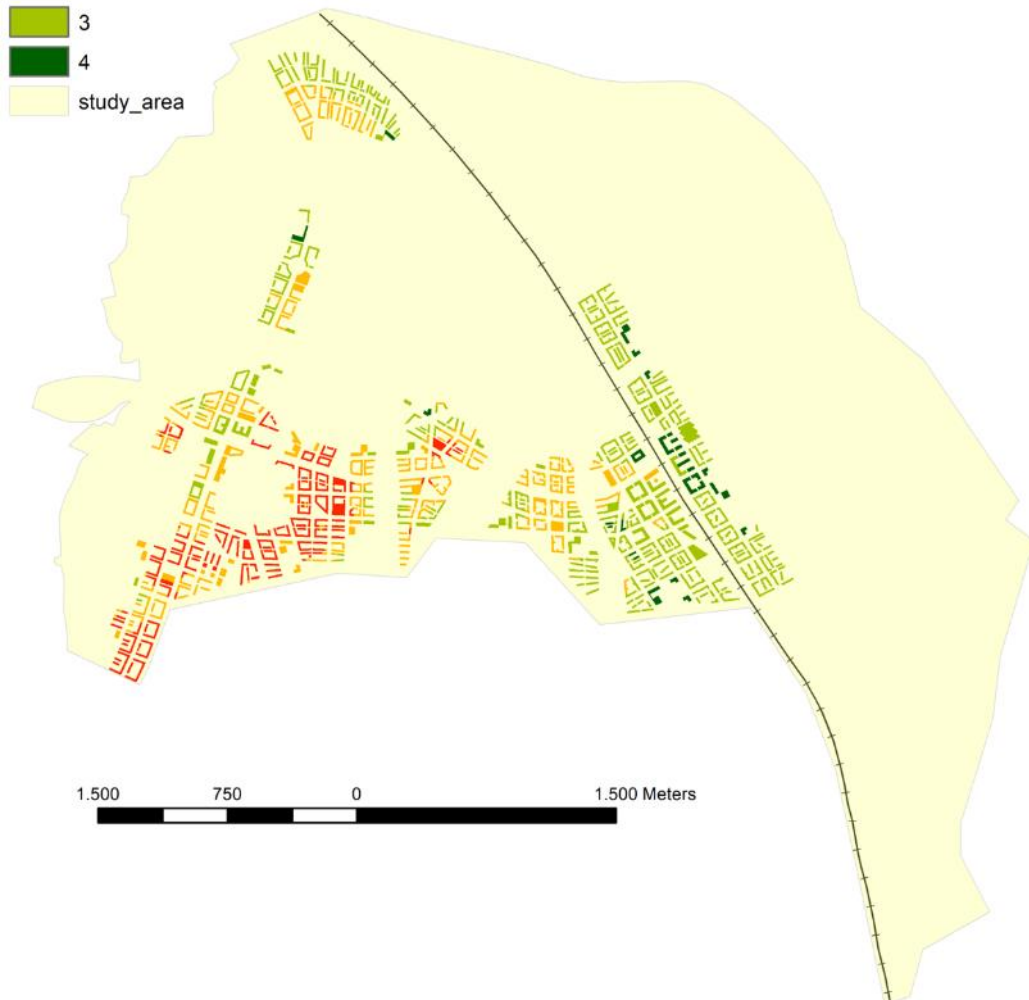
Figure 29. Food production roof suitability map

4.5. Recreation Roof

The recreation roof model scores range from 2 to 4, meaning that there may be potential effects from using one in certain locations, to it being highly recommended in others. Given that a recreation roof is more geared towards providing cultural ecosystem services, i.e. mostly related to human experience, it is rather explanatory that it is not considered unsuitable in any locations (some exceptions may be in cases of some specific types of buildings). Given that the provision of CES are dependent mostly on human presence and the low ES of other

categories (e.g. supporting), the synergies with the surrounding environment are less of a deciding factor, which may explain why no rank 5 is observed in the map. Notable in this case is the distribution of rank 2 along the major transportation axes.

Figure 30. Recreation roof suitability map

4.6. Multifunctionality Potential

The multifunctionality potential map reveals areas with high summed ranking scores of different roof types (figure 31). The higher a roof scores for a given roof type, the higher its overall multifunctionality score. On this scale, values theoretically fluctuate between 5 and 25, though this scenario showcases a real variation between approximately 10 and 20, with 20 being the highest

multifunctionality score. Areas in red have the highest multifunctionality, i.e. the highest likelihood for effectiveness of multiple roof types. Conversely, areas in blue demonstrate locations with low multifunctionality, that is, areas where roof types are likely not very interchangeable because most green roofs score low in that given area. Thus, low multifunctionality would theoretically not require as much as effort in determining which green roof type to use while a high multifunctionality score would offer e.g. property developers a choice into what they consider most adapted to their situation based on needs and wishes. Low multifunctionality concentrated in the southwestern part of Sydöstra staden while the south eastern and northern part of the city demonstrate much better multifunctionality potential.
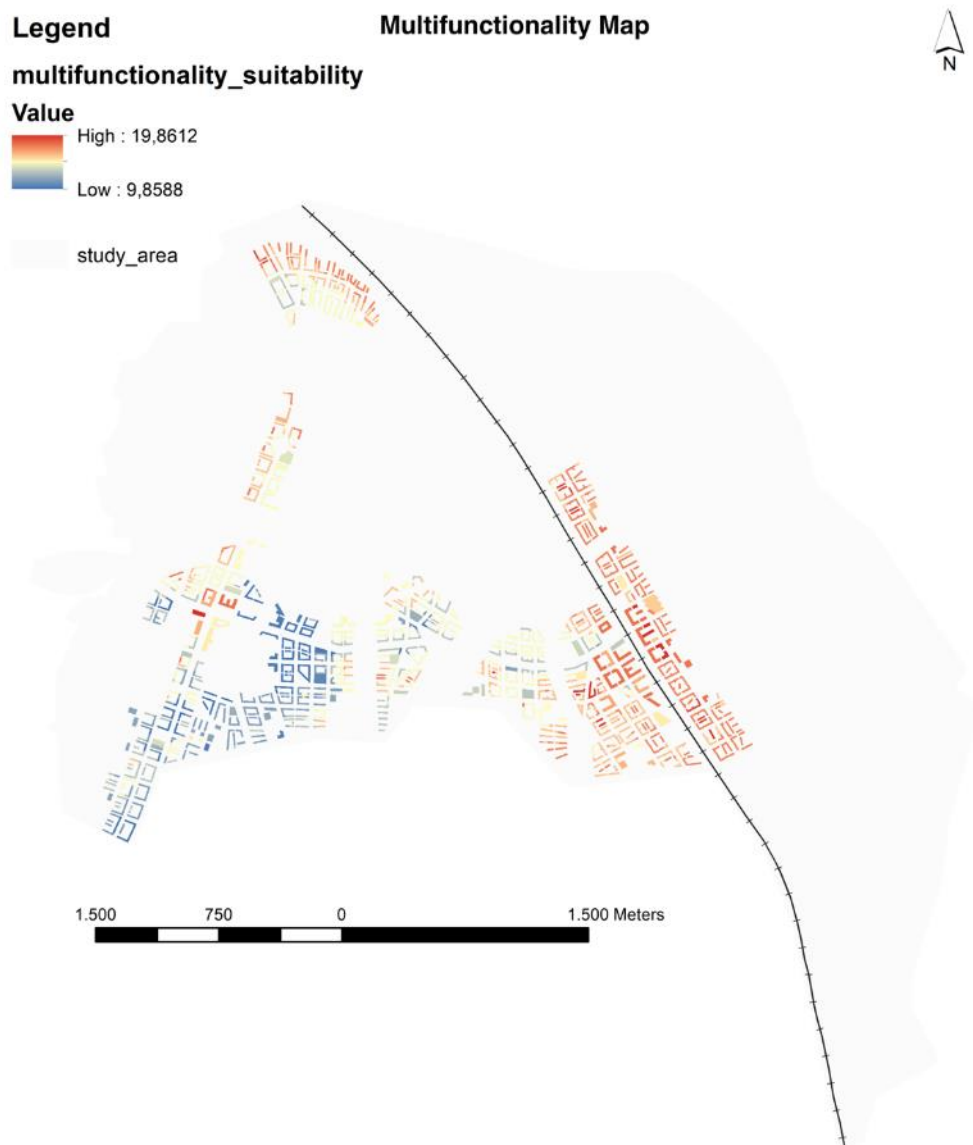
Figure 31. Multifunctionality potential map

5. Discussion

Increasingly, cities are compelled to seek benefits from ecosystem services and find creative ways to integrate them in the urban planning process. Green roofs are a technology that has only recently been merged with the concept of ecosystem services. Through practical studies such as that by Persson et al. (2020), there is an understanding that green roofs can be optimized and meticulously planned to ensure very specific functions, while not compromising essential ecosystem services, such as biodiversity habitat creation or air quality regulation. While most studies have focused on the individual function of a roof, its benefits or challenges, the approach presented in this study uses the scale of an entire city, that is yet to be built. It uses information relating to where ecosystem services are needed in order to determine the type of infrastructure best suited for a given area. In other words, it brings forth a new practical perspective that builds on previous studies of green roofs and urban ecosystem services to propose a methodology to better integrate them and enhance their ecosystem service provision.

