**Master Thesis Report**

**Master Construction Management & Engineering (CME)**

**Department of Built Environment**

# *'An explorational case study towards an integrated Environmental -and Social Framework to Assess the Impact related to high rise buildings in the Netherlands in a dense urban area due to urban transitions'*

F.J. van de Geijn

1014458

# Colophon

**Author MSc. Student:**
F.J. (Frank) van de Geijn
f.j.v.d.geijn@student.tue.nl

**Graduation Committee:**

**Commissionaire:**
Prof. dr. ir. Bauke de Vries
b.devries@tue.nl

**1st supervisor:**
Dr. Qi Han
q.han@tue.nl

**2nd supervisor:**
Prof. dr. ir. Theo Arentze
t.a.arentze@tue.nl

**Company Supervisor:**
Walter Hulsker
Walter.hulsker@ecorys.com

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# Summary

The purpose of the study is related to the rapidly increasing urbanisation and is estimated to be around 66% and 70% by 2050. The world population is reaching a new balance. As a result, the United Nations is demanding a change in how we think about the construction and reconstruction of urban areas.

This growth does not come without any impacts and consequences in and around urban areas; problems arise such as: mobility issues, clean water shortage, pollution, traffic congestion, housing issues and urban expansion. The problems are related; one will not go without the other and therefore the issues do not stand on their own. Cities, municipalities, real estate developers and other stakeholders will (or already) deal with these types of problems. Further, to encounter urbanisation, it is likely to assume that cities will construct high rise buildings. These urban transitions cause significant environmental and social impacts.

In order to reduce or regulate such impacts, impacts assessments are performed. However, current practice shows that impact assessments have their flaws. The main issue of impact assessments within urban planning is the use and extent of such tools. The Environmental Impact Assessment (EIA) is a common used assessment tool and in some cases even mandatory. The efficiency of such tool increases due to its' legal powers. Several researchers mention inaccurate and too less information is included within an EIA e.g. due to lacking experience of practitioners. Further, directives and guidelines within the EIA are incomplete and are not satisfying for a branch as the construction industry and urban planning. Therefore, an integrated EIA and Social Impact Assessment (SIA) could be a fertile impact assessment tool. Probably several benefits will come forward regarding an integrated EIA and SIA. For instance, an improved prediction of the potential impacts for urban land use functions. This leads to improved mitigation and reduction of impacts. On its turn, this should result into a 'compatible' building within the to be developed area.

Considering the above mentioned, the goal of this research is to develop an extensive tool which can systematic analyse the environmental and social impacts caused by high rise buildings. This tool is named as the Environmental Social Impact Model (ESIM). The first step of this research is providing an integrated environmental and social impact criteria framework, which leads to a better understanding of urban impacts. This integrated impact criteria framework will be used in order to investigate the compatibility of land use functions relating to each environmental and social impact criteria. However, these compatibility values need to be further processed by means of horizontal and vertical aggregation. These calculations will provide the compatibility scores which are thus in horizontal and vertical directions. This approach makes it very suitable for buildings as high rise buildings. The compatibility will be related to its area and the land use functions around the high rise building will be investigated. Considering above mentioned, the land use function of the high rise building will be compared to land use functions around the building. By using the compatibility matrix, the value can be noticed. This compatibility value can be processed by combining land use functions. By integrating the horizontal and vertical aggregation, the compatibility scores of the high rise building can be presented per floor and impact criteria. This means that it can be calculated that the building scores relatively low on ground level for transport, while the parking garage on -1 has a higher compatibility value. This tool also provides these insights per impact level radius (100m-200m-300m) and also applies scenario analysis.

The ESIM showed that mono functional buildings, such as office buildings and residential buildings have a relatively high compatibility on the social impact criteria, but low on environmental aspects. However, a mix of land use functions have a higher compatibility on environmental and lower on social aspects. But, overall the mix land use functions show the best 'fit' within the area. Further, it depends on the vision of a municipality which building is the most suitable. This can be explained by the fact that, more weight could be assigned to social aspects. In that case a mono functional building is more suitable.

By doing such analysis, in depth insight is created for optimising the function division of floors within the high rise building. Therefore, building characteristics can be adapted in early design phase to its' area and increase the compatibility values of each impact criteria. Besides, appropriate measures can be undertaken in order to reduce the biggest concerns of the stakeholders. By using the ESIM and thus involving also social impact criteria rather than only environmental impact criteria a better prediction and estimation of the potential impacts on the urban area can be made. Especially, when it is known that these two type of impact criteria are strongly related. This could for instance be useful to developed a sustainable long term well functional urban environment.

However, to discuss it could be said that social experts could be involved for the purpose of this study. Urban experts were included to judge the impact criteria. By involving social experts, more accurate predictions will be obtained. Further, the ESIM encountered a few major land use types, rather than specific land use types. Further, the weight of the impact criteria determines the most suitable building. By including multiple stakeholders, the weight of each impact criteria can be determined. This results towards a better fit of the building within the area. Additionally, Python can be used combined with QGIS in order to automatically calculation the compatibility values regarding each impact criteria.

It can be said that ESIM is succeeded in predicting the potential compatibility and impact values of the fourteen impact criteria. Considering the above mentioned discussing points, several improvements should be added to the tool in order to have even more precise data and results. Hence, insight is obtained for each floor and each impact criteria by applying ESIM. Combining environmental and social impacts in such tool an improved prediction can be made of the final compatibility value.

# Samenvatting


De studie is gerelateerd aan de snel toenemende urbanisatie, de verwachting is dat deze in 2050 tussen de 60% en 70% ligt. De wereldbevolking bereikt dus een nieuwe balans. Als gevolg daarvan, eist de United Nations een verandering op de denkwijze van ontwikkelingsprojecten van stedelijke projecten.

Urbanisatie kent verschillende problemen en consequenties in en buiten stedelijke gebieden; verschillende problemen ontstaan of nemen toe, bijvoorbeeld: transport, tekort aan (schoon) water, vervuiling, verkeer opstoppingen, woning problematiek, stedelijke groei. De problemen zijn gerelateerd; het ene probleem komt niet zonder het ander en staan niet op zichzelf. Momenteel zijn steden, gemeenten, vastgoed ontwikkelaars en andere stakeholders al bezig om oplossingen te bedenken voor deze problematiek op lange termijn. Echter, om urbanisatie te reguleren is het zeer aannemelijk dat er meer hoogbouw wordt toegepast in stedelijke omgevingen. Deze stedelijke transities veroorzaken significante effecten op milieu en sociaal gebied.

Hierdoor worden er impact assessments uitgevoerd om zulke effecten te verminderen en regulieren. Echter, blijkt in praktijk dat zulke impact assessments niet altijd even effectief zijn. Momenteel zijn deze impact assessments gelimiteerd voor het gebruik voor stedelijke projecten. Hoewel deze assessment systemen worden toegepast is het bekend dat er problemen zijn met het gebruik en invloed ervan. De Environmental Impact Assessment (EIA) (in Nederlands: m.e.r.) is een vaak gebruikte tool en in sommige projecten (intensieve planontwikkelingen) zelfs verplicht. De tool wordt mede versterkt door zijn juridische aspecten. Verschillende onderzoeken laten zien dat de EIA verkeerde maar ook te weinig informatie bevat om een correct rapport te creëren. Dit wordt met name veroorzaakt door onervaren medewerkers. Verder zijn de richtlijnen en handleidingen van de EIA incompleet en niet toereikend genoeg voor bijvoorbeeld stedelijke ontwikkelingen. Daarom is het van belang dat er uitgebreide tool ontwikkeld wordt gerelateerd aan stedelijke ontwikkelingen. De tool benaderd niet alleen de milieu aspecten, maar ook sociale aspecten. Door deze combinatie kunnen er betere predicties gemaakt worden van de mogelijke effecten, veroorzaakt door intensieve projecten zoals hoogbouw. Dit kan weer leiden tot een verbeterde leefomgeving op lange termijn.

Overwegende het bovenstaande, zal dit onderzoek een uitgebreide tool ontwikkelen die systematisch de milieu en sociale impact kan analyseren van verschillende gebruiks functies veroorzaakt door hoogbouw. De tool die ontwikkeld wordt is het Environmental Social Impact Model (ESIM) en wordt getest d.m.v. een case study. De eerste stap in dit onderzoek is geïntegreerd impact criteria framework te vormen. Hierdoor wordt de impact door stedelijke projecten beter begrepen. Dit geïntegreerde framework zal worden gebruikt om de compatibiliteit tussen de gebruiks functies te toetsen. De compatibiliteit zal verder berekend worden door de horizontale en verticale aggregatie. Deze waarden geven inzicht in de compatibiliteit tussen gebruiks functies in horizontale en verticale richting, gerelateerd aan ieder milieu en sociale impact criteria. Deze benadering is dus erg gunstig voor het gebruik van hoogbouw projecten. De compatibiliteit zal berekend worden tussen de vloeren van het hoogbouw project en de omgeving. De compatibiliteit matrix gekwantificeerd de compatibiliteit tussen gebruiks functies. Door het gebruik van horizontale en verticale aggregatie wordt duidelijk wat de uiteindelijke compatibiliteit van het gebouw is. Dit wordt gepresenteerd per vloer, per impact criteria en per impact radius level (100m-200m-300m). Verder worden er voor deze berekeningen scenario en sensitivity analyse toegepast om de robuustheid van het model te testen. Tevens wordt het inzichtelijk welk gebouw het optimale scenario is.

Het ESIM laat zien dat mono-functionele gebouwen, zoals kantoor gebouwen en woontorens relatief een hoge compatibiliteit op het sociale gebied hebben. Deze mono-functies scoren laag op het milieu aspect. Dit wordt veroorzaakt dat een concentratie van kantoor of woningen resulteert in verhoogde mobiliteit en wellicht daardoor verslechterde luchtkwaliteit. De sociale aspecten zijn hoog bijvoorbeeld omdat door relatief veel personen in het gebied het gevoel van veiligheid toeneemt, of juist meer voorzieningen komen. Echter, een mix van gebruiksfuncties heeft globaal een vrij hoge compatibiliteit. De mix van gebruiksfuncties scoort op milieu aspect juist hoger en sociaal wat lager, dit komt omdat er geen 'concentratie' van een gebruiksfunctie is. Verder, bestaat een perfect gebouw in een omgeving niet. Dit hangt af van de visie van de gemeente. Bijvoorbeeld het sociale domein kan een hogere prioriteit hebben. Hierdoor past een mono functioneel gebouw beter in het gebied.

Door een analyse uit te voeren zoals een ESIM, wordt er gedetailleerde inzicht verkregen in de consequenties van een hoogbouw object. Deze inzichten kunnen gebruikt worden voor het optimaliseren van een hoogbouw object. Door dit in 'early development phase' toe te passen, kunnen er nog verschillende aanpassingen gedaan worden om de grootste impacts te verminderen. Daarnaast kunnen er maatregelen getroffen worden om de zorgen van stakeholders terug te dringen. Al met al kan er dus door het gebruik van de ESIM een betere predictie gemaakt worden van de potentiele impacts. Dit komt doordat de milieu en sociale aspecten samen worden onderzocht, aangezien beide domeinen gerelateerd aan elkaar zijn. Al met al, is deze tool bruikbaar om een optimaal totaal ontwerp te maken, waardoor het gebouw zal functioneren op lange termijn.

Echter, zijn er ook discussie punten voor deze studie aan te merken. Bijvoorbeeld kunnen er experts van sociale studies betrokken worden voor het beoordelen van de sociale criteria. In deze studie zijn alleen stedelijk bouwkundige of consultants benadert. Door sociale experts te benaderen zullen er waarschijnlijk accuratere predicties gegenereerd worden. Verder, is er in deze studie niet het gewicht van de impact criteria meegenomen. Zoals eerder benoemd, kan de focus en het gewicht van bepaalde criteria het optimale gebouw in de omgeving beter voorspellen. Daarom, zou er in vervolg onderzoek verschillende stakeholders benadert kunnen worden om het gewicht van de impact criteria te bepalen. Verder, kan er een combinatie van Python en QGIS gebruikt worden om een automatisch calculatie proces te initiëren voor het berekenen van de compatibiliteit.