As green roofs get more specialized and mandated by legislation, there is also a growing need to place them strategically. Redundancy and diversity are essential characteristics of a resilient system (Mori et al. 2013), so too should we consider those traits in the types of infrastructure we utilize. Monocultures for example, are not resilient; the same thinking could be applied to the utilization of space. Using every roof in the city for solar panels may seem like an attractive option at first though there is a strong case to be made about the necessity of diversity in other functions too, such as habitat creation, water retention, recreational spaces and even food production, especially at a larger scale. This may be due to several reasons: varying goals among planners and property developers, different prioritizations of residents, aesthetic value, larger societal benefits, better air quality, health, etc. The complexity of cities is difficult to capture and recognizing it is an inherent characteristic essential for sustainable planning.

This study has successfully demonstrated that using a methodology as the one developed above generates viable suitability maps that can be used by planners and property developers ahead of a construction project to determine what roof type is best suited for their needs and which roof type is likely to be the most effective. For

some roof types such as the water roof, the maps clearly showcase that some areas are much better suited since it results in rooftops graded from 1 to 5, ranging from not particularly effective to almost necessary. This type of result illustrate well that a water roof would likely retain more water that would otherwise end up in vulnerable areas when they are placed in the correct location. On the other hand, the energy roof seems more flexible in that the analysis showcases a final scale from 3 to 4 where no roof is considered unsuitable, but none is considered necessary either with the criteria used in this analysis, likely due to solar potential being more or less similar across all buildings in the city and it being the main component in the model, hence most of the buildings score around the same values. Practically, the suitability maps may be relevant for property developers and urban planners alike to coordinate in more efficient ways for integration of the existing urban green and blue infrastructure as well as elevation into cities.

The multifunctionality map on the other hand, presents a different kind of usefulness. Isolating area of varying degrees of multifunctionality may firstly facilitate the planning process since it narrows down the intervention area significantly. An example from this study is the southwestern part of the city which ranks low on the multifunctionality scale, meaning only few types of green roofs are likely provide synergies with the natural environment. Energy roofs or recreation roofs are those that score highest in those areas and therefore the choice is simpler and boils down to what is most relevant for property developers, and what may be financially more beneficial e.g. lower operational costs through energy production versus higher rents in buildings with recreation roofs. This may be due to the energy and recreation roof being more likely and favorable to be used in residential settings for example, in combination to solar radiation being similar throughout the city. The highly multifunctional areas, however, may require more concertation together with city officials in order to determine the priorities of the local government and those of property developers. In those cases, agreements could theoretically be envisioned whereby payment for ecosystem services could be attributed for those who choose to utilize the most appropriate and prioritized type UGI. Given that the multifunctionality is intimately tied to the weightings made in the individual roof models, it is important to keep in mind that it may be subject to change according to what is considered 'valuable' in specific scenarios, relating to if e.g. a city decides that water management is more important that biodiversity management.

One of the most compelling ways to ensure that any technology is adopted rapidly is to showcase its financial value. In the case of green roofs, this practically translates to demonstrating to property developers, investors and planners alike that using green roofs can either generate more income or reduce operating costs. That

is when monetary valuation of ecosystem services enters into play. Persson et al. (2020), along with multiple other researchers have shown that it is indeed possible to estimate the financial gains of ecosystem services though this varies widely depending on the type of ecosystem services and thus also ecosystem services on roofs. It is for example easier to calculate the financial gains from noise reduction than those of aesthetic value or local temperature regulation. This does not necessarily mean that aesthetic value or local temperature regulation are inherently worth less than noise reduction, but rather that set values already exists for the compensation costs related to noisy environments.

In order to render this model even more relevant from an urban planning perspective, it should ideally integrate the monetary value of ecosystem services. There are several ways of conceptualizing this approach, depending of how the ecosystem service provision works. In the case of noise reduction, it is rather straightforward as there are existing guidelines on noise levels and their associated financial compensations (see Persson et al. 2020). If their changes are linear, then reproducing the noise pollution map with financial values decreasing linearly from the source point could be an option. For an ecosystem service such as water retention, one would need to calculate the amount of water that a roof type could theoretically retain and use individual building surfaces to determine the total amount of water. If the price of managed stormwater runoff exists (in e.g. m^3), an additional attribute column could be granted to roofs multiplied by their surface to give an estimation of how much this roof could save. These individual ES monetary estimations could then be summed with others to determine an overall savings estimation.

There are multiple aspects of this modeling approach that could be improved and thus improve the overall precision of the model. For each roof type, not all of its provided ES were included in the site selection. This was generally due to data issues: either the data for using that ES was not accessible, unavailable or too complex to process in the time window. A more robust analysis would therefore incorporate all the ES provided by a UGI to ensure optimal reliability in the site selection. By using the main ES services listed for the concept roof, this study does however provide a thorough representation of the spatial dimensions of GI placement. The weight of each criteria was also assigned as a static value (e.g. 60% for food risk in the water roof). An alternative approach would be to determine the main component value based on other grounds, such as surveying local residents, experts and scientist on the important ES in a given area Alternatively, or in combination, another approach could develop different scenarios, such as one where water management or noise reduction are considered as the key priorities to better visualize where changes occur and this open the

possibility for sensitivity analysis. A main limitation for the water roof model and the flood risk model in general is also the lack of incorporation of drainage basins and flow quantities. By incorporating those, the flood risks could be improved even more and e.g. values could be assigned to individual drainage basins. It is also worth mentioning that the models should be closely modified with the local specificities in mind and with urban planning officials to account for errors of judgement, valuations and priorities.

6. Conclusion

Green roofs are a re-emerging technology that is being perfected as the global understanding of ecosystem services is improving and the need to reconnect cities to the biosphere is growing. This thesis provides an overview of green roofs in sustainable urban development and proposes a GIS model to find and optimize their placement using Sydöstra staden in Uppsala as a case area yet to be built. For each type of green roof, the provided ES are identified and weighted according to how efficiently they can ensure these functions. A model was then developed to locate areas that could benefit the most from these ES and rank them according to the usefulness.

The results are twofold. Firstly, developers and urban planners alike are able to visualize where certain ecosystem services – and by extension also urban green infrastructure – and needed and where NBS can be best suited to respond to and provide those ES. Secondly, it also showcases areas with varying multifunctionality potential and lets planners know which areas can be subject to 'negotiations' regarding placement and provision of ecosystem services and where to focus resources. This model can therefore assist in urban decision making.

Such a specific modelling approach to ecosystem service integration through urban green infrastructure as used here has not been previously developed. This study thus provides a new approach for integrating ecosystem services into the urban spatial planning process. Such a model, when scaled up, may assist urban planners in making informed decisions about where to utilize NBS and GI to maximize beneficial synergies with the surrounding environment. Thus, using a landscape perspective of integrating green roofs on a larger scape as well as integrating these roofs with existing UGI. This may for example strengthen the use of urban biodiversity corridors, create new corridors, help certain city districts that are particularly exposed to flooding better manage their infrastructure. With improvements in economic valuation of ecosystem services, the model suggested here could ultimately be used more generally when designing districts from the ground up and integrating ecosystem services into the built environment.

7. References

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9. Appendix

This appendix contains all the python scripts for each of the 5 models presented in the methods. This allows anyone to verify which tools, values and criteria were used in the GIS modeling process. This also allows anyone to reproduce the same analysis based on these criteria. The destination folders for each component used in the analysis are also useful to indicated where is source file originates, for reproduction purposes. Please contact the author to obtain access to the original files.