Al met al, kan er gezegd worden dat de ESIM succesvol predicties heeft kunnen maken betreft de compatibiliteit voor iedere impact criteria. Gezien de bovengenoemde discussie punten kunnen er nog wat verbeterpunten geïmplementeerd worden voor een accuratere predictie van impacts. Door het gebruik van de ESIM is er inzicht verkregen in de compatibiliteit iedere vloer van het hoogbouw project gerelateerd aan de omgeving en iedere impact criteria. Door het combineren van de milieu en sociale aspecten kan er dus een verbeterde predictie gemaakt worden.

# Abstract

Due to increasingly urbanisation a new approach is needed for urban planning. Besides, urban environments become more complex. This growth does not come without any impacts and consequences in and around urban areas; problems arise such as: mobility issues, clean water shortage, pollution, traffic congestion, housing issues and urban expansion. To encounter the urbanisation high rise buildings will be constructed and severe impacts will follow. In order to assess such impacts, impact assessments exist such as an EIA. However, the EIA have well known continuous flaws in practice. Therefore a new approach is needed and the ESIM tool is developed. This tool determines the compatibility of different land use functions indicated by fourteen environmental and social impact criteria. This compatibility is firstly calculated in horizontal and vertical direction and this will finally lead to a compatibility value of the high rise building for each floor and each impact criteria. A case study and scenario analysis are applied to find the optimal building within a city centre area. The results show that a mono functional building (e.g. office, residential buildings) have a high compatibility on the social impact criteria, but low for environmental aspects. A mix of land use functions within a high rise building show a relatively ‘good’ compatibility on all impact criteria. However, to improve the study some improvements could be mentioned. Such as inclusion of social experts, an overview of detailed land use functions rather than major land use functions, involvement of stakeholders for weight determination of impact criteria and the use of Python combined with QGIS.

*Keywords: Social Impact Assessment; Environmental Impact Assessment; Urban Impact criteria; Integrated Impact Assessment Tool; Land use compatibility; High Rise Buildings; comprehensive assessment tool.*

# 1. Introduction

The topic is related to the rapidly increasing urbanisation (per year) and is estimated to be around 66% and 70% by the year of 2050 (Bocquier, 2014). The world population is reaching a new balance. As a result, the United Nations is demanding a change in how we think about the construction and reconstruction of urban areas (Technische Universiteit Eindhoven, 2019).

This growth does not come without any impacts and consequences in and around urban areas; problems arise such as: mobility issues, clean water shortage, pollution, traffic congestion, housing issues, urban expansion (Hayati & Sayadi, 2012). The problems are related, one cannot go without the other and therefore the issues do not stand on their own (Mcdonald et al., 2011). Cities, municipalities, real estate developers and other stakeholders will (or already) deal with these types of problems such as water planning in dense areas (Gemeente Rotterdam & Waterschap Hollandse Delta, 2013). Several different solutions will come forward and will be implemented. But, what does this mean for the environment and social environment? It could be said, that some of these solutions will be implemented short sighted and without any well thought decision making; considering rapid increasing urbanisation. This is also confirmed by Bocquier (2014) and mention: “Nevertheless, rapid and unplanned urban growth threatens sustainable development when the necessary infrastructure is not developed or when policies are not implemented to ensure that the benefits of city life are equitably shared” (Bocquier, 2014, p. 3). Bocquier (2014) further notice: “In some cities, unplanned or inadequately managed urban expansion leads to rapid sprawl, pollution, and environmental degradation, together with unsustainable production and consumption patterns” (Bocquier, 2014, p. 3). This is also mentioned by Giyasov & Giyasova (2018) and notice that the growth of modern high-rise buildings could damage and change the climatic situation of the terrain. Further, it will imbalance the environmental situation of the living environment. At the same moment, factors such as: urban development, infrastructural and transport networks are pivotal of changing the living environment. Therefore, it can be said that structures as high-rise building will cause severe damage to the environmental situation of urban areas (Giyasov & Giyasova, 2018).

Consequently, it is obvious that several city issues are known due to urbanisation such as: decreasing value of land or overpriced dwellings. area deterioration, decreasing living environments, etc. Municipalities cannot simply expand their current urban area -and borders to encounter the increasing housing demand (Ward, Aguilar, & Smith Sr, 2003), considering urbanisation. As a result of this, the city structure as can be seen in figure 1 (e.g. Burgess Concentric zone model, Hoyt Sector Model, Urban Realms Model) will then also change. This could lead to inconsistent and dispersed built-up areas of the city. Therefore, it is likely that high rise buildings will be constructed in the city centre, however this has an impact on the current and future situation (Arslan & Sev, 2014). Further, it will even have an enormous impact on the quality of life (Horton & Reynolds, 1971). Such buildings will likely to be implemented in several urban area types. It is known that these constructions in these urban environment will have a big impact on the environmental as well as the social environment. The above mentioned problems will also account for the Dutch planning system and urban environments.

*Figure 1. Oblique View City of London*

Dutch cities are frequently asked about their development plans for high rise building projects. The real estate market is polling cities towards opportunities for such complex construction projects. Local governments and urban planning authorities find construction projects of high rise buildings interesting in order to achieve the ‘compact city’ as proposed by governmental policies. In most medium-large cities such high rise building policies are developed.

However, knowledge of municipalities and local planning authorities consist of very limited knowledge, is based on intuition, utopia and stories. On its turn, this means that high rise building projects cannot meet the pre-determined expectations. High rise building expectations consist of several opportunities to promote the city, boost the local economy and extent the real estate market with trending living-working environment. (Zandbelt, van den Berg, Bokkers, & Witteman, 2008). However, there are some known issues to high rise building projects as discussed by Zandbelt et al. (2008). In this study it is mentioned that high rise projects should be considered as a chance not a must, since such buildings also arise in smaller cities (Den Bosch, Tilburg, etc.). High rise projects could be an extension on the local office and housing market, but does not guarantee urban 'success'. Smaller cities should firstly investigate whether high rise buildings fit in their urban planning framework. Therefore, a clear concept could work for providing a design and project to human dimensions, for instance by focussing on a particular area within the city. If it is decided that high rise buildings will be constructed, the project should have a meaning to the environment. Since the project is complex, as also discussed in the EIA and SIA screening and scoping early involvement of stakeholders within this process should be realised. Furthermore, other potential impacts are noticed by Zandbelt et al. (2008), such as saturation of the housing and office stock, transportation issues due to increase of several transport modes, wind hinder and design of the plinth should maintain human dimensions. (Zandbelt et al., 2008).

Hence, urban planning face complexity due to potential issues of high rise buildings. Severe discussions between stakeholders will exist due to each own interests within the development project. High rise building projects do have a large impact within the existing neighbourhood and area, such as visual, wind, traffic, etc. However, for the real estate developer the building will be marked as a status symbol. The risk exist that saturation could occur on the housing and office stock and unsellable offices and dwellings will increase. The residents and tenants of the building will have an unique view over the city area but comprise this by the feeling of freedom (windows cannot open, French balcony's). Therefore, the development of high rise building projects is due to above mentioned impacts and issues complex and for long term purposes. Above of all this, a successful development relies on early and clear communication between multiple stakeholders. High rise buildings can succeed when potential impacts are considered and extend the existing urban environment.

Furthermore, the need of variety of functions within a city area is increasing. The Dutch planning system can be judged as defensive (strict separate functional zones) rather than offensive (mingling of several functions within a certain area). This will lead to a structural planning approach with an increasing involvement of interests from different stakeholders (Koops, 2012). Additionally to this, a recent published article discussed a new planning method in urban areas and could have big influence in the future planning methodology of the Dutch Government.

The recently published article is called 'Metro-Mix'. This is an extensive study about the increasing demand of a mix of functions within a dense urban area. The economic 'core-areas' have an increasing demand of quality relating to work and living. However, this aspect is too hard to simply implement and requires complex thinking in order to distinguish itself from the moderate living and work area. In order to satisfy these new demands and requirements a new approach is needed (College van Rijksadviseurs, 2018).

Therefore, among other things an new systematic approach need to be developed for assessing the impacts of such complex projects and buildings. It could be said that sustainable development (SD) could be applied, which encounters ecology, nature, social and cultural aspect. However, the methodology is still vague and missing elements as proper theoretical foundation are missing (Li, Yang, & Lam, 2013). Consequently, SD is considered as disputable and a confusing territory (George & Kirckpatrick, 2007). Since the EIA is widely developed and applied (Schmidt, Glasson, Emmelin, & Helbron, 2008), it is likely to draft an integrated impact criteria framework where also the SIA related to the urban environment is included, rather than apply sustainable development assessments.

# 2. Research Framework

It should firstly be stressed that this report does not discuss a full EIA and SIA. The focus is on the screening and scoping process of these impact systems. The research develop a tool which predicts the potential environmental and social impact caused by high rise building projects. This is related to the screening and scoping of the EIA and SIA. Given these reasons, a full assessment is therefore excluded. Several researchers mention inaccurate and too less information is included within an EIA e.g. due to lacking experience of practitioners. Further, directives and guidelines within the EIA are incomplete and are not satisfying for a branch as the construction industry and urban planning. It is noticed that an EIA could include a SIA in order to improve predictions of potential impacts. Therefore, an integrated criteria framework will be constructed. By applying screening and scoping obtained from the impact assessments, such framework can be constructed. This emphasizes the most important and likely impacts related to the urban environment/planning/development. These impact criteria will be calculated and further translated into the compatibility of a high rise building in a particular area. However, the framework will be further discussed and explained in chapter 3.

## 2.1 Research Relevance

Sustainable development (EIA and SIA contributes to this) has become a central theme in urban planning all over the world in the recent years. Urban transitions and repositioning functions could contribute creating a more sustainable and future-proof build environment (VROM-Raad 2010). However, current practice in the process of composing a program of demands for an area of building starts with mapping of stakeholders' values and wishes in the process of composing a program of demands for an area of a building. Subsequently, concrete solutions are developed based on knowhow and intuition (Wood, Glasson, & Becker, 2006). It is also mentioned that decisions are made by professional judgement, therefore it is likely to assume that new insights are not obtained in specific context situations.

It is also mentioned that urban development processes become increasingly complex. However, an integrated tool for assessing such developments is lacking. Anyway, the certain developments need to consider environmental and area aspects. This is required for large development projects rather than single project, the extent of certain projects extent is not clearly described. An area development work through four main phases: initiative, feasibility, realisation and maintenance. The urban development procedure (planologische procedure) is partly parallel related to the area development (gebiedsontwikkeling). This process is applicable for bigger and smaller developments. Firstly, the initiative phase will be performed, here the plan will be compared to the municipal structure vision and a quick-scan will be executed in order to investigate the environmental aspects. Once this phase is conducted the feasibility phase starts. The feasibility exists of three subphases: definition, design and preparation (Rijkswaterstaat, 2019a).

Concerning the EIA and SIA, the feasibility phase will be further elaborated on the environmental research (in Dutch: milieuonderzoek / m.e.r.). Here the area plan will be tested against the environmental criteria, and further legislation concerning ecology, water and archaeology. Considering the environmental research, measures should then be applied if the plan exceeds the current legislations, this is done order to reduce the environmental impact (Rijkswaterstaat, 2019a). The m.e.r. is a procedure to consider the environment impact during the design phase and need to be involved during establishing further agreements between several parties. (Rijkswaterstaat, 2019b). The MER only look into the direct effects of the physical environment where the social impacts are more or less ignored, no inter-relational effects are thus measured and assessed. For instance, the MER indicates nuisance and should be therefore adjusted in the development plan, however, no specific concerns for the social impact is considered.