Water Roof Script

```
# -*- coding: utf-8 -*-
# ------------------------------------------------------------
---------------
# water_roof_script.py
# Created on: 2021-01-12 12:12:17.00000
#   (generated by ArcGIS/ModelBuilder)
# Usage: water_roof_script <clipped_dem_tif>
# Description:
# ------------------------------------------------------------
---------------

# Import arcpy module
import arcpy

# Script arguments
clipped_dem_tif = arcpy.GetParameterAsText(0)
if clipped_dem_tif == '#' or not clipped_dem_tif:
    clipped_dem_tif =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\DEM_SYO,ï†√™_merged\\clipped_dem.tif" # provide a
default value if unspecified

# Local variables:
AllSinksFilled =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\AllSinksFilled"
SmallSinksFilled =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\SmallSinksFilled"
```

```
SubstractedSinks =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\SubstractedSinks"
Input_true_raster_or_constant_value___1 = "1"
prel_bluespots =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\prel_bluespots"
BSRegions =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\BSRegions"
Bluespot_polygons =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\Bluespot_polygons"
Bluespots__3_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\Bluespots"
Bluespots = Bluespots__3_
Byggnader__2_ = Bluespots__3_
Bluespots_with_m2 = Bluespots
bs_rast =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\bs_rast"
bs_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\bs_reclass"
Buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\reprojected_building
s"
dissolved_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\dissolved_buildings"
buildings_mts =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\buildings_mts"
buildings_mts__3_ = buildings_mts
Buildings_with_m2 = buildings_mts__3_
intersect_bs_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\intersect_bs_buildin
gs"
intersect_bs_buildings__2_ = intersect_bs_buildings
intersect_bs_buildings__4_ = intersect_bs_buildings__2_
intersect_bs_buildings__6_ = intersect_bs_buildings__4_
intersect_bs_buildings__5_ = intersect_bs_buildings__6_
bs_build_cov_rast =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\bs_build_cov_rast"
bs_cover_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
```

```
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\bs_cover_reclass"
cloudburst_risk_zones =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\cloudburst_risk_zone
s"
byggnader_funktioner_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\byggnader_funktioner.shp"
Byggnader = "Byggnader"
selec_building =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\selec_building"
gator_och_floeden_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
gator_floeden =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\gator_floeden"
motorfordon =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\motorfordon"
Output_direction_raster = ""
Output_back_direction_raster = ""
buss =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buss"
Output_direction_raster__2_ = ""
Output_back_direction_raster__2_ = ""
jarnvag =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\jarnvag"
Output_direction_raster__3_ = ""
Output_back_direction_raster__3_ = ""
buildings_mts__2_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Cloudburst\\cloudburst_outputs.gdb\\buildings_mts"
gator_och_floeden_shp__2_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
flows_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\flows_reprojected"
selected_flows =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\selected_flows"
biodiv_corr_buffer__2_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\biodiv_corr_buffer"
bcb_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\bcb_reclass"
bs_buildcov_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\bs_buildcov_reclass"
```

```
bs_recl_0basevalue =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\bs_recl_0basevalue"
wo_floodrisk =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk"
buff_traffic =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buff_traffic"
traffic_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\traffic_reclass"
buff_pubtra =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buff_pubtra"
pubtra_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\pubtra_reclass"
buff_train =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buff_train"
train_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\train_reclass"
wo_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\wo_noise_map"
suit_watroo =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Assembled
Model\\assembled_water_roof.gdb\\suit_watroo"
zs_waterroof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\zs_waterroof"
Output_direction_raster__4_ = ""
Output_back_direction_raster__4_ = ""

# Set Geoprocessing environments
arcpy.env.snapRaster = ""
arcpy.env.extent = "649698,452210831 6629840,80356448
655539,196052361 6635623,66866142"

# Process: Fill
arcpy.gp.Fill_sa(clipped_dem_tif, AllSinksFilled, "")

# Process: Fill (2)
arcpy.gp.Fill_sa(clipped_dem_tif, SmallSinksFilled, "0,1")

# Process: Minus
arcpy.gp.Minus_sa(AllSinksFilled, SmallSinksFilled,
SubstractedSinks)

# Process: Con
arcpy.gp.Con_sa(SubstractedSinks,
Input_true_raster_or_constant_value___1, prel_bluespots, "",
"Value > 0")
```

```
# Process: Region Group
arcpy.gp.RegionGroup_sa(prel_bluespots, BSRegions, "EIGHT",
"WITHIN", "NO_LINK", "")

# Process: Raster to Polygon
tempEnvironment0 = arcpy.env.outputZFlag
arcpy.env.outputZFlag = "Disabled"
tempEnvironment1 = arcpy.env.outputMFlag
arcpy.env.outputMFlag = "Disabled"
arcpy.RasterToPolygon_conversion(BSRegions, Bluespot_polygons,
"NO_SIMPLIFY", "VALUE", "SINGLE_OUTER_PART", "")
arcpy.env.outputZFlag = tempEnvironment0
arcpy.env.outputMFlag = tempEnvironment1

# Process: Dissolve (2)
arcpy.Dissolve_management(Bluespot_polygons, Bluespots__3_,
"GRIDCODE", "", "MULTI_PART", "DISSOLVE_LINES")

# Process: Add Field (2)
arcpy.AddField_management(Bluespots__3_, "bluespot_area_m2",
"DOUBLE", "", "", "", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (2)
arcpy.CalculateField_management(Bluespots, "bluespot_area_m2",
"!shape.area!", "PYTHON_9.3", "")

# Process: Polygon to Raster (2)
arcpy.PolygonToRaster_conversion(Bluespots_with_m2,
"bluespot_area_m2", bs_rast, "CELL_CENTER", "NONE", "2")

# Process: Reclassify (2)
arcpy.gp.Reclassify_sa(bs_rast, "VALUE", "4,000000 312,000000
1;312,000000 1356,000000 2;1356,000000 7956,000000
3;7956,000000 24512,000000 4;24512,000000 69160,000000 5",
bs_reclass, "DATA")

# Process: Dissolve
arcpy.Dissolve_management(Buildings, dissolved_buildings, "",
"", "MULTI_PART", "DISSOLVE_LINES")

# Process: Multipart To Singlepart
arcpy.MultipartToSinglepart_management(dissolved_buildings,
buildings_mts)

# Process: Add Field
arcpy.AddField_management(buildings_mts, "buildings_area_m2",
"DOUBLE", "", "", "", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field
arcpy.CalculateField_management(buildings_mts__3_,
"buildings_area_m2", "!shape.area!", "PYTHON_9.3", "")

# Process: Intersect
arcpy.Intersect_analysis("'C:\\Users\\Olivier\\Documents\\Anth
esis_SLU\\Geodata\\Transformed
```

```
data\\Cloudburst\\cloudburst_outputs.gdb\\Bluespots'
#;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Cloudburst\\cloudburst_outputs.gdb\\buildings_mts' #",
intersect_bs_buildings, "ALL", "", "INPUT")

# Process: Add Field (3)
arcpy.AddField_management(intersect_bs_buildings,
"bluespot_cover_m2", "DOUBLE", "", "", "", "", "NULLABLE",
"NON_REQUIRED", "")

# Process: Calculate Field (3)
arcpy.CalculateField_management(intersect_bs_buildings__2_,
"bluespot_cover_m2", "!shape.area!", "PYTHON_9.3", "")

# Process: Add Field (4)
arcpy.AddField_management(intersect_bs_buildings__4_,
"percentage_building_cover", "DOUBLE", "", "", "", "",
"NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (4)
arcpy.CalculateField_management(intersect_bs_buildings__6_,
"percentage_building_cover", "( [bluespot_cover_m2] /
[buildings_area_m2] ) *100", "VB", "")

# Process: Polygon to Raster
arcpy.PolygonToRaster_conversion(intersect_bs_buildings__5_,
"percentage_building_cover", bs_build_cov_rast, "CELL_CENTER",
"NONE", "2")

# Process: Reclassify
arcpy.gp.Reclassify_sa(bs_build_cov_rast, "VALUE", "0 10 1;10
25 2;25 40 3;40 60 4;60 100 5", bs_cover_reclass, "DATA")

# Process: Weighted Sum
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Cloudburst\\cloudburst_outputs.gdb\\bs_reclass' VALUE
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Cloudburst\\cloudburst_outputs.gdb\\bs_cover_reclass'
Value 1", cloudburst_risk_zones)

# Process: Make Feature Layer
arcpy.MakeFeatureLayer_management(byggnader_funktioner_shp,
Byggnader, "", "", "FID FID VISIBLE NONE;Shape Shape VISIBLE
NONE;OBJECTID OBJECTID VISIBLE NONE;Real_Shape Real_Shape
VISIBLE NONE;Shape__Are Shape__Are VISIBLE NONE;Shape__Len
Shape__Len VISIBLE NONE;Shape_Leng Shape_Leng VISIBLE
NONE;Shape_Area Shape_Area VISIBLE NONE;funktion funktion
VISIBLE NONE")

# Process: Select Layer By Location
arcpy.SelectLayerByLocation_management(Byggnader, "INTERSECT",
Bluespots__3_, "", "NEW_SELECTION", "NOT_INVERT")
```

```
# Process: Copy Features
arcpy.CopyFeatures_management(Byggnader__2_, selec_building,
"", "0", "0", "0")

# Process: Project
arcpy.Project_management(gator_och_floeden_shp, gator_floeden,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (2)
arcpy.Select_analysis(gator_floeden, motorfordon, "type =
'huvudgata_motorfordon'")

# Process: Euclidean Distance
arcpy.gp.EucDistance_sa(motorfordon, buff_traffic, "500", "2",
Output_direction_raster, "PLANAR", "",
Output_back_direction_raster)

# Process: Select (3)
arcpy.Select_analysis(gator_floeden, buss, "type = 'buss' ")

# Process: Euclidean Distance (2)
arcpy.gp.EucDistance_sa(buss, buff_pubtra, "500", "2",
Output_direction_raster__2_, "PLANAR", "",
Output_back_direction_raster__2_)

# Process: Select
arcpy.Select_analysis(gator_floeden, jarnvag, "type =
'jarnvag'")

# Process: Euclidean Distance (3)
arcpy.gp.EucDistance_sa(jarnvag, buff_train, "1500", "2",
Output_direction_raster__3_, "PLANAR", "",
Output_back_direction_raster__3_)

# Process: Project (2)
arcpy.Project_management(gator_och_floeden_shp__2_,
flows_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
```

```
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (4)
arcpy.Select_analysis(flows_reprojected, selected_flows,
"\"type\" IN ( 'ekologiska_samband' , 'gront_rorelsestrak' )")

# Process: Euclidean Distance (4)
arcpy.gp.EucDistance_sa(selected_flows,
biodiv_corr_buffer__2_, "300", "2",
Output_direction_raster__4_, "PLANAR", "",
Output_back_direction_raster__4_)

# Process: Reclassify (7)
arcpy.gp.Reclassify_sa(biodiv_corr_buffer__2_, "VALUE", "0
40,447498 1;40,447498 89,375610 2;89,375610 146,013702
3;146,013702 212,640549 4;212,640549 300 5;NODATA 0",
bcb_reclass, "DATA")

# Process: Reclassify (8)
arcpy.gp.Reclassify_sa(bs_build_cov_rast, "VALUE", "0 10 1;10
25 2;25 40 3;40 60 4;60 100 5;NODATA 0", bs_buildcov_reclass,
"DATA")

# Process: Reclassify (6)
arcpy.gp.Reclassify_sa(bs_rast, "VALUE", "4,000000 312,000000
1;312,000000 1356,000000 2;1356,000000 7956,000000
3;7956,000000 24512,000000 4;24512,000000 69160,000000
5;NODATA 0", bs_recl_0basevalue, "DATA")

# Process: Weighted Overlay (2)
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\WaterRoof\\water_roof.gdb\\bs_buildcov_reclass' 50
'Value' (0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\bs_recl_0basevalue' 50
'Value' (0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA));1 9 1",
wo_floodrisk)

# Process: Reclassify (3)
arcpy.gp.Reclassify_sa(buff_traffic, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", traffic_reclass,
"DATA")

# Process: Reclassify (4)
arcpy.gp.Reclassify_sa(buff_pubtra, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", pubtra_reclass,
"DATA")
```

```
# Process: Reclassify (5)
arcpy.gp.Reclassify_sa(buff_train, "VALUE", "0 300 5;300 600
4;600 900 3;900 1200 2;1200 1500 1;NODATA 0", train_reclass,
"DATA")

# Process: Weighted Overlay
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\Noise\\noise_map.gdb\\traffic_reclass' 33 'Value' (0 1;
1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\pubtra_reclass' 33 'Value' (0
1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\train_reclass' 34 'Value' (0
1; 1 1; 2 2; 3 3; 4 4; 5 4;NODATA NODATA));1 9 1",
wo_noise_map)

# Process: Weighted Overlay (3)
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\WaterRoof\\water_roof.gdb\\bcb_reclass' 20 'Value' (0 1;
1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk' 60 'Value'
(1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\wo_noise_map' 20 'VALUE' (1
1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA));1 9 1", suit_watroo)

# Process: Zonal Statistics
arcpy.gp.ZonalStatistics_sa(buildings_mts__2_, "OBJECTID",
suit_watroo, zs_waterroof, "MAJORITY", "DATA")
```