Furthermore, also other tools or decision protocols are used in order to judge and assess significant projects. For instance, a Strategic Environmental Assessment (SEA) can be applied which is broad framework for the inclusion of environmental consideration in policies, plans and programs source guide (OECD, 2006). This method could be applied for the built environment and has several ranges of applications and is mainly used by the Organisation Economic Cooperation and Development (He et al., 2011). Therefore, it can be mentioned that also this method is relatively broad and has no specific aspects relating to Architecture Engineering and Construction Industry (AEC industry).

Considering the impact of a project currently the Environmental Impact Assessment (EIA) need to be performed mandatory before a project will be implemented in the area (European Commission, 2019). However, this is a major assessment which could be applied on several different projects, e.g. wind turbines, solar parks, infrastructural purposes and also urban construction purposes. The types of projects differ significantly and it is likely to assume that the EIA is rather broad than specific for each type of project. Only the environmental impacts are estimated, where social impacts are involvement is limited (Huesca-pérez et al., 2018). This is critical since several studies mentioned that high rise building have also a significant impact on several social aspects (Gifford, 2014).

Considering above mentioned, it can be said that the current practice requires an improved or even new planning assessment tool. By only considering the EIA a limited and one sided judgement is given. Inclusion of a SIA could improve the prediction of potential impacts and the compatibility of a building within a particular area.

## 2.2 Research Problem Analysis

It is evident that the increasing urbanisation in several different countries and cities will cause different issues. This means that urban transitions will also increase and change drastically (Koomen, Stillwell, Bakema, & Scholten, 2007), therefore high rise buildings will be built in order to encounter the big demand of real estate in the city area. Consequently, such drastic projects have impacts on environment as well as the social domain. At the same time EU and national government, municipalities and other organisations are improving their impacts assessments, but can rather be seen as broad than specifically for urban transitions. Besides of this, relatively less studies are performed to impact assessments specifically for the urban environment. In order to create a sustainable living area it is important that the environmental and social impacts are well considered in the early design phase.

Sustainability does not necessarily mean that innovative construction methodologies should be applied. In this case it means that the living environment and the functional behaviour within a certain area should be maintained during a time period of 50 years or longer (Robinson et al., 1996). This prevents deterioration and an idling position of the area. However, when the opposite occurs possible further consequences account for demolishing and re-engineering is a short time period. Besides of this, the Dutch planning system can be judged as defensive, where cities and individuals currently demand an offensive planning approach. This means that areas need to provide a mix of functions. Consequently there is a need for an improved systematic assessment tool, due to increasing complexity of the combined city functions and development.

It is known that high-rise buildings in urban areas have big impacts on the environment as well as on the social domain in that area. Considering extensive projects such as high-rise buildings; by only executing an EIA or m.e.r. is too limited in order to assess the impacts on the living environment and social impacts (Montano & Pereira de Souza, 2015).

Besides, for some projects it is not even common to execute an EIA, only complex urban developments is this mandatory such as infrastructural projects or area developments (Hobma & Jong, 2016). Further, is it mentioned that current impact assessments are broad and can be applied for several different project types.

However, considering high rise buildings projects; impacts are related (Dietz, Rosa, & York, 2009), for instance: an increase of mobility does not only results in environmental impacts, but also increases social impacts such as noise and health pollution. Therefore, it is important that a new assessment tool should be developed as an integration of the EIA and SIA, where it is mentioned by several researches and researchers that a new approach is needed in order to obtain and perform an improved prediction of the likely consequences which are caused by projects in the urban environment (Dendena & Corsi, 2015; Peche & Rodríguez, 2009). In these two examples it is mentioned that thus, the mandatory EIA only is currently too limited in order to measure the total interrelated effects on the environment as well as the social domain.

Also the study of Sairinen (2004) mention this issue: there is a need for such impact assessments specifically for urban planning (R Sairinen, 2004). From the case study applied by Sairinen (2004) several benefits became clear when involving an SIA: (1) Better understanding on social conditions and impacts of the plan and the links between social and biophysical worlds, (2) Better management of urban growth or decline, (3) Tool for conflict management, (4) Tool for developing the quality of environment, (5) Improved understanding on the contents of social sustainability, etc. (R Sairinen, 2004, p. 430). Also another recent study of Montano & Pereira de Souza (2015) mention the importance of the involvement of a Social Impact Assessment (Montano & Pereira de Souza, 2015), when considering the impact of high-rise buildings in the living environment of cities and local neighbourhoods in urban areas. By involving such SIA, potential impacts can be predicted more accurately.

## 2.3 Research Questions

In order to achieve the above described objectives, the following main question is drafted:

‘*How can the SIA be implemented in the EIA in order to construct an integrated ESIA impact criteria framework, which systematically values the impact characteristics of high rise buildings in the Netherlands due to urban transition?*

The following sub-questions will contribute in answering the main question:

A. What aspects do EIA and SIA contain and how can these impacts be measured?
B. To what extent can the impact variable aspects from the EIA and SIA be used in high rise building projects?
C. How can the environmental and social impacts related to high rise buildings be systematically analysed?
D. To which extent does a functional combination in a high rise building contribute to the environmental and social impacts?
E. Which functional land use combination of a high rise building results in the less environmental and social impacts by means of scenario analysis

## 2.4 Research Objective & Limitations

The research should result in a tool which analyses the environmental and related social impacts of high rise buildings. However, this research will use ‘screening and scoping’ for constructing the integrated impact criteria framework as mentioned within an EIA and SIA. Further, a full EIA and SIA will not be performed. This research will show compatibility (value) of a high rise building related to each environmental and social impact criteria.

This study relies on the integrated environmental-social criteria framework by means of input of journal articles which argue the inclusion of different impact criteria in urban planning. Therefore, the research is an explorational case study assessing the Environmental -and Social impacts in an urban environment. An integral methodology is needed to consider the total impact of interacting urban functions on ecological, economical and socio-cultural values.

Nevertheless, the case study research is bounded to Dutch standards, dimensions and scales which means that further extended applications of the tool are likely to adapt to their built environment.

Therefore, it should be noted that high rise buildings in the Netherlands differ in size, scale and dimensions compared to e.g. Hong Kong, Dubai, New York[1]. Therefore, this research will focus on the dimensions of high rise buildings which fit the Dutch urban area, where high rise in this research is considered to be between a length of 80 and 120 meters. However, based on the aforementioned developments and identified gap in knowledge and expertise, this research aims to develop a systemic assessment tool in order to visualise and identify the environmental and social impacts of high rise buildings which could come forward as a consequence of urban transitions. This tool could be useful during the (early) development phase of a project, considering the increasing complexity of cities.

## 2.5 Research Approach

The research design is divided into four different main stages: 'Research', 'Modelling Design', 'Data collection' and 'Data processing and Modelling', this is further visualised in figure 2.

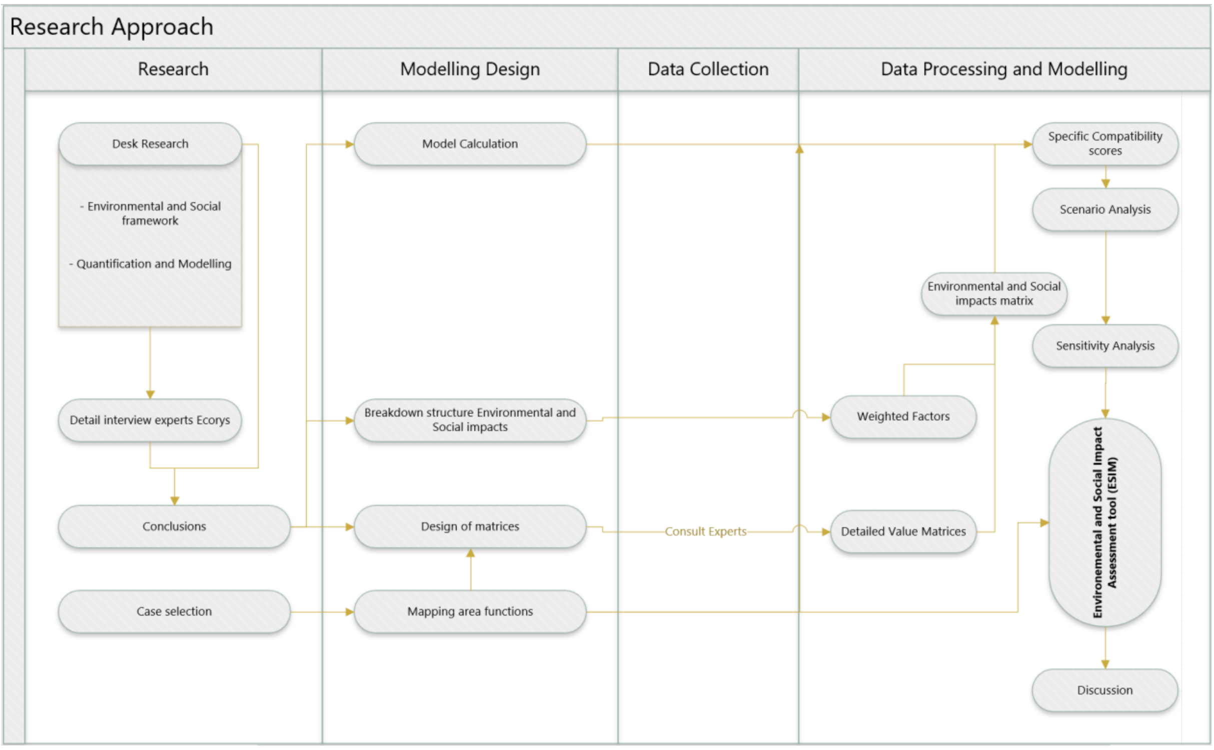



*Figure 2. Research Approach*

The desk research phase will lay foundations mostly of the sub-questions and finally for modelling the impact assessment tool. More insight is obtained within the environmental and social impacts within a certain area, the sub-questions A and B will account for this. The output of the first phase will be the input of the second phase.

In this phase the tool will get its form and which criteria and remaining variables will be used for the impact compatibility calculation. Besides of this a breakdown structure will be created which give a systematic overview of all the environmental and social impacts involved during urban transitions for high rise buildings, sub question C will be accountable for this phase.

[1] Stichting Hoogbouw mention: When it comes to new developments in New York City, the supertall tower is still king: many of the city's most high-profile developments, from One World Trade Center to Central Park Tower, all exceed the 984-foot (300m) limit that takes a building from merely tall to supertall. (https://www.stichtinghoogbouw.nl/new-york-citys-20-supertall-towers/)

Further, experts will be considered for this process after a breakdown structure is created in order to see which aspects should be included in the tool.

In the final phase, sub questions D and E will be answered and the data is analysed and processed into the final model which will be a tool providing insight in the environment as well as the social impacts as a result of urban transition by means of constructing a high rise building in a dense area.