Energy Roof Script

```
# -*- coding: utf-8 -*-
# ---------------------------------------------------------------
---------------
# solar_roof_script.py
# Created on: 2021-01-12 12:11:45.00000
#    (generated by ArcGIS/ModelBuilder)
# Description:
# ---------------------------------------------------------------
---------------

# Import arcpy module
import arcpy


# Local variables:
```

```
gator_och_floeden_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
gator_floeden =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\gator_floeden"
motorfordon =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\motorfordon"
Output_back_direction_raster = ""
Output_direction_raster = ""
buss =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buss"
Output_direction_raster__2_ = ""
Output_back_direction_raster__2_ = ""
jarnvag =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\jarnvag"
Output_direction_raster__3_ = ""
Output_back_direction_raster__3_ = ""
buff_traffic =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buff_traffic"
traffic_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\traffic_reclass"
buff_pubtra =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buff_pubtra"
pubtra_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\pubtra_reclass"
buff_train =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\buff_train"
train_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\train_reclass"
wo_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\wo_noise_map"
gator_och_floeden_shp__2_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
flows_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\flows_reprojected"
selected_flows =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\selected_flows"
Output_direction_raster__4_ = ""
Output_back_direction_raster__4_ = ""
mark_vatten_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\mark_vatten.shp"
```

```
mark_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\mark_reprojected"
mark_selected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\mark_selected"
Output_direction_raster__5_ = ""
Output_back_direction_raster__5_ = ""
clipped_dem_tif =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\DEM_SYO,ï†√™_merged\\clipped_dem.tif"
byggnader_funktioner_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\byggnader_funktioner.shp"
buildings_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\buildings_reprojected"
height_raster =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\height_raster"
height_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\height_reclass"
dem_with_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\dem_with_buildings"
asr_dir_rad =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\asr_dir_rad"
asr_diff_rad =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\asr_diff_rad"
asr_dir_dur =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\asr_dir_dur"
asr_dem_w_build =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\asr_dem_w_build"
zs_solar =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\zs_solar"
zs_solar_integer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\zs_solar_integer"
rtp_solar =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\rtp_solar"
rtp_solar__2_ = rtp_solar
rtp_solar__4_ = rtp_solar__2_
rtp_solar__5_ = rtp_solar__4_
rtp_solar__3_ = rtp_solar__5_
reprojected_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Cloudburst\\cloudburst_outputs.gdb\\reprojected_building
s"
```

```
ed_mark =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\ed_mark"
rc_mark_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\rc_mark_buffer"
biodiv_corr_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\biodiv_corr_buffer"
rc_corridor_buff =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\rc_corridor_buff"
ws_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\ws_biodiv"
rc_ws_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity.gdb\\rc_ws_biodiv"
ws_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\ws_noise_map"
rc_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\rc_noise_map"
rc_solar =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\rc_solar"
ws_solar_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\ws_solar_roof"
zs_solar_roof_majority =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\zs_solar_roof_majority"
zs_solar_roof_mean =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\zs_solar_roof_mean"

# Process: Project
arcpy.Project_management(gator_och_floeden_shp, gator_floeden,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (2)
```

```
arcpy.Select_analysis(gator_floeden, motorfordon, "type =
'huvudgata_motorfordon'")

# Process: Euclidean Distance
arcpy.gp.EucDistance_sa(motorfordon, buff_traffic, "500", "2",
Output_direction_raster, "PLANAR", "",
Output_back_direction_raster)

# Process: Select (3)
arcpy.Select_analysis(gator_floeden, buss, "type = 'buss' ")

# Process: Euclidean Distance (2)
arcpy.gp.EucDistance_sa(buss, buff_pubtra, "500", "2",
Output_direction_raster__2_, "PLANAR", "",
Output_back_direction_raster__2_)

# Process: Select
arcpy.Select_analysis(gator_floeden, jarnvag, "type =
'jarnvag'")

# Process: Euclidean Distance (3)
arcpy.gp.EucDistance_sa(jarnvag, buff_train, "1500", "2",
Output_direction_raster__3_, "PLANAR", "",
Output_back_direction_raster__3_)

# Process: Reclassify
arcpy.gp.Reclassify_sa(buff_traffic, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", traffic_reclass,
"DATA")

# Process: Reclassify (2)
arcpy.gp.Reclassify_sa(buff_pubtra, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", pubtra_reclass,
"DATA")

# Process: Reclassify (3)
arcpy.gp.Reclassify_sa(buff_train, "VALUE", "0 300 5;300 600
4;600 900 3;900 1200 2;1200 1500 1;NODATA 0", train_reclass,
"DATA")

# Process: Weighted Overlay
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\Noise\\noise_map.gdb\\traffic_reclass' 33 'Value' (0 1;
1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\pubtra_reclass' 33 'Value' (0
1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\train_reclass' 34 'Value' (0
1; 1 1; 2 2; 3 3; 4 4; 5 4;NODATA NODATA));1 9 1",
wo_noise_map)

# Process: Project (2)
arcpy.Project_management(gator_och_floeden_shp__2_,
flows_reprojected,
```

```
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (4)
arcpy.Select_analysis(flows_reprojected, selected_flows,
"\"type\" IN ( 'ekologiska_samband' , 'gront_rorelsestrak' )")

# Process: Euclidean Distance (4)
arcpy.gp.EucDistance_sa(selected_flows, biodiv_corr_buffer,
"300", "2", Output_direction_raster__4_, "PLANAR", "",
Output_back_direction_raster__4_)

# Process: Project (3)
arcpy.Project_management(mark_vatten_shp, mark_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (5)
arcpy.Select_analysis(mark_reprojected, mark_selected,
"land_type IN ( 6 , 9  , 10 )")

# Process: Euclidean Distance (5)
arcpy.gp.EucDistance_sa(mark_selected, ed_mark, "300", "2",
Output_direction_raster__5_, "PLANAR", "",
Output_back_direction_raster__5_)

# Process: Project (4)
arcpy.Project_management(byggnader_funktioner_shp,
buildings_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
```

```
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Feature to Raster
arcpy.FeatureToRaster_conversion(buildings_reprojected,
"height", height_raster, "2")

# Process: Reclassify (8)
arcpy.gp.Reclassify_sa(height_raster, "VALUE", "7 7;19
19;NODATA 0", height_reclass, "DATA")

# Process: Plus
arcpy.gp.Plus_sa(clipped_dem_tif, height_reclass,
dem_with_buildings)

# Process: Area Solar Radiation
arcpy.gp.AreaSolarRadiation_sa(dem_with_buildings,
asr_dem_w_build, "59,8121392248689", "200", "WholeYear
2020", "14", "0,5", "NOINTERVAL", "1", "FROM_DEM", "32", "8",
"8", "UNIFORM_SKY", "0,3", "0,5", asr_dir_rad, asr_diff_rad,
asr_dir_dur)

# Process: Zonal Statistics
arcpy.gp.ZonalStatistics_sa(byggnader_funktioner_shp,
"funktion", asr_dem_w_build, zs_solar, "MEAN", "NODATA")

# Process: Int
arcpy.gp.Int_sa(zs_solar, zs_solar_integer)

# Process: Raster to Polygon
tempEnvironment0 = arcpy.env.outputZFlag
arcpy.env.outputZFlag = "Disabled"
tempEnvironment1 = arcpy.env.outputMFlag
arcpy.env.outputMFlag = "Disabled"
arcpy.RasterToPolygon_conversion(zs_solar_integer, rtp_solar,
"NO_SIMPLIFY", "VALUE", "SINGLE_OUTER_PART", "")
arcpy.env.outputZFlag = tempEnvironment0
arcpy.env.outputMFlag = tempEnvironment1

# Process: Add Field
arcpy.AddField_management(rtp_solar, "area_m2", "LONG", "",
"", "", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field
arcpy.CalculateField_management(rtp_solar__2_, "area_m2",
"!shape.area!", "PYTHON_9.3", "")
```

```
# Process: Add Field (2)
arcpy.AddField_management(rtp_solar__4_, "roof_energy_prod",
"LONG", "", "", "", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (2)
arcpy.CalculateField_management(rtp_solar__5_,
"roof_energy_prod", "([area_m2] * [gridcode] * (1/2) * (0.13))
/ 1000", "VB", "")

# Process: Reclassify (6)
arcpy.gp.Reclassify_sa(ed_mark, "VALUE", "0 5;0 61,057350
4;61,057350 127,310646 3;127,310646 204,156799 2;204,156799
300 1;NODATA 0", rc_mark_buffer, "DATA")

# Process: Reclassify (5)
arcpy.gp.Reclassify_sa(biodiv_corr_buffer, "VALUE", "0
40,447498 5;40,447498 89,375610 4;89,375610 146,013702
3;146,013702 212,640549 2;212,640549 300 1;NODATA 0",
rc_corridor_buff, "DATA")

# Process: Weighted Sum (2)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity.gdb\\rc_mark_buffer' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Biodiversity\\biodiversity.gdb\\rc_corridor_buff'
Value 1", ws_biodiv)

# Process: Reclassify (7)
arcpy.gp.Reclassify_sa(ws_biodiv, "VALUE", "0 0;0 2 1;2 4 2;4
6 3;6 8 4;8 10 5", rc_ws_biodiv, "DATA")

# Process: Weighted Sum
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Noise\\noise_map.gdb\\traffic_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Noise\\noise_map.gdb\\pubtra_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Noise\\noise_map.gdb\\train_reclass' Value 1",
ws_noise_map)

# Process: Reclassify (4)
arcpy.gp.Reclassify_sa(ws_noise_map, "VALUE", "0 3 1;3 6 2;6 9
3;9 12 4;12 15 5", rc_noise_map, "DATA")

# Process: Reclassify (9)
arcpy.gp.Reclassify_sa(asr_dem_w_build, "VALUE", "3110,512451
173449,884961 1;173449,884961 343789,257471 2;343789,257471
514128,629980 3;514128,629980 684468,002490 4;684468,002490
854807,375000 5;NODATA 0", rc_solar, "DATA")

# Process: Weighted Overlay (2)
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity.gdb\\rc_ws_biodiv' 10 'VALUE'
```

```
(0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Noise\\noise_map.gdb\\rc_noise_map' 10 'VALUE' (1
1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Solar Map\\solar_map.gdb\\rc_solar' 80 'VALUE' (1
1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA));1 9 1", ws_solar_roof)

# Process: Zonal Statistics (2)
arcpy.gp.ZonalStatistics_sa(reprojected_buildings, "funktion",
ws_solar_roof, zs_solar_roof_majority, "MAJORITY", "DATA")

# Process: Zonal Statistics (3)
arcpy.gp.ZonalStatistics_sa(reprojected_buildings, "funktion",
ws_solar_roof, zs_solar_roof_mean, "MEAN", "DATA")
```

Biodiversity Roof Script

```
# -*- coding: utf-8 -*-
# ----------------------------------------------------------
--------------
# biodiversity_roof_script.py
# Created on: 2021-01-12 12:58:58.00000
#   (generated by ArcGIS/ModelBuilder)
# Description:
# ----------------------------------------------------------
--------------

# Import arcpy module
import arcpy


# Local variables:
gator_och_floeden_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
flows_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\flows_reprojected"
selected_flows =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\selected_flows"
Output_direction_raster = ""
Output_back_direction_raster = ""
mark_vatten_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\mark_vatten.shp"
mark_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\mark_reprojected"
```

```
mark_selected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\mark_selected"
Output_direction_raster__3_ = ""
Output_back_direction_raster__3_ = ""
gator_floeden =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\gator_floeden"
motorfordon_select =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\motorfordon_select"
Output_direction_raster__2_ = ""
Output_back_direction_raster__2_ = ""
buss =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\buss"
Output_direction_raster__4_ = ""
Output_back_direction_raster__4_ = ""
jarnvag =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\jarnvag"
Output_direction_raster__5_ = ""
Output_back_direction_raster__5_ = ""
buff_traffic =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\buff_traffic"
traffic_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\traffic_reclass"
buff_pubtra =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\buff_pubtra"
pubtra_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\pubtra_reclass"
buff_train =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\buff_train"
train_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\train_reclass"
wo_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\wo_noise_map"
byggnader_funktioner_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\byggnader_funktioner.shp"
reproj_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\reproj_buildings"
```

```
ed_mark =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\ed_mark"
rc_mark_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_mark_buffer"
biodiv_corr_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\biodiv_corr_buffer"
rc_corridor_buff =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_corridor_buff"
ws_biodiversity =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\ws_biodiversity"
rc_biodiv_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_biodiv_suitabili
ty"
buildings_raster_area =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\buildings_raster_ar
ea"
rc_build_area_size =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_build_area_size"
buildings_raster_height =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\buildings_raster_he
ight"
rc_build_height =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_build_height"
ws_buidling_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\ws_buidling_suitabi
lity"
rc_buildings_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_buildings_suitab
ility"
ws_building_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\ws_building_biodiv"
```

```python
rc_building_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_building_biodiv"
wo_floodrisk =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk"
ws_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\ws_noise_map"
rc_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\rc_noise_map"
wo_final_biodiv_roof_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\wo_final_biodiv_roo
f_suitability"
zs_biodiv_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\zs_biodiv_roof"

# Set Geoprocessing environments
arcpy.env.snapRaster = ""
arcpy.env.extent = "649700 6629842 655538 6635622"

# Process: Project (2)
arcpy.Project_management(gator_och_floeden_shp,
flows_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select
arcpy.Select_analysis(flows_reprojected, selected_flows,
"\"type\" IN ( 'ekologiska_samband' , 'gront_rorelsestrak' )")

# Process: Euclidean Distance
arcpy.gp.EucDistance_sa(selected_flows, biodiv_corr_buffer,
"300", "2", Output_direction_raster, "PLANAR", "",
Output_back_direction_raster)

# Process: Project (3)
```

```
arcpy.Project_management(mark_vatten_shp, mark_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (3)
arcpy.Select_analysis(mark_reprojected, mark_selected,
"land_type IN ( 6 , 9  , 10 )")

# Process: Euclidean Distance (3)
arcpy.gp.EucDistance_sa(mark_selected, ed_mark, "300", "2",
Output_direction_raster__3_, "PLANAR", "",
Output_back_direction_raster__3_)

# Process: Project (4)
arcpy.Project_management(gator_och_floeden_shp, gator_floeden,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (4)
arcpy.Select_analysis(gator_floeden, motorfordon_select, "type
= 'huvudgata_motorfordon'")

# Process: Euclidean Distance (2)
arcpy.gp.EucDistance_sa(motorfordon_select, buff_traffic,
"500", "2", Output_direction_raster__2_, "PLANAR", "",
Output_back_direction_raster__2_)

# Process: Select (5)
arcpy.Select_analysis(gator_floeden, buss, "type = 'buss' ")

# Process: Euclidean Distance (4)
```

```
arcpy.gp.EucDistance_sa(buss, buff_pubtra, "500", "2",
Output_direction_raster__4_, "PLANAR", "",
Output_back_direction_raster__4_)

# Process: Select (2)
arcpy.Select_analysis(gator_floeden, jarnvag, "type =
'jarnvag'")

# Process: Euclidean Distance (5)
arcpy.gp.EucDistance_sa(jarnvag, buff_train, "1500", "2",
Output_direction_raster__5_, "PLANAR", "",
Output_back_direction_raster__5_)

# Process: Reclassify (5)
arcpy.gp.Reclassify_sa(buff_traffic, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", traffic_reclass,
"DATA")

# Process: Reclassify (6)
arcpy.gp.Reclassify_sa(buff_pubtra, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", pubtra_reclass,
"DATA")

# Process: Reclassify (7)
arcpy.gp.Reclassify_sa(buff_train, "VALUE", "0 300 5;300 600
4;600 900 3;900 1200 2;1200 1500 1;NODATA 0", train_reclass,
"DATA")

# Process: Weighted Overlay
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity_roof.gdb\\traffic_reclass' 33
'Value' (0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\pubtra_reclass' 33
'Value' (0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\train_reclass'
34 'Value' (0 1; 1 1; 2 2; 3 3; 4 4; 5 4;NODATA NODATA));1 9
1", wo_noise_map)

# Process: Project
arcpy.Project_management(byggnader_funktioner_shp,
reproj_buildings,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
```

```
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Reclassify (4)
arcpy.gp.Reclassify_sa(ed_mark, "VALUE", "0 5;0 61,057350
4;61,057350 127,310646 3;127,310646 204,156799 2;204,156799
300 1;NODATA 0", rc_mark_buffer, "DATA")

# Process: Reclassify (3)
arcpy.gp.Reclassify_sa(biodiv_corr_buffer, "VALUE", "0
40,447498 5;40,447498 89,375610 4;89,375610 146,013702
3;146,013702 212,640549 2;212,640549 300 1;NODATA 0",
rc_corridor_buff, "DATA")

# Process: Weighted Sum (3)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_mark_buffer'
VALUE
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_corridor_buff'
VALUE 1", ws_biodiversity)

# Process: Reclassify (10)
arcpy.gp.Reclassify_sa(ws_biodiversity, "VALUE", "0 2 1;2 4
2;4 6 3;6 8 4;8 10 5;NODATA 0", rc_biodiv_suitability, "DATA")

# Process: Feature to Raster
arcpy.FeatureToRaster_conversion(reproj_buildings, "area_m2",
buildings_raster_area, "2")

# Process: Reclassify
arcpy.gp.Reclassify_sa(buildings_raster_area, "VALUE", "36 304
5;304 852 4;852 1643 3;1643 2880 2;2880 5385 1;NODATA 0",
rc_build_area_size, "DATA")

# Process: Feature to Raster (2)
arcpy.FeatureToRaster_conversion(reproj_buildings, "height",
buildings_raster_height, "2")

# Process: Reclassify (2)
arcpy.gp.Reclassify_sa(buildings_raster_height, "VALUE", "7
5;7 19 3;NODATA 0", rc_build_height, "DATA")

# Process: Weighted Sum (2)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_build_area_size'
VALUE
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_build_height'
VALUE 1", ws_buidling_suitability)
```

```
# Process: Reclassify (9)
arcpy.gp.Reclassify_sa(ws_buidling_suitability, "VALUE", "0 2
1;2 4 2;4 6 3;6 8 4;8 10 5;NODATA 0",
rc_buildings_suitability, "DATA")

# Process: Weighted Sum (4)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_biodiv_suitabili
ty' VALUE
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_buildings_suitab
ility' VALUE 1", ws_building_biodiv)

# Process: Reclassify (11)
arcpy.gp.Reclassify_sa(ws_building_biodiv, "VALUE", "2
3,600000 1;3,600000 5,200000 2;5,200000 6,800000 3;6,800000
8,400000 4;8,400000 10 5;NODATA 0", rc_building_biodiv,
"DATA")

# Process: Weighted Sum
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity_roof.gdb\\traffic_reclass'
Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Biodiversity\\biodiversity_roof.gdb\\pubtra_reclass'
Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed
data\\Biodiversity\\biodiversity_roof.gdb\\train_reclass'
Value 1", ws_noise_map)

# Process: Reclassify (8)
arcpy.gp.Reclassify_sa(ws_noise_map, "VALUE", "0 3 1;3 6 2;6 9
3;9 12 4;12 15 5;NODATA 0", rc_noise_map, "DATA")

# Process: Weighted Overlay (2)
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\Biodiversity\\biodiversity_roof.gdb\\rc_building_biodiv'
60 'Value' (1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk' 20 'Value'
(1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Biodiversity\\biodiversity_roof.gdb\\rc_noise_map'
20 'Value' (1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA));1 5 1",
wo_final_biodiv_roof_suitability)

# Process: Zonal Statistics
arcpy.gp.ZonalStatistics_sa(reproj_buildings, "OBJECTID_1",
wo_final_biodiv_roof_suitability, zs_biodiv_roof, "MAJORITY",
"DATA")
```