## 2.6 Reading Guide

As the introduction and research framework are discussed, this paragraph will highlight the remaining chapters of this research. Therefore, chapter 3 will follow and elaborates on the EIA and SIA. Here the background and current issues around the scoping and screening will be presented. Furthermore, each impact assessment system will propose an impact criteria framework related to high rise buildings and urban planning. This will used for assessing the compatibility matrixes as in proposed in chapter 4. Therefore, chapter 4will discuss the Environmental Social Impact Model (ESIM). In this chapter first an overview and background of the ESIM will be presented since this model relies on several inputs of data and calculations. Also the purpose of this model is highlighted and after the integrated impact criteria framework (obtained from chapter 4) is discussed. Chapter 4, will discuss the ESIM process. The background and overview will be presented, but also the purpose and the impact criteria framework. This framework will be used in order to construct the compatibility matrixes as in paragraph 4.4. In paragraph 4.4 the inputs for the ESIM calculation process will be discussed such as: compatibility matrixes and case study data. Further, in this chapter the ESIM calculation process will be discussed and the ESIM output of this process. In chapter 5, the ESIM application is discussed. This chapter will thus utilize the ESIM given the input of chapter 4 regarding the case study. First, the case study and characteristics of it will be mentioned. After, the land use compatibility matrixes will be discussed separately and the relation towards the impact criteria is noticed. The results of the case, scenario -and sensitivity analysis will be discussed and concluded. In chapter 6, the conclusion will be presented, as well the inclusion of the sub-questions as the main research question. Chapter 7 will finalise the research by discussion the results and provide input for further research. After, this chapters the references and Appendixes are placed.

# 3 Environmental -and Social Impact Assessment

This chapter will discuss and further elaborate on the environmental and social impact assessments. However, only the definitions of the EIA and SIA, screening and scoping of both assessment systems is discussed. This report do calculate and indicate the potential impacts, which are encountered within the screening and scoping. Therefore, this report does not perform a full EIA and SIA. Insight is obtained into the potential environmental and social impacts regarding the urban environment. Therefore, firstly the background and content of each impact assessment will be shortly addressed which explains the origin and the need of purpose of these assessments. Besides, screening and scoping will be discussed which are relatable to this report. After, the content of the EIA and SIA will be shortly discussed and the relation to urban environment -and planning. Also the draft of the EIA and SIA urban impact criteria framework discussed. This impact criteria framework will used in this research in order to calculate the compatibility of a high rise building. Finally, the need of integration of social impact criteria into a EIA is discussed which can be identified as the 'gap' and will conclude chapter 3.

## 3.1 A Brief Evolvement of Environmental and Social Impact Assessments

The environmental impact assessment refers to the evaluation of effects which are most likely to arise from a project or other action and could significantly affect the natural environment. This makes the EIA a systematic and integrative approach. The EIA is a result from the National Environmental Policy Act (NEPA) in 1969. The environmental impact statement (EIS) is pivotal in the NEPA, the EIS describes the environmental impacts likely to arise from an action (Wood, 2014). The development of the EIA dates from the 1970's, where several countries developed their own EIA. The quality and strength of such EIA varies per country, however it can be seen that EIA's in developing countries are lacking (Wood, 2003). The EIA became a widely used assessment tool and is practised in more than 100 countries. It emerged in different forms and countries developed their own assessments. For instance, the Netherlands the EIA is named as MER (milieu-effectenrapportage), in Canada as environment assessment (Donnelly, Dalal-Clayton, & Hughes, 1998).

The purpose of the EIA is to give insight into the consequences of decision makers their actions. Therefore, it can be said that the EIA should lead to informed decision making when properly used. This should lead to a positive contribution to stakeholders and to population at large. Also Sadler (1996) found that the EIA plays an important role for the incorporation of concepts; for instance: the reduction or avoidance of natural loss and precautionary principles. In fact, the EIA targets the abandonment of environmental unsatisfactory actions and the mitigation of actions towards an acceptable point of environmental effects (Wood, 2014).

However, the SIA is related to the NEPA and has also its' roots in the Act of 1969, but is legislated in 1973 (Burdge & Vanclay, 1996). This is because the NEPA demands that after an EIA, the social interactions should be related to the quality of the human. While the EIA is more applied among projects, yet the SIA becomes increasingly important. The EIA does have a longer development period however, the importance of the SIA is increasing among agency planners and decision makers. These groups claim for a better understanding of the social consequences projects and policies. Social impacts can be described as the consequences to human beings which alter ways in living, working, playing and cope as members in the society (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994). However, the definition of the SIA is rather broad and need thus some scope refinement for every project, policy or other development. Otherwise, this could lead to the inclusion of every social aspect; insignificant results are then likely to be happen (Lockie, 2001). The impact assessments are dynamic (legal) documents. Recent studies show that institutions, governments and other parties are coping with the development of the impact assessments (Arce-Gomez, Donovan, & Bedggood, 2015; Mahmoudi, Renn, Vanclay, Hoffmann, & Karami, 2013; Morgan, 2012).

One of the reason is that impact assessments (e.g. EIA and SIA) differ per country, this is also adjusted to the cultural, habits and the way of planning development in a certain country (Ahmad & Wood, 2002; Donnelly et al., 1998). Wood (2003a) gives an excellent example and mention: Indeed, there is a considerable diversity of views about the essential elements of an effective EIA system which should, in any event, be tailored to individual national circumstances (Wood, 2014, p. 6). Furthermore, difficulties exist with the definition or evaluation of the SIA since it can be executed in altering contexts and purposes. Besides of this, the SIA can be considered as an extension of the EIA where impact criteria are limited discussed (e.g. demographic changes, job issues, financial security) (Vanclay, 2003, pp. 7–8).

The SIA can be seen as an extension of the EIA. Both documents are constantly developing and changing, since these should adapt to several trends. When performing and EIA or SIA, it is estimated that improved predictions of the possible impacts can be made. However, both documents have also its' limitations when estimating the potential impacts. Therefore, the limitations and current problems of both documents will be shortly discussed relating to the objective and scope of this report in the next paragraph and subparagraphs.

## 3.2 Environmental Impact Assessment

Over the last 40 years the EIA became increasingly important, during this period the assessment methodology developed and changed. This change was caused by decision-makers and also (field) experts such as Morgan and Wood. However, it is noted that the EIA does not have as much influence as it was intended, due to different visions about nature and purposes about the EIA. Three broad themes of concern are mentioned based on review of literature on environmental assessment, namely (Morgan, 2012):

- Theoretical grounding: is the scope and purpose of the EA clear, besides what does it exactly compromise?
- Quality: what is a good practice, is there a framework for quality and what guidance is provided?
- Effectiveness: what is the achievement of the process?

Also Noble (2000) can confirm this by giving an example: "Attempts to evaluate the environmental consequences of human activities before such activities take place is an essential part of environmental planning and management. However, it is important to be realistic about the limitations involved in making predictions and developing blueprint management and mitigative strategies for complex and dynamic environmental systems" (Noble, 2000, p. 98). Furthermore, Noble (2000) notes: "Defining the boundary within which to conduct an environmental impact assessment is often a challenging task. Perhaps the area of greatest concern, and ironically the area of least attention, is the definition of temporal boundaries in EIA" (Noble, 2000, p. 105).

However, the elements of the EIA process are further elaborated by Wood (2003a). It should be noted that not every EIA contains all the elements originated from NEPA. The iterative steps of the EIA process can be defined as follows, the process steps 1 – 8 will form a completeEIA:

1. Consideration of alternative means of achieving objects;
2. Designing selected proposal;
3. Determination if an EIA is required in a certain case;
4. Scoping the report, decision making covered topics;
5. Preparing the EIA report;
6. Reviewing EIA report to check on adequacy;
7. Making decision on the proposal;
8. Monitoring the impacts of the proposal once implemented.

This report only discusses the points 1 till 4. Point 1, 2 and 3 encounters the screening process and 4 the scoping process. Points 1-3 will concern the possible environmental impacts (water, soil, noise) damage and point 4 will further 'filter' the urgent impacts where only a few impact criteria remain.

### 3.2.1. EIA Definitions and Dimensions

In the EIA two important aspects play a role namely, standards and thresholds. These two aspects determine to what extent a particular impact maximum or minimum can have on the environment. The threshold refers to the points that have to be exceeded to begin response to a given effect or result (Schmidt et al., 2008). Such standards and thresholds mention the lower and upper bound extend if there will be an effect. As Schmidt et al. (2008) mention, the study of Kozlowski (1968) used thresholds in order to support several levels of urban growth in relation to steps in infrastructure provisions. Additionally, in the study of Sassaman (1981) thresholds were identified for environmental criteria (e.g. water quality) at which those assessing a proposal should become concerned with an impact. The thresholds of the EIA are related to the 'standards' and need further explanation. Standards within an EIA provide guidance and steering which regulates the effects of an activity on a recipient. To be more specific, effects caused by human activity are regulated by environmental standards. Standards can be divided into two purposes, a (a) desired state and (b) acceptable range of change. For instance, (a) regulations of noise levels from road traffic in an residential area during night; (b) a maximum of 40% of urban development can be built on green area land purpose.

By clarifying in advance what criteria will be applied, standards could help certain developments for environmental issues. Both thresholds and standards are bounded to dimensions, these differ in legislation, guidance and social values and preferences. For instance, different legal requirements and building regulations related to structures, lightning and heating are obliged by a country; however, what standards for crime, perceiving safety, well-being, quality of life and other social dimensions and housing are applied? These dimensions have an overlap with other factors related to the degree of quantification of the thresholds and standards (Schmidt et al., 2008).

Some type of thresholds and standards are easy to quantify, however some of these aspects are more difficult to measure than others, for instance social dimensions such as health, crime and quality of life values. Another form of difficulties may arise due to complexities of individual situations, even though numerical standards are used. Additionally, the contrast between safe impact and a hazardous physical impact could also include a fuzzy element. The thresholds and standards can also vary in their degree of aggregation. The failure of disaggregate impacts on different stakeholders affected by a project is one of the weakness of an EIA. The threshold may be an aggregate on highlighting that the project is likely to cause, for instance increasing traffic in a neighbourhood, pressure on the housing market, however fails to identify the relational impacts on the affected stakeholders. Additionally, several external dimensions can be identified, e.g. relation to nature of project; relation to nature of the environmental receptor (air quality, water quality). Besides of this, standards and thresholds could also have a spatial dimension; others are more a-spatial. A spatial threshold could be related to a certain type of environmental purpose; for instance the strict controls for certain types of development, in natural areas, such as National Parks (Schmidt et al., 2008).

Several decision points are in the EIA process, also several stages where thresholds and standards could be applied play an important role. The next subparagraphs will explain the application of thresholds and standards within the screening and scoping of the EIA. For example Schmidt et al. (2008) mention: "scoping seeks to identify the types of impacts that should be investigated for a particular project, and to establish which of them are likely to be the key to the acceptability of the project. Many of the standards and thresholds used in the screening stage will also be relevant in scoping" (Schmidt et al., 2008, pp. 7–9).

Thus, standards and thresholds play an important role in order to perform the screening and scoping processes in an EIA. It helps to set boundaries and estimate the potential impacts caused by a project. Therefore, subparagraph 3.2.2. and 3.2.3. will shortly discuss the screening and scoping process since this relates to the construction and filtering of the environmental and social impact criteria framework by means of a literature study presented in paragraph 3.3.

### 3.2.2. EIA Screening

In basis EIA screening investigates and determine whether an EIA should be executed for a particular project Slootweg & Kolhoff (2003) mention that screening is needed in order to determine which 'to be developed' projects need further environmental deliberations in order to exclude unlikely harmful environmental impacts and indicate the level of environmental appraisal that a project probably will require (Slootweg & Kolhoff, 2003). Decision could be made upon subjective arguments. However, a strong variation of screening approaches do exist, such as: an threshold approach, rational approach, intuition, case-by-case (Weston, 2000).

Screening of an EIA within the boundaries of the EU are statured in EU legislations and laws. The European Council provided a solid EIA process guidelines in their statues which can be pragmatically applied by a variety of projects. The member states in the EU adopted in fact two types of screening tools: listing projects with specified thresholds value and criteria and case-by-case analysis (Pinho, McCallum, & Cruz, 2010). Further, during screening also criteria are indicative in order to decide if an EIA should be applied. The criteria which are highlighted in the screening process should be further investigated in the scoping procedure. Here, the final noted impact criteria will be elaborated upon and studied in detail. In the study of Weston (2000), the importance of common used screening criteria are discussed. Also there criteria contribute to the decision whether an EIA should be applied for a project. In table 1 the most common criteria of the screening procedure are showed.