Food Production Roof Script

```
# -*- coding: utf-8 -*-
# --------------------------------------------------------------
--------------
# food_rood_script.py
# Created on: 2021-01-12 12:12:48.00000
#   (generated by ArcGIS/ModelBuilder)
# Description:
# --------------------------------------------------------------
--------------


# Import arcpy module
import arcpy


# Local variables:
zs_biodiv_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\Biodiversity\\biodiversity_roof.gdb\\zs_biodiv_roof"
rc_biodiv_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_biodiv_roof"
rtp_biodiv_roofs =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rtp_biodiv_roofs"
select_biodiv_roofs =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\select_biodiv_roofs"
Output_direction_raster__2_ = ""
Output_back_direction_raster__2_ = ""
gator_och_floeden_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
flows_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\flows_reprojected"
selected_flows =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\selected_flows"
Output_direction_raster = ""
Output_back_direction_raster = ""
mark_vatten_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\mark_vatten.shp"
mark_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\mark_reprojected"
mark_selected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\mark_selected"
```

```
Output_direction_raster__3_ = ""
Output_back_direction_raster__3_ = ""
gator_och_floeden_shp__2_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
gator_floeden =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\gator_floeden"
motorfordon =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\motorfordon"
Output_direction_raster__4_ = ""
Output_back_direction_raster__4_ = ""
buss =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\buss"
Output_direction_raster__5_ = ""
Output_back_direction_raster__5_ = ""
jarnvag =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\jarnvag"
Output_direction_raster__6_ = ""
Output_back_direction_raster__6_ = ""
buff_traffic =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\buff_traffic"
traffic_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\traffic_reclass"
buff_pubtra =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\buff_pubtra"
pubtra_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\pubtra_reclass"
buff_train =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\buff_train"
train_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\train_reclass"
wo_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\wo_noise_map"
reproj_buildings = "reproj_buildings"
buffer_biodiv_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\buffer_biodiv_roof"
rc_buff_biodiv_roofs =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_buff_biodiv_roofs"
select_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\select_buildings"
```

```
build_raster =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\build_raster"
rc_select_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_select_buildings"
ws_suitable_roofs =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\ws_suitable_roofs"
rc_ws_buildings_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed
data\\FoodRoof\\FoodRoof.gdb\\rc_ws_buildings_suitability"
ed_mark =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\ed_mark"
rc_mark_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_mark_buffer"
biodiv_corr_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\biodiv_corr_buffer"
rc_corridor_buff =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_corridor_buff"
ws_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\ws_biodiv"
rc_ws_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_ws_biodiv"
ws_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\ws_noise_map"
rc_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_noise_map"
wo_floodrisk =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk"
wo_food_roof_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\wo_food_roof_suitability"
zs_food_roof_suitability =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\zs_food_roof_suitability"

# Set Geoprocessing environments
arcpy.env.snapRaster = ""
arcpy.env.extent = "649700 6629842 655538 6635622"

# Process: Reclassify
arcpy.gp.Reclassify_sa(zs_biodiv_roof, "Value", "1 0;2 0;3 1;4
3;5 5;NODATA 0", rc_biodiv_roof, "DATA")

# Process: Raster to Polygon
```

```
tempEnvironment0 = arcpy.env.outputZFlag
arcpy.env.outputZFlag = "Disabled"
tempEnvironment1 = arcpy.env.outputMFlag
arcpy.env.outputMFlag = "Disabled"
arcpy.RasterToPolygon_conversion(rc_biodiv_roof,
rtp_biodiv_roofs, "SIMPLIFY", "Value", "SINGLE_OUTER_PART",
"")
arcpy.env.outputZFlag = tempEnvironment0
arcpy.env.outputMFlag = tempEnvironment1

# Process: Select (2)
arcpy.Select_analysis(rtp_biodiv_roofs, select_biodiv_roofs,
"gridcode IN ( 3 , 5 )")

# Process: Euclidean Distance (2)
arcpy.gp.EucDistance_sa(select_biodiv_roofs,
buffer_biodiv_roof, "75", "2", Output_direction_raster__2_,
"PLANAR", "", Output_back_direction_raster__2_)

# Process: Project
arcpy.Project_management(gator_och_floeden_shp,
flows_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (3)
arcpy.Select_analysis(flows_reprojected, selected_flows,
"\"type\" IN ( 'ekologiska_samband' , 'gront_rorelsestrak' )")

# Process: Euclidean Distance
arcpy.gp.EucDistance_sa(selected_flows, biodiv_corr_buffer,
"300", "2", Output_direction_raster, "PLANAR", "",
Output_back_direction_raster)

# Process: Project (2)
arcpy.Project_management(mark_vatten_shp, mark_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
```

```
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (4)
arcpy.Select_analysis(mark_reprojected, mark_selected,
"land_type IN ( 6 , 9  , 10 )")

# Process: Euclidean Distance (3)
arcpy.gp.EucDistance_sa(mark_selected, ed_mark, "300", "2",
Output_direction_raster__3_, "PLANAR", "",
Output_back_direction_raster__3_)

# Process: Project (3)
arcpy.Project_management(gator_och_floeden_shp__2_,
gator_floeden,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (6)
arcpy.Select_analysis(gator_floeden, motorfordon, "type =
'huvudgata_motorfordon'")

# Process: Euclidean Distance (4)
arcpy.gp.EucDistance_sa(motorfordon, buff_traffic, "500", "2",
Output_direction_raster__4_, "PLANAR", "",
Output_back_direction_raster__4_)

# Process: Select (7)
arcpy.Select_analysis(gator_floeden, buss, "type = 'buss' ")

# Process: Euclidean Distance (5)
arcpy.gp.EucDistance_sa(buss, buff_pubtra, "500", "2",
Output_direction_raster__5_, "PLANAR", "",
Output_back_direction_raster__5_)

# Process: Select (5)
arcpy.Select_analysis(gator_floeden, jarnvag, "type =
'jarnvag'")

# Process: Euclidean Distance (6)
```

```
arcpy.gp.EucDistance_sa(jarnvag, buff_train, "1500", "2",
Output_direction_raster__6_, "PLANAR", "",
Output_back_direction_raster__6_)

# Process: Reclassify (8)
arcpy.gp.Reclassify_sa(buff_traffic, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", traffic_reclass,
"DATA")

# Process: Reclassify (9)
arcpy.gp.Reclassify_sa(buff_pubtra, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", pubtra_reclass,
"DATA")

# Process: Reclassify (10)
arcpy.gp.Reclassify_sa(buff_train, "VALUE", "0 300 5;300 600
4;600 900 3;900 1200 2;1200 1500 1;NODATA 0", train_reclass,
"DATA")

# Process: Weighted Overlay
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\FoodRoof\\FoodRoof.gdb\\traffic_reclass' 33 'Value' (0
1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\pubtra_reclass' 33 'Value'
(0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\train_reclass' 34 'Value'
(0 1; 1 1; 2 2; 3 3; 4 4; 5 4;NODATA NODATA));1 9 1",
wo_noise_map)

# Process: Reclassify (2)
arcpy.gp.Reclassify_sa(buffer_biodiv_roof, "VALUE", "0
74,966660 5;NODATA 0", rc_buff_biodiv_roofs, "DATA")

# Process: Select
arcpy.Select_analysis(reproj_buildings, select_buildings,
"funktion IN ( 'kontor_hotell_handel' , 'skola_1_9_forskola' ,
'gymnasium' )")

# Process: Feature to Raster
arcpy.FeatureToRaster_conversion(select_buildings, "OBJECTID",
build_raster, "2")

# Process: Reclassify (3)
arcpy.gp.Reclassify_sa(build_raster, "Value", "57 3103
5;NODATA 0", rc_select_buildings, "DATA")

# Process: Weighted Sum
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\FoodRoof\\FoodRoof.gdb\\rc_buff_biodiv_roofs' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\FoodRoof\\FoodRoof.gdb\\rc_select_buildings'
VALUE 1", ws_suitable_roofs)
```

```
# Process: Reclassify (4)
arcpy.gp.Reclassify_sa(ws_suitable_roofs, "VALUE", "0 2 1;2 4
2;4 6 3;6 8 4;8 10 5;NODATA 0", rc_ws_buildings_suitability,
"DATA")

# Process: Reclassify (6)
arcpy.gp.Reclassify_sa(ed_mark, "VALUE", "0 5;0 61,057350
4;61,057350 127,310646 3;127,310646 204,156799 2;204,156799
300 1;NODATA 0", rc_mark_buffer, "DATA")

# Process: Reclassify (5)
arcpy.gp.Reclassify_sa(biodiv_corr_buffer, "VALUE", "0
40,447498 5;40,447498 89,375610 4;89,375610 146,013702
3;146,013702 212,640549 2;212,640549 300 1;NODATA 0",
rc_corridor_buff, "DATA")

# Process: Weighted Sum (2)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\FoodRoof\\FoodRoof.gdb\\rc_mark_buffer' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\FoodRoof\\FoodRoof.gdb\\rc_corridor_buff' Value
1", ws_biodiv)

# Process: Reclassify (7)
arcpy.gp.Reclassify_sa(ws_biodiv, "VALUE", "0 0;0 2 1;2 4 2;4
6 3;6 8 4;8 10 5", rc_ws_biodiv, "DATA")

# Process: Weighted Sum (3)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed
data\\FoodRoof\\FoodRoof.gdb\\traffic_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\FoodRoof\\FoodRoof.gdb\\pubtra_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\FoodRoof\\FoodRoof.gdb\\train_reclass' Value 1",
ws_noise_map)

# Process: Reclassify (11)
arcpy.gp.Reclassify_sa(ws_noise_map, "VALUE", "0 3 1;3 6 2;6 9
3;9 12 4;12 15 5", rc_noise_map, "DATA")

# Process: Weighted Overlay (2)
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed
data\\FoodRoof\\FoodRoof.gdb\\rc_ws_buildings_suitability' 40
'Value' (1 1; 3 3; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_ws_biodiv' 20 'VALUE' (0
1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\FoodRoof\\FoodRoof.gdb\\rc_noise_map' 20 'VALUE' (1
1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk' 20 'Value'
```

```
(1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA));1 5 1",
wo_food_roof_suitability)

# Process: Zonal Statistics
arcpy.gp.ZonalStatistics_sa(reproj_buildings, "OBJECTID_1",
wo_food_roof_suitability, zs_food_roof_suitability,
"MAJORITY", "DATA")
```

Recreation Roof Script

```
# -*- coding: utf-8 -*-
# ------------------------------------------------------------
# --------------
# recreation_roof_script.py
# Created on: 2021-01-20 10:21:21.00000
#    (generated by ArcGIS/ModelBuilder)
# Description:
# ------------------------------------------------------------
# --------------

# Import arcpy module
import arcpy


# Local variables:
gator_och_floeden_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
gator_floeden =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\gator_floeden"
motorfordon =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\motorfordon"
Output_direction_raster = ""
Output_back_direction_raster = ""
buss =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\buss"
Output_direction_raster__2_ = ""
Output_back_direction_raster__2_ = ""
jarnvag =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\jarnvag"
Output_direction_raster__3_ = ""
Output_back_direction_raster__3_ = ""
gator_och_floeden_shp__2_ =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\gator_och_floeden.shp"
flows_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
```

```
rmed data\\Recreation
Roof\\recreation_roof.gdb\\flows_reprojected"
selected_flows =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\selected_flows"
Output_direction_raster__4_ = ""
Output_back_direction_raster__4_ = ""
mark_vatten_shp =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Extract
ed Data from FO,ï†√™P SYO,ï†√™\\mark_vatten.shp"
mark_reprojected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\mark_reprojected"
mark_selected =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\mark_selected"
Output_direction_raster__5_ = ""
Output_back_direction_raster__5_ = ""
reproj_buildings = "reproj_buildings"
select_buildings =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\select_buildings"
raster_funktion =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\raster_funktion"
funktion_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\funktion_reclass"
buildings_to_raster =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\buildings_to_raster"
reclass_surface =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\reclass_surface"
ws_funktion_size =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\ws_funktion_size"
reclass_ws_size_funktion =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\reclass_ws_size_funktion"
buff_traffic =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\buff_traffic"
traffic_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
```

```
rmed data\\Recreation
Roof\\recreation_roof.gdb\\traffic_reclass"
buff_pubtra =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\buff_pubtra"
pubtra_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\pubtra_reclass"
buff_train =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\buff_train"
train_reclass =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\train_reclass"
ws_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\ws_noise_map"
rc_noise_map =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\rc_noise_map"
ed_mark =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\ed_mark"
rc_mark_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\rc_mark_buffer"
biodiv_corr_buffer =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\biodiv_corr_buffer"
rc_corridor_buff =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\rc_corridor_buff"
ws_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\ws_biodiv"
rc_ws_biodiv =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\rc_ws_biodiv"
wo_floodrisk =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk"
wo_recreation_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\wo_recreation_roof"
zs_recreation_roof =
"C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation
Roof\\recreation_roof.gdb\\zs_recreation_roof"

# Set Geoprocessing environments
```

```
arcpy.env.snapRaster = ""
arcpy.env.extent = "649700 6629842 655538 6635622"

# Process: Project
arcpy.Project_management(gator_och_floeden_shp, gator_floeden,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (3)
arcpy.Select_analysis(gator_floeden, motorfordon, "type =
'huvudgata_motorfordon'")

# Process: Euclidean Distance
arcpy.gp.EucDistance_sa(motorfordon, buff_traffic, "500", "2",
Output_direction_raster, "PLANAR", "",
Output_back_direction_raster)

# Process: Select (4)
arcpy.Select_analysis(gator_floeden, buss, "type = 'buss' ")

# Process: Euclidean Distance (2)
arcpy.gp.EucDistance_sa(buss, buff_pubtra, "500", "2",
Output_direction_raster__2_, "PLANAR", "",
Output_back_direction_raster__2_)

# Process: Select (2)
arcpy.Select_analysis(gator_floeden, jarnvag, "type =
'jarnvag'")

# Process: Euclidean Distance (3)
arcpy.gp.EucDistance_sa(jarnvag, buff_train, "1500", "2",
Output_direction_raster__3_, "PLANAR", "",
Output_back_direction_raster__3_)

# Process: Project (2)
arcpy.Project_management(gator_och_floeden_shp__2_,
flows_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
```

```
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (5)
arcpy.Select_analysis(flows_reprojected, selected_flows,
"\"type\" IN ( 'ekologiska_samband' , 'gront_rorelsestrak' )")

# Process: Euclidean Distance (4)
arcpy.gp.EucDistance_sa(selected_flows, biodiv_corr_buffer,
"300", "2", Output_direction_raster__4_, "PLANAR", "",
Output_back_direction_raster__4_)

# Process: Project (3)
arcpy.Project_management(mark_vatten_shp, mark_reprojected,
"PROJCS['SWEREF99_TM',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF99'
,SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwi
ch',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER[
'False_Northing',0.0],PARAMETER['Central_Meridian',15.0],PARAM
ETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "",
"PROJCS['SWEREF99_18_00',GEOGCS['GCS_SWEREF99',DATUM['D_SWEREF
99',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Gree
nwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Tra
nsverse_Mercator'],PARAMETER['False_Easting',150000.0],PARAMET
ER['False_Northing',0.0],PARAMETER['Central_Meridian',18.0],PA
RAMETER['Scale_Factor',1.0],PARAMETER['Latitude_Of_Origin',0.0
],UNIT['Meter',1.0]]", "NO_PRESERVE_SHAPE", "", "NO_VERTICAL")

# Process: Select (6)
arcpy.Select_analysis(mark_reprojected, mark_selected,
"land_type IN ( 6 , 9 , 10 )")

# Process: Euclidean Distance (5)
arcpy.gp.EucDistance_sa(mark_selected, ed_mark, "300", "2",
Output_direction_raster__5_, "PLANAR", "",
Output_back_direction_raster__5_)

# Process: Select
arcpy.Select_analysis(reproj_buildings, select_buildings,
"funktion IN ( 'kontor_hotell_handel' , 'vard' , ' ' )")

# Process: Feature to Raster (2)
arcpy.FeatureToRaster_conversion(select_buildings, "OBJECTID",
raster_funktion, "2")

# Process: Reclassify (2)
arcpy.gp.Reclassify_sa(raster_funktion, "Value", "1 3103
5;NODATA 0", funktion_reclass, "DATA")

# Process: Feature to Raster
```

```
arcpy.FeatureToRaster_conversion(reproj_buildings, "area_m2",
buildings_to_raster, "2")

# Process: Reclassify
arcpy.gp.Reclassify_sa(buildings_to_raster, "Value", "36 305
1;305 852 2;852 1644 3;1644 2880 4;2880 5384 5;NODATA 0",
reclass_surface, "DATA")

# Process: Weighted Sum
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed data\\Recreation
Roof\\recreation_roof.gdb\\funktion_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Recreation
Roof\\recreation_roof.gdb\\reclass_surface' Value 1",
ws_funktion_size)

# Process: Reclassify (7)
arcpy.gp.Reclassify_sa(ws_funktion_size, "VALUE", "0 2 1;2 4
2;4 6 3;6 8 4;8 10 5;NODATA 0", reclass_ws_size_funktion,
"DATA")

# Process: Reclassify (3)
arcpy.gp.Reclassify_sa(buff_traffic, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", traffic_reclass,
"DATA")

# Process: Reclassify (4)
arcpy.gp.Reclassify_sa(buff_pubtra, "VALUE", "0 100 5;100 200
4;200 300 3;300 400 2;400 500 1;NODATA 0", pubtra_reclass,
"DATA")

# Process: Reclassify (5)
arcpy.gp.Reclassify_sa(buff_train, "VALUE", "0 300 5;300 600
4;600 900 3;900 1200 2;1200 1500 1;NODATA 0", train_reclass,
"DATA")

# Process: Weighted Sum (2)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed data\\Recreation
Roof\\recreation_roof.gdb\\traffic_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Recreation
Roof\\recreation_roof.gdb\\pubtra_reclass' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Recreation
Roof\\recreation_roof.gdb\\train_reclass' Value 1",
ws_noise_map)

# Process: Reclassify (6)
arcpy.gp.Reclassify_sa(ws_noise_map, "VALUE", "0 3 1;3 6 2;6 9
3;9 12 4;12 15 5", rc_noise_map, "DATA")

# Process: Reclassify (9)
```

```
arcpy.gp.Reclassify_sa(ed_mark, "VALUE", "0 5;0 61,057350
4;61,057350 127,310646 3;127,310646 204,156799 2;204,156799
300 1;NODATA 0", rc_mark_buffer, "DATA")

# Process: Reclassify (8)
arcpy.gp.Reclassify_sa(biodiv_corr_buffer, "VALUE", "0
40,447498 5;40,447498 89,375610 4;89,375610 146,013702
3;146,013702 212,640549 2;212,640549 300 1;NODATA 0",
rc_corridor_buff, "DATA")

# Process: Weighted Sum (3)
arcpy.gp.WeightedSum_sa("'C:\\Users\\Olivier\\Documents\\Anthe
sis_SLU\\Geodata\\Transformed data\\Recreation
Roof\\recreation_roof.gdb\\rc_mark_buffer' Value
1;'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Trans
formed data\\Recreation
Roof\\recreation_roof.gdb\\rc_corridor_buff' Value 1",
ws_biodiv)

# Process: Reclassify (10)
arcpy.gp.Reclassify_sa(ws_biodiv, "VALUE", "0 0;0 2 1;2 4 2;4
6 3;6 8 4;8 10 5", rc_ws_biodiv, "DATA")

# Process: Weighted Overlay
arcpy.gp.WeightedOverlay_sa("('C:\\Users\\Olivier\\Documents\\
Anthesis_SLU\\Geodata\\Transformed data\\Recreation
Roof\\recreation_roof.gdb\\reclass_ws_size_funktion' 55
'VALUE' (1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\rc_noise_map'
15 'VALUE' (1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\Recreation Roof\\recreation_roof.gdb\\rc_ws_biodiv'
15 'VALUE' (0 1; 1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA);
'C:\\Users\\Olivier\\Documents\\Anthesis_SLU\\Geodata\\Transfo
rmed data\\WaterRoof\\water_roof.gdb\\wo_floodrisk' 15 'Value'
(1 1; 2 2; 3 3; 4 4; 5 5;NODATA NODATA));1 5 1",
wo_recreation_roof)

# Process: Zonal Statistics
arcpy.gp.ZonalStatistics_sa(reproj_buildings, "funktion",
wo_recreation_roof, zs_recreation_roof, "MAJORITY", "DATA")
```