*Table 1. Most important screening criteria of LPA's (Source: Weston, 2000)*

| Screening criteria | % of hits |
|---|---|
| Nature of project/processes and likely emissions | 20 |
| Proximity to a sensitive environmental receptor | 19 |
| Likely traffic or access impacts | 14 |
| Size or scale of project | 12 |
| Likely public/political concern | 8 |
| Landscape impacts | 7 |
| Other physical impacts (noise, odour, drainage, etc.) | 12 |
| Socio-economic impacts (retail, tourism, etc.) | 8 |
| | 100 |

As presented in table 1, two screening criteria are most often used by the governmental part namely, 'nature of project/processes and likely emissions' and 'proximity to a sensitive environmental receptor'. As third most used screening criteria is 'likely traffic or access impacts'. Further screening criteria are having the same score. However, the small differences of the table can be explained by the fact that these criteria are subjective (Weston, 2000).

However, it is mentioned that screening shouldn't be underestimated, since crucial and major effects could be missed during the project an inaccurate and incomplete judgement of the potential impacts within the EIA could be determined (Weston, 2011). It is known that the screening procedure within the EIA process is an extensive and pivotal process. Besides of this, it is mentioned that this step is vital and also tricky. This is because among other things, the screening process has several different approaches (e.g. threshold approach, rational approach, intuition, case-by-case) which could be used in order to obtain an accurate prediction. As mentioned screening involves several different methodologies in order to determine whether a EIA is needed (Schmidt et al., 2008). Further, many decision theories and methodologies are not corresponding with practice (Weston, 2011).

Several main issues are noted and also relate to this research, such as: interpretation problems to specific sectors (e.g. urban development projects); ambiguous screening decisions; difficulties in dealing with effects and more precise specification of selection criteria for screening and clearer advice for practical application (Pinho et al., 2010).

So, screening process provides insight in the potential impacts due to a particular project. Several different criteria are involved when screening such project. However, screening should not be underestimated since an incomplete final judgement could appear.

### 3.2.3. EIA Scoping

This report is a case study where finally the improved environmental social impact tool will be tested. To do so, an impact criteria framework should be created and involved, in order to check the compatibility value of the high rise building in the case area. Therefore, it is also wise to discuss the scoping and purpose of it within the EIA. However, this process is mentioned as an important but underestimated part of the EIA (Wood, Glasson, & Becker, 2006). The scoping process will be performed after the screening process and involves the determination of the key impacts of the project. Specific environmental criteria (e.g. water pollution, noise hinder, soil pollution) could be involved as this could be caused due to human interactions. Once, the key criteria or possible impacts are identified the significance of impacts can be predicted. Thresholds and standards are applied to investigated by screening, scoping will be applied to check the limit of tolerance. The defined thresholds are created by development of the criteria. This all allows for a systematic analysis and this reduces uncertainty in the decision-making process. However, there may be limitations to this form of determination. In some projects, the significance of impact do not exceed values of the thresholds and standards and will therefore be excluded from the EIA, even though such impacts are hazardous (Canter & Canty, 1993).

In order to scope the potential impact several approaches are noticed in order to further narrow the amount of possible impacts, these are presented in table 2.

*Table 2. Five most used methods determine significant impacts – adjusted by author (Source: Wood et al., 2006)*

| Method | LPA (%) | Consultants (%) | Statutory consultees (%) |
|---|---|---|---|
| Professional judgement and experience | 74 | 78 | 79 |
| Consultation | 55 | 55 | 29 |
| Case by case basis | 33 | 67 | 21 |
| Checklist | 36 | 36 | 29 |
| Did not use any particular method | 30 | 9 | 29 |

The percentages in table 2 seem to be odd as these don't add up to 100%, however, the % figure for each approach is a proportion of the total number of respondents from each practitioner group. As showed in table 2, several methods can be used in order to determine the significance of impacts. Significance determination in EIA practice makes judgments about what is important, desirable or acceptable. It also interprets degrees of importance (Lawrence, 2007). This is thus a part of the scoping process, where indeed the most important criteria or impacts are included into the EIA process and development project. Anyway, the results in table 2 show that most of the 'practitioners' use (1) professional judgement, followed by (2) consultation and (3) case-by-case (4) checklist and last (5) no particular method was used.

Further, there are multiple data sources for impacts identification which originates from rational comprehensive tradition, such as: checklist, matrixes, maps and computing. However, also difficulties here exist, it is noticed that even the most complex techniques cannot predict all the environmental potential effects. Therefore, external values should be included, as risks value and system boundaries which are subjective (Snell & Cowell, 2006). Indeed, the scoping process can therefore be not seen as objective, as already mentioned by Wood et al. (2006).

It is noted that scoping plays a vital role in examining the extent of the environmental information in an Environmental Impact Statement (EIS) (EIS is final report of an EIA). However, scoping is mentioned as a common weakness within the EIA because of the poorly understood theoretical and pragmatic application of this and an remains an under-researched component of the EIA (Wood et al., 2006). Also Snell & Cowell (2006) mention that the scoping process is under-research part of the EIA and therefore falls behind its conceptual ideals (Snell & Cowell, 2006).

To continue on the weaknesses, the scoping process in practice fails to focus and narrow down and focus on the pivotal aspects in a EIA project, this results in an inefficient and widely EIS (Hansen & Wood, 2016). Besides of this this, Wood et al. (2006) found that inexperienced practitioners faced difficulties with scoping, also the results of Runhaar, van Laerhoven, Driessen, & Arts (2013) showed that inexperienced parties/authorities faced difficulties and criticised the broad EIA scope, which could lead to inconsistent environmental reports (e.g. ES) with an broad scope. As a matter of fact, in most cases the scoping process is conducted as it meets the need of a project (Snell & Cowell, 2006). As Morgan (2012) notes: “EIA practitioners should also be more aware of, and sensitive to, the inherent power relations found in rationalist decision-making processes that can hinder effective participation and exacerbate environmental injustice” (Morgan, 2012, p. 8). As also mentioned by Hansen & Wood (2016), that inaccurate scoping of an EIA can lead to non-satisfying results, such as excessive spending on minor impacts which could lead on its turn to an broad EIS. Consequently, a voluminous EIS will thus be created where several types of impacts are included and therefore lose the pragmatic point of view (Hansen & Wood, 2016). Such issues for scoping are unwanted and will decrease the accuracy of the EIA.

The purpose, methodologies and weaknesses of the scoping process are discussed. As mentioned should scoping narrow down and estimate the potential impacts due to a project. However, voluminous and therefore inaccurate EIA could occur due to inexperienced practitioners. In order to prevent such problems, the next paragraph is drafted. Paragraph 3.3 will ‘screen and scope’ the potential environmental impacts regarding urban planning.

## 3.3 Environmental Impacts in Urban Development -and Planning

This paragraph will discuss the potential environmental impacts due to urban development projects. In paragraph 4.3, experts will note concerns related to high rise building projects. Therefore first, an introduction will be given to urban development and environment impacts. Potential criteria will be enlisted including journal articles. This relates to the previous discussed screening process, this will be done in subparagraph 3.3.1. Relating to the previous mentioned scoping process the enlisted potential impact criteria will be ‘filtered’ and will be done in subparagraph 3.3.2. Anyway, urban planning involves among other things urban transitions and involves other development projects. It is self-evident that such developments have impact on the environment. However, where do such impacts come from and which criteria are urgent in urban development projects? The EIA is not an common used assessment tool for urban development projects, only as listed for zone planning or infrastructural projects (Hobma & Jong, 2016; Snell & Cowell, 2006). Besides, it is mentioned that specific criteria or impacts are missing for urban planning and other disciplines. Even more, specific impacts for high rise buildings are relatively rare and thus impact criteria from the EIA and SIA obtained in journal articles related to urban planning will be used, and after reviewed by experts.

In urbanised countries and areas, transformation from natural and open land to urban land causes one of the major environmental impacts. Considering urban rural areas, such land consumption come along with dispersed developments, mono-functional and low-density land uses and high private car ownership this displays typical features of veritable urban sprawl. However, land consumption is not the only problem, since it is contradicting with a normative ideal of spatial planning. It also is known that land consumption affects the environment in different ways. For instance, it reduces the nature to adapt to human requirements and is thus hazardous for the ecosystem in several ways.

Such hazard to ecosystems could occur in the way that individual ecosystem services (affected by land use transition) include e.g. production of food, regulation of energy and matter flows, water supply, supply of recreational space, biodiversity or natural aesthetic values. The assessment of impact due to land use transitions (e.g. construction of high rise buildings within a city centre area) and land consumption is an urgent task for landscape research in major (Nuissl, Haase, Lanzendorf, & Wittmer, 2009).

Environmental impact assessment (EIA) is a widely applied tool to promote among other things sustainable development, however its' effectiveness is increasingly doubtful (Loomis & Dziedzic, 2018). This is because the EIA shows some missing elements (e.g. social impacts) which is necessarily within the increasing complexity of the urban environment (Morgan, 2012). Besides, it is observed that cumulative effects are more or less ignored, while such impacts are addressing issues within a longer time frame and thus also affect sustainability. Scientists and policymakers increasingly realises that measures towards adaption becoming more important for addressing the impacts due to climate change, this has effect on biophysical and human environment.

Urbanisation and external factors such as climate change globally affects the human settlement, however, it is expected that impacts due to climate change are more severe in urban environments. This can be explained by the fact that most of the people are living within cities and urbanisation rate is only increasing. (Sharifi & Yamagata, 2014). The EIA was initially not created in order to assess, consider and include above mentioned issues within the urban context. It is likely to assume that the extension of the EIA could therefore be adapted. For instance, an integrated criteria framework (EIA & SIA) could help decision makers and planners to investigate which areas need adaption and improvement. It is noted that there is a broad consensus in that a urban and city environment is dynamic and can therefore not only be identified as an ecological system, but also relies on social impacts. (Sharifi & Yamagata, 2014).

The EIA is an assessment tool which support or enhance sustainable development. Further, is the effectiveness of the EIA doubtful because of its wide applicability, such as missing elements for specific sectors. Consequently, such urban transitions causes seriously environmental impacts. Due to urban transitions nature cannot adapt to human needs, further, affected ecosystems also have a negative consequences for e.g. water regulations, drainage etc. This all affects the (human)environment, total ecosystems and finally the liveability.

### 3.3.1. Environmental Impact Criteria

This subparagraph will provide the basis for an integrated impact criteria framework regarding the EIA part. The approach of this subparagraph can be related to the earlier mentioned 'screening process', in this subparagraph the potential environment impact criteria are enlisted. It mention the involved environmental criteria of several different studies. On its turn, the mentioned impact criteria in the journal articles will be used to construct an integrated criteria framework in this report. The journal articles are searched by keywords, terms and phrases such as: environmental impacts, urban impacts, urban environmental impacts or other related combinations, also keyword synonyms are used. Further, the articles are screened and judged to determine if these articles 'fit' within the purpose of this report. After this search strategy, thirteen journal articles were included within this research.

In order to maintain a clear and structured overview, the considered journal articles will not thoroughly discussed or analysed. Only the purpose and intention of two studies will be noticed. Several criteria from different perspectives should be involved in order to obtain a full range. The filtering (in EIA terms; scoping) of the criteria in subparagraph 3.3.2. will narrow down the involved criteria. The filtering or scoping process of the criteria is performed by means of most common mentioned and overlapping impact criteria. By involving 13 journal articles and further filtering the obtained environmental impact criteria, screening and scoping is applied.

It should be mentioned that this research does not rely on a full screening and scoping process, but as it is recommended in the literature study: external sources of literature should be involved in order to construct a well-defined impact criteria overview.

Later on in paragraph 4.3, experts will review the included impact criteria. In a later stadium of this research, the integrated impact criteria framework will be used in order to calculate the compatibility value of the high rise building in the case area. In fact, the compatibility between particular land use functions and the high rise will be estimated for each impact criteria. In order to predict an average compatibility value several impact criteria should be included.

This subparagraph reports on the environmental impact criteria for development for an integrated framework for assessment for urban transition projects relating to high rise buildings. A literature study is conducted in order to identify environmental impact criteria and indicators which are related to urban planning. Literature from various perspectives and types of disciplines are included and reviewed. However, in basis all the journal articles tend to indicate environmental urban impacts and specific impacts due to high rise building is relatively scarce. Further, these impacts should be categorised into 'main impact criteria' and 'specified criteria' since the journal articles include different types of related and similar impact criteria (e.g. water quality, water demand, and this means that the main impact criteria will be Water).

As mentioned a total number of 13 journal articles were analysed for the purpose of acquiring environmental impact criteria within the discipline of urban planning. All included journal articles are literature studies which construct an impact criteria list for the purpose of urban planning, for instance the study of Sharifi & Yamagata (2014) acquired 332 publications.

The thirteen screened studies will construct the environmental impact criteria framework. This can be seen in table 3. The wide application of potential environmental impacts can be presented. In fact two examples can be presented by Burinskien et al. (2017) and Nuissl et al. (2009), in order to show the wide application of environmental impact criteria. A recent study of Burinskien, Bielinskas, Podviezko, Gurskiene, & Maliene (2017) presented the findings of a case study of redevelopment of brownfield in the city of Vilnius. Brownfield development is perceived as a complex task which involves aspects of different economic, social, physical and environmental factors. The strategic decision-making has a long term impact on the quality of life, ecological balance and urban structure (Burinskien et al., 2017). However, after multi-criteria analyses a few criteria remain which are: soil contamination, heavy industry pollution, green areas, transport pollution, magnitude of new constructions. Another study of Nuissl et al. (2009) a study was performed on the environmental impact assessment of urban land use transitions for residential purposes. Land consumption and urban land use transition are linked and bring some environmental pressures concerning economic growth and transportation particular in urbanised areas. However, such approach must extent information regard the functionality of soils, water balance or habitat quality at specific locations (Nuissl et al., 2009). In this study the following impact criteria are included: impact of groundwater recharge due to surface run-off, evaporation, filter capacity, soil organisms, biodiversity, habitat integrity, loss of arable land, traffic (increase).

As can be seen above, different environmental impact criteria are mentioned and noticed by two different studies, while both are related to urban planning -and transitions. This depends on the focus on the research. The study of Burinskien et al. (2017) considers the redevelopment of brownfield decision making and therefore involves relatively main impact criteria. The study of Nuissl et al. (2009) performed an EIA on urban transitions for residential purposes, here more specific impact criteria are used. By giving only these two examples a relative but a broad set of environmental impact criteria can be noticed. The thirteen included articles show similarities of environmental impacts in urban planning.

By applying the search strategy and further screening of the articles a wide range, but relatable journal articles are included to construct this environmental impact criteria framework. Therefore, by including thirteen relatable journal articles a well-developed framework can be presented. After considered 13 journal articles the following table (table 3) can be presented.

*Table 3. Categorised and inventoried Environmental impact criteria*

| Main Impact Criteria | Specified impact criteria |
|---|---|
| Ecology | Biodiversity, restoration of hydrologic flows, conservation of ecologically vulnerable areas, proximity of different habitats, erosion rates, total maximum daily load, flora and fauna, pollution, microclimate, endangered species, biodiversity, habitat integrity, wildlife and vegetation, effects on biodiversity, loss of arable land, habitat destruction, storm water/erosion, pollution |
| Landscape/Visual | Building layout and orientation, magnitude of new constructions, area conditions, attractiveness, use of green, preservation of green areas, green zones, nature conservation area, view opportunities, landmarks, land occupancy, landscape alteration, visual disturbance, urbanisation, increase in population, urban form (compact, dispersed, poly-centric), density of buildings, independent infrastructure, urban size, elevation, mixed-use development, variability and spatial heterogeneity, avoiding flood plains, |
| Soil | soil contamination, filter capacity, soil organisms, soil erosion, soil preservation, land surface temperature |
| Water | Permeable pavement and bioswales, urban tree canopy, water demand and consumption, water efficient landscaping, protection of water-sensitive lands (wetlands, etc.), water demand and conservation systems, water quantity and quality monitoring, high-efficiency irrigation, water use, impact of groundwater recharge due to surface run-off, water consumption, sewage treatment rate, recycled water utilisation rate, transboundary water meeting required standards, water quality, releases to water (Execution foundations and retaining walls, Cleaning process of machinery and tools, Sanitary water), Water pollution, water resources |
| Energy | Energy demand and consumption, flexibility of grid, urban energy supply systems for increasing shares of renewable energy, reduce end use energy demand, energy monitoring, energy use, energy (Energy consumption, Power consumption, Increase in temperature, Resource use of building materials, Energy wastage) |
| Infrastructure | Street connectivity, pedestrian route connectivity, walking trails that link with public transportation routes, accessible connection to evacuation routes, placing interdependent infrastructure close to each other, infrastructure redundancy, infrastructural provision and quality |
| Transport | High frequency schedule public transportation, principle arterial miles per square mile, vehicle ownership, transport pollution, public transport, traffic (increase), transport issues, traffic/transport |
| Air Quality | air, heavy industry pollution, emission SO2, intensity of COD, air quality, Greenhouse gas emissions, Odour, Dust, Greenhouse effect, Air pollution |
| Noise | noise hinder, noise and vibrations, noise from construction operation, noise from people, noise due increase traffic, etc. |
| Pollution | transport pollution, waste recycling, household garbage disposal rate, waste recycling rate, waste generation (Inert waste, non-special waste, special waste), waste disposal, water pollution, air pollution, pollution matters, waste Management |

Considering the journal articles several different impact criteria are involved during urban planning. Consequently, these impacts are caused by construction projects by means of urban planning. Problems and impacts are become more severe due to urbanisation issues. However, little research is conducted to environmental impacts specifically on high rise buildings. Therefore, the selected impacts (see chapter 4.3) will be judged by experts be related more to high rise building (energy use, waste management) than mainstream urban planning. By providing table 3, potential involved environmental criteria are structured and to give an overview of the considered journal articles.

### 3.3.2. Filtering and Select Environmental criteria in Urban Planning

In the previous subparagraph environmental impact criteria were obtained from 13 different journal articles related to construction projects, urban planning and urbanisation and enlisted as in table 3. However, not all environmental impact criteria can be included within this study. It is mentioned in paragraph 3.2 that scoping and a critical review should limit the involved impact criteria. A wide approach is therefore unwanted and leads to inaccuracy. A frequency table is created which shows how common environmental impact topics of different studies regarding urban planning are mentioned, this is presented in table 4. The most common mentioned impact criteria will probably remain.

*Table 4. Frequency table Main Environmental Impact Criteria*

| Main Impact Criteria | Sharifi & Yamagata (2014) | Canter & Canty (1993) | Burinskien et al. (2017) | Berardi (2013) | Nuissl et al. (2009) | Che et al. (2011) | Cavallin et al. (1994) | Gangolells et al. (2009) | Ijigah et al. (2013) | Wood et al. (2006) | Abu Bakar & Cheen (2013) | Singh (2014) | Dutch m.e.r. | Frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ecology | X | X | | | X | | X | X | X | X | X | | X | 9 |
| Landscape/Visual | X | | X | X | X | X | X | X | X | X | | X | X | 11 |
| Soil | | X | X | | X | | | | X | X | X | X | X | 8 |
| Water | X | X | | X | X | X | X | X | X | X | X | | X | 11 |
| Energy | X | | | X | | | | | X | | X | | X | 5 |
| Infrastructure | X | | | X | | | | | | | | | | 2 |
| Transport | X | | X | X | X | X | | X | | X | | | | 7 |
| Air Quality | | X | | | | X | X | X | X | X | X | | | 7 |
| Noise | | | | | | | X | X | | X | | | X | 4 |
| Pollution | | X | X | X | | X | | X | X | | X | | X | 8 |

As can be seen in table 4, several impact criteria are less mentioned in the researches. However, some criteria can be placed within other major criteria and/or are strongly related. For instance, infrastructure can be distributed within landscaping purposes, also transport and infrastructure are closely related. Therefore, some criteria are thus divided, e.g. the Dutch m.e.r. is counting soil and water as one criteria. However, for the increasing complexity of cities it could be necessary to divide such major criteria. Table 4 indicates 'how common' main impact criteria regarding construction projects, urban planning and urbanisation are mentioned within the 13 journals articles.

The 'less mentioned' criteria are, infrastructure, energy and noise. However, it could be mentioned that infrastructure is less mentioned since this also could be assigned to transport. The impact criteria 'noise' and 'energy' are relatively less mentioned. However, it depends on the focus of each journal article which environmental impact criteria is included. Apparently according to the literature 'noise', but also 'energy' are thus less urgent. Taken this into account, the following main environmental impact criteria will probably be excluded in the scope of this report: energy, infrastructure, noise. However, the exclusion of these criteria is not final, since experts will also review this list.

The common mentioned impact criteria are relatable to the 'environment'. These impact criteria are tangible and can be considered as objective, contrary to noise and energy. By considering these aspects it is imaginable that criteria such as: air quality, water, soil, etc. could be more mentioned within the journal articles. Considering table 4, the following impact criteria are frequently mentioned: landscape/visual, water, ecology, soil, pollution, air quality and transport. Also here, experts will judge these impact criteria.

Considering the 'common' mentioned impact criteria The following criteria for now can be summed up as follows, ranked by importance (common mentioned):

1. Landscape/Visual
2. Water
3. Ecology
4. Soil
5. Pollution
6. Air quality
7. Transport

It should be said that, Landscape/Visual and Water; Soil and Pollution; Air quality and Transport are equally ranked, this can be seen by the frequency in table 4. The proposed criteria will also be judged by experts within the urban environment and planning. This is also recommended by Canter & Canty (1993), since such aspects are more or less subjective. The impact criteria could also differ after judgment of experts which considering high rise building projects. Thus, this list of impact criteria is not definitive, but will be finalised and discussed in paragraph 4.3. This list is final and will be used for the compatibility matrixes. Here, each expert will judge the 'compatibility' between several land use functions regarding each impact criteria.

## 3.4 EIA Missing Social Elements

Relating to the scope of this report, the inclusion of socio-(economic) impacts within the EIA need to be discussed. Currently these aspects are more or less ignored performing an EIA. However, inclusion of social impacts will increase inaccuracy of an EIA. None the less, practice shows that much of the planning authorities, decision makers and also consultancies are dealing to construct a well performed screening and scoping process and thus an efficient EIA. Training and inexperience are mostly the causes for such incomplete EIA and EIS. It is thus discussable if socio-(economic) elements or impacts should be included, considering above mentioned. Since urban environments are becoming more complex, it is discussed by Wood (2006) that inclusion of social impacts will likely to result in improved predictions.

It is evident that social and economic impacts are closely related, mostly in complex ways. Primary economic impacts will trigger several social issues. For instance the generation of employment is of big importance, since this trigger several socio-economic effects, such as: mitigation to a certain area; changes in population; pressure on community facilities; changes in community and cohesion. However, also socio-economic and biophysical impacts are related. Several socio-economic aspects are caused by biophysical impacts of a particular project. For example: noise, air or water pollution (or perception of the risk of such pollution) might result in reductions in property prices or in the development potential of the area, or economic effects on adjacent commercial activities, such as reduced revenue for tourism operators or commercial fisheries (Chadwick, 2002).

By including socio-economic aspects within an EIA is beneficial, since it provides an opportunity to adjust the project design at early stage in order to minimize the adverse socio-economic effects and to maximize beneficial effects. Additionally, potential environment consequences of socio-economic effects in early project planning, which results that mitigation measures can be implemented more accurately (Chadwick, 2002). Furthermore, deeper nested problems (cumulative impacts) are not explained by the involvement of only environmental impacts (Alshuwaikhat, 2005).

A real solution is still lacking, however researchers agree that current wide applied and pragmatic assessment systems are lacking in order to provide full and 'well' measurement of possible environmental and social impacts. The EIA need also develop new models which include social, cultural, political and economic perspectives (Morgan, 2012).

Considering the social gap, current issues (lack of experience, underestimation, inaccurate predictions) and that the pragmatic application of the EIA is beneficial, solutions for an integrated assessment system is likely to be a future concept.

## 3.5 EIA Conclusion

Initially, the EIA is drafted from the NEPA 1969 and is since then further developed and adjusted, the EIA became an 'assessment tool'. Besides of this, the assessment tool later contributed to sustainable development of several different project types. The sustainability can be explained by the fact that such assessment judge the environmental impact and mitigates and reduces the consequences of it for a long-term period. Among other things, the assessment thus contributes to a well-developed long-term living environment.

In order to investigate the potential environmental impacts, screening and scoping plays an important role. Such activities determine if the possible impacts are above or under the limit of a threshold or standard. Such thresholds and standards are existing to reduce and mitigate the exceeding impact. Besides, it is mentioned that screening and scoping are often an underestimated process, but yet becomes more important due to increasing complexity of projects, urban developments and the human environment. The difficulties related to the screening and scoping process relies on several aspects: 1) unexperienced practitioners; 2) inadequate screening process; 3) too broad scoping; 4) limited involvement of external knowledge; 5) implied screening criteria from directives and guidelines are too limited. This all leads to an inefficient and over extended EIA, which thus fails to investigate the critical environmental impacts. On its turn, this could lead to area development where the environmental impact remains bigger, or mitigation/reducing impacts is even missing. Consequently, humans and also flora/fauna are thus affected by this failing assessments. In order to screen and scope an EIA, impact criteria should be involved.

Each EIA is project related and thus involves different impact criteria. However, in this report 13 journal articles are considered to determine the environmental impact criteria relating to the urban environment -and planning. The criteria can be divided into main impact criteria and specified criteria. In this case the following criteria were identified: 1) ecology; 2) landscape/visual; 3) soil; 4) water; 5) energy; 6) infrastructure; 7) transport; 8) air quality; 9) noise and 10) pollution. After, a frequency table is constructed where the criteria are counted and thus can be filtered after, it is evident that several criteria will be deleted. The following remaining impact criteria can be listed as: 1) landscape/visual; 2) water; 3) ecology; 4) soil; 5) pollution; 6) air quality and 7) transport.

To look back, the EIA is constantly developing and improving. However, it is discussed that the EIA is lacking in involvement of social impact criteria or even social considerations. In a study of Wood et al. (2006) it came forward that social aspects were even neglected within the scope of criteria within the EIA. When including socio-economic impact criteria within the EIA, early opportunities to modify the project design exist in order to minimize the related socio-economic impacts. Again, this means that an integrated impact assessment could stimulate sustainable development and therefore social sustainability should not be ignored.

## 3.6 Social Impact Assessment

Initially the SIA originates from the EIA which is developed in the early 1970s, in response to the earlier developed requirements of the NEPA 1969. The SIA is formalised in legal requirements as a part of project planning and is related to the legislation originates from the NEPA. (Esteves, Franks, & Vanclay, 2012). In order to address the social aspects as a part of sustainable development, the SIA evolved as a part of the EIA which is used to define, estimate and mitigate the effects of the planned interventions. However, only the definitions of the SIA, screening and scoping of this assessment systems is discussed. This report do calculate and indicate the potential impacts, which are encountered within the screening and scoping. Therefore, this report does not perform a full SIA.

Since then the SIAs developed into a separate disciple as part of the 'impact assessment field', the SIA is capable of providing methods to integrate human and social ecosystems as support for decision making (Arce-Gomez et al., 2015). However, the impacts caused by projects, programmes, plans and policies on the social quality of communities also became top of concern during the development of the SIA. This explains why the development and practice of the SIA increased in the past years.

The SIA is increasingly used among different countries, also in different continents, such as: Finland, Iran, Bangladesh, which reflects on the importance of the SIA as a key element in planning procedures. Such developments have led to a range of methods to conduct a SIA. This allows that several unique aspects are introduced which satisfy the needs on community and individual level. (Arce-Gomez et al., 2015).As Sairinen (2004) mention: "SIA can be defined as a systematic effort to identify and analyse social impacts of a proposed project or plan on the individual, on social groups within a community, or on an entire community in advance of the decision making process. Social impacts of urban plans refer to various factors such as quality of housing, local services and living environment, gentrification or segregation, conditions of transportation etc." (Sairinen, 2004, p. 423).

The SIA has developed its practical and theoretical application over time, it is recognised that the SIA should be assigned as a non-prescriptive process that embraces flexibility during its practical application. However, not only the importance of flexibility remains important to provide guidance on appropriate approaches to be adopted by practitioners, also the development, codification and associated procedures should not be neglected. It is mentioned that the inclusion of the community and public participation within a SIA is still a lacking aspect (Arce-Gomez et al., 2015).

### 3.6.1 SIA Definitions and Dimensions

The Interorganizational Committee on Guidelines and Principles (ICGP) developed in 1995 a first attempt for a framework for the SIA procedures. The study of (Arce-Gomez, Donovan, & Bedggood, 2015) further elaborates on the SIA framework. The procedure is characterised by a technical approach, this means that it based upon findings, studies and expertise of social scientists in order to determine the assessment of the social impacts which are caused by different measures. However, the research mention that participatory techniques leads to a better estimation of the impacts in the SIA and will increase the predictive capacity of the decision makers (Arce-Gomez et al., 2015) therefore a consolidating SIA framework is drafted which can be seen in figure 3.

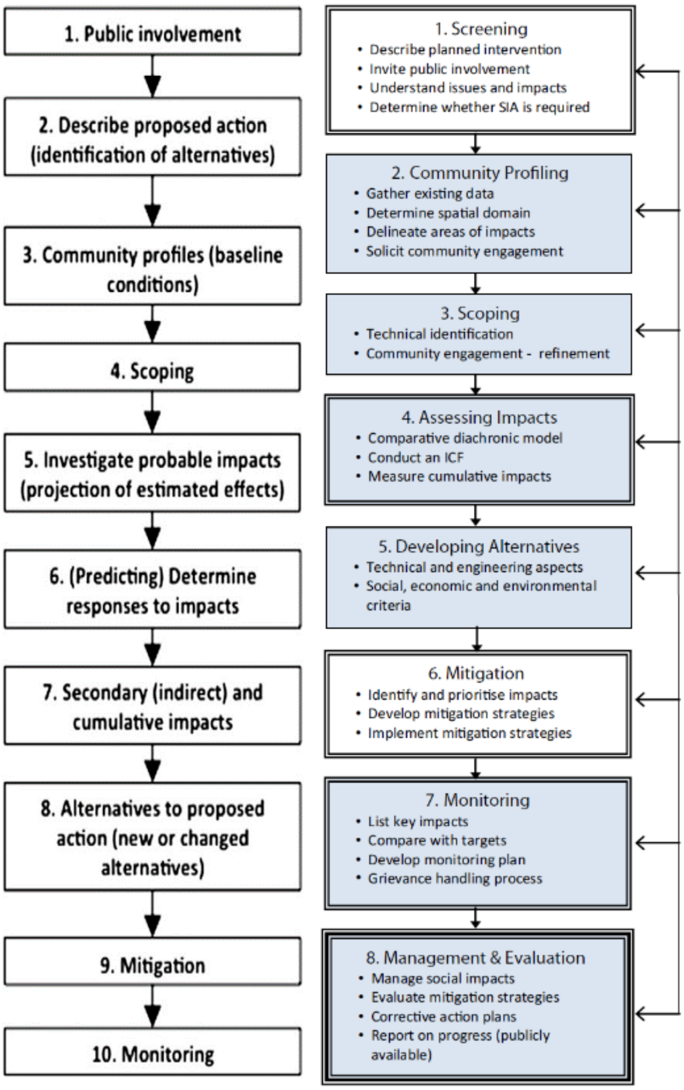



*Figure 3. ICGP SIA framework vs. improved Consolidated SIA framework (Source: Arce-Gomez et al., 2015, pp. 87-88)*

The consolidated framework in figure 3 will be shortly discussed and explained. The framework as in figure 3, can be seen as a full SIA. Step 1 ‘screening’, where the planned intervention should be described, rather than only involvement of stakeholders and possible impacts should be described. Step 2 ‘community profiling’, investigate where the impacts do encounter the community. Step 3 ‘scoping’, involves the identification of the breath of potential social impacts along with the planned interventions. Step 4 ‘assessing impacts’, this requires the assessment of each separate impact in order to understand the effects this could have on the community. Step 5 ‘developing alternatives’, explore alternative ways in order to carry out the interventions and avoiding any unavoidable impacts. Step 6 ‘mitigation’, this involves the minimisation of any negative impacts. Step 7 ‘monitoring’, designing a system to keep track of the impacts. Step 8 ‘management and evaluation’, this involves the planning of interventions and evaluation of the effectiveness of the SIA process implemented (Arce-Gomez et al., 2015).

However, keeping in mind the above described process: social practitioners have insufficient influence compared to the EIA. For instance Esteves et al. (2012) mention: “in shaping project/development alternatives, and, despite the increase in social roles within many organizations, the project managers who are responsible for commissioning and delivering impact assessments often have little social experience. The limited capacity of regulators and the limited resources devoted to quality control have a significant impact on the standard of SIAs, with a tendency for proponents to produce assessments that only just pass the minimum expectations of regulators” (Esteves et al., 2012, p. 36).

Considering the insufficient influence of social practitioners within a certain project it could affect the quality of the SIA. However, it is mentioned that there is a greater recognition of the inclusion of the SIA. It is plausible to assume that this underlines the importance of inclusion of such SIA and embraces the influence of social practitioners.

### 3.6.2 SIA Screening

The screening approach of the SIA is comparable to the EIA, where also the major project plan and related possible issues are investigated. Some of these steps should be described shortly, as also presented in figure 4 (ICGP step 1-3, Consolidated framework Step 1).

The social impact assessment itself should contain the ten steps outlined in figure 4. These steps are logically sequential, but often overlap in practice. The diagram aligned by the red sign as presented in figure 4, visualises the ‘screening process’ of the SIA. This phase can also be mentioned as the initial phase in an social impact assessment, where the first extensions and likely impacts of scenarios are indicated (Becker, 2001).

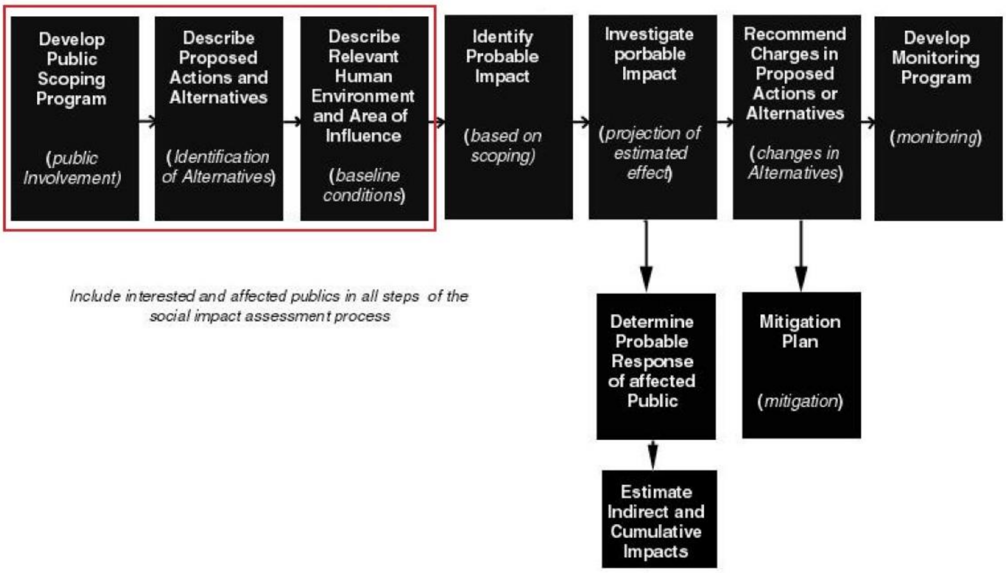



*Figure 4. Screening process in the SIA - adjusted by author (Source: The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994)*

Firstly, the process starts with the involvement of the public (figure 4). This means that the possible affected stakeholders should be identified at the first beginning of a project. Such direct stakeholders are groups who are affected by impacts such as: noise, smell, relocation due to project and also interested into the project. Further, also other type of stakeholders could be affected, those who might normally use land on where the project will be located, for instance agricultural activities. Besides of this, also economic consequences could affect several groups. (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994).

The second step within the screening process of the SIA is the identification of alternatives. In some cases the description of the proposed alternatives is lacking information, which is required for a SIA. Also the provision of summary numbers is a problem, while disaggregated numbers are needed (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994). The third step is are determining the baseline conditions.

This can be described as the combination of existing conditions and past trends which are associated with the human environment where the intervention is planned. This is called the baseline study. Looking at construction projects, area is identified along with several risks for special populations. However, for programs and policies, the human environment can be a collection of multiple affected stakeholders (e.g. publics, interested groups, organisations, institutions) which is more dispersed. A set of different dimensions is listed in order to investigate the impacts of the human environment due to construction projects and geographically-located programs and policies. The following principles are investigated by the ICGP (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994, p. 16):

- Relationships with the biophysical environment, including ecological setting;
- Historical background, including initial settlement and subsequent shifts in population;
- Political and social resources, friendship networks and patterns of cleavage or cooperation among potentially affected groups;
- Culture, attitudes and social-psychological conditions, including attitudes toward the proposed action;
- Population characteristics including the demo-graphics of relevant groups (including all significant stakeholders and sensitive populations and groups);

To identify such baseline conditions different sources of information could be encountered, for instance: existing literature on comparable interventions or projects, inclusion of experts, and readily available documents such as government reports should be consulted at minimum (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994).

To conclude the screening process of the SIA can be compared to the screening process of the EIA. It indeed show similarities between such assessment systems. Both screening processes are indicating the potential impacts. After, both assessment systems will initiate the scoping process to narrow down the involved impacts. Screening will be applied by constructing a framework based on several journal articles, later scoping will be performed in order to further narrow down the included impact criteria.

### 3.6.3 SIA Scoping

Once, the screening process is finalised the scoping process starts and involves a more detailed overview of the possible impacts as a consequence of human interactions within a certain area (major effects are thus studied in the screening). In fact it can be compared to scoping processes in the EIA and show relatable basic principles (see subparagraph 3.2.3.). However, such impacts need to be considered into depth and provide an improved prediction of the possible social impacts in a particular area. Therefore, the following actions and steps in the process should be considered, as the red sign indicates as can be seen in figure 5. This process is part of the main phase in a social impact assessment project, in fact the extension and dimension of the project are defined (Becker, 2001).

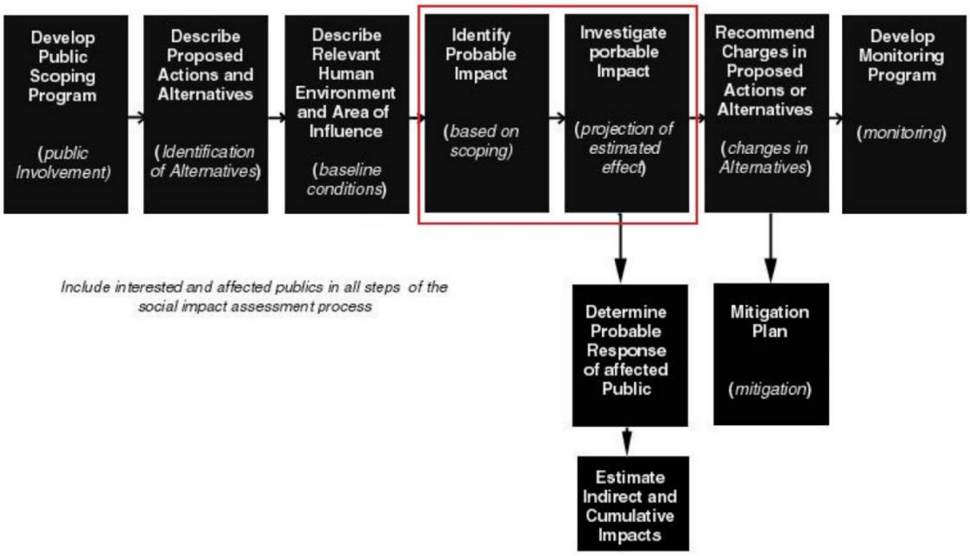



*Figure 5. Scoping process in the SIA - adjusted by author (Source: The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994)*

After the screening the initial scoping will be performed. Scoping considerations need to be assessed by agencies and affected groups and communities. The methods used by experts are as follows and reviews of existing documentation such as: social science literature, public scoping, public surveys, and public participation techniques. Besides, the concerns of the affected stakeholders have to be taken into account. (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994).

The likely social impacts should be formulated and considering the following: predicted conditions without the actions (baseline projection); predicted conditions with the actions; and predicted impacts. Consequently, this can be interpreted as the differences between the future without and with the proposed intervention. For further investigation the five following data sources should be included (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994): (1) Data from project proponents; (2) Records of previous experience with similar actions as represented in reference literature as well as other EIS's; (3) Census and vital statistics; (4) Documents and secondary sources; (4) Field research, including informant interviews, hearings, group meeting, and surveys of the general population (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994).

By involving such methodologies and information sources several criteria come forward, as will be enlisted below. The relevant criteria for including significant impacts are summed up in the CEQ Regulations which involve (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994):

- Probability of the event occurring;
- Number of people including native communities that will be affected;
- Duration (long-term and short-term) of impacts;
- Value of costs and benefits (intensity of impacts) to impacted stakeholders;
- Extent that the impact is reversible or can be mitigated;
- Likelihood and chances of impacts;
- Relevance of existing and future decisions towards policies;
- Uncertainty and risks of possible impacts;
- Presence or absence of dispute over the issue.

Recording the previous mentioned methodologies, information sources and obtained experiences is an important aspect in order to better predict the future impacts. By obtaining potential social impacts, another important aspect plays a role, namely cumulative impacts (indirect impacts) and should be estimated considering a long term period. Cumulative impacts (also in EIA) give a better understanding of the long term consequences of human interactions within a specific area or scope. (The Interorganizational Committee Guidelines and Principles for Assessment Social Impact, 1994).

Hence, the scoping process in the SIA can be compared to the scoping process as described in the EIA. The obtained potential effects are different since the focus lies on the social impacts. It could be argued that the cumulative effects of social interventions in this assessment system compared to the EIA play a bigger part since complex social relations between biophysical and human environment exist. After screened impact in subparagraph 3.7.1 and further scoping a few social impact criteria will remain. Scoping will be used in this project (subparagraph 3.7.2.) to narrow down the involved impact criteria.

## 3.7 Social Impacts in Urban Development and Planning

Cities can be described as 'open systems which have impact on several areas as well on the earth'. Urban growth rests on a trade-offs being made between agglomeration economies and diseconomies (e.g. dense population and environmental decay). It is plausible the environmental quality decreases and become more severe as the urban size increases. However, other factors such as: land use, transport, spatial layout of the urban area are also crucial factors in order to determine the 'urban environmental carrying capacity' (Munda, 2006). Specifically, to give another example also social impacts such as: health, quality of life and well-being of people can be affected due to urban transitions and urban construction projects. Health and land use planning are historically linked. Modern planning of cities was developed in the nineteenth century specifically to encounter the unhealthy living conditions such as: unsanitary, over-crowded and inhumane conditions of the fast growing industrial cities. The problems are interrelated and have many other indirect effects, not only direct physical impacts on health (e.g. poor air quality, water shortage), also behavioural and social effects (e.g. exercise, social cohesion, inequality in housing access, employment, health services, other facilities). (Munda, 2006).

As known, social impacts occur due to human interventions. Considering urban environments, high rise buildings or other urban transition projects especially in dense areas cause several different direct and indirect impacts (cumulative effects). Several benefits on a technical aspect come forward when an SIA is involved during a project, for instance as mentioned by Esteves et al. (2012): "greater certainty for project investments and increased chance of project success; avoidance and reduction of social and environmental risks and conflicts faced by industry and communities; improved ability to identify issues early on, and therefore to reduce costs and to incorporate unavoidable costs into feasibility assessments and project planning" (Esteves et al., 2012, p. 36). Therefore, the SIA is increasingly used compared to earlier decades, however, development is needed and also specification matters. Such inclusion and combination with EIA are extremely helpful for assess increasingly complex urban developments. (Arce-Gomez et al., 2015).

Also some non-technical benefits could be observed, such consideration of social impacts related to environmental can (Barton, 2009) for instance: (1) decrease the inequalities that could occur in access to housing; (2) increase the amount of physical activity to improve health conditions; (3) contribution of improved health of the population by reducing air and water pollution and greenhouse emissions; (4) contribution to changing social environment by improving the liveability of neighbourhoods. Therefore, social consistency within urban planning has been recognised as a precondition to increase the liveability of a city (R Sairinen, 2004).

### 3.7.1 Criteria Social Impacts

This subparagraph will provide the basis for an integrated impact criteria framework regarding the social part. Several studies regarding social impact assessment and social impact criteria within the urban environment will be involved. By using the same search strategy as for the environmental impacts, here also thirteen journal articles were included. The journal articles are searched by keywords, terms and phrases such as: environmental impacts, urban impacts, urban environmental impacts or other related combinations, also keyword synonyms are used. Further, the articles are screened and judged to determine if these articles 'fit' within the purpose of this report. A numerous amount of journal articles were initially found, but after screening thirteen remained. On its turn, the mentioned social impact criteria will be used to construct an integrated criteria framework for the purpose of this report.

The included journal articles will not thoroughly discussed or analysed, only the purpose and intention of the study will be noticed, in order to maintain a clear and structured overview. Further, discussing all the articles, would be too extensive and time consuming. In fact, two studies will be mentioned and compared. After, the involved impact criteria will be selected and filtered (subparagraph 3.7.2) by means of most common and mentioned social impact criteria by the journal articles. To relate to the assessment terminology, in fact screening will be applied in this subparagraph (3.7.1) and scoping in subparagraph 3.7.2. of such social impact criteria.

However, it should be mentioned that this research does not rely on a full screening and scoping process, but as it is recommended in the literature study: external sources of literature should be involved in order to construct a well-defined impact criteria overview. This subparagraph aggregates the social impact criteria for the purpose of developing an integrated impact criteria framework for assessing urban (transition) projects regarding high rise buildings. Later on in paragraph 4.3, experts will review the included impact criterium. Besides, in paragraph 4.3 the final environmental social impact criteria framework will be presented. As mentioned in subparagraphs 3.3.1. and 3.3.2., the compatibility of the high rise building will be determined by using the impact criteria framework.

A literature study is conducted in order to identify the potential social impact criteria and indicators which are related to urban planning. Literature from various perspectives and types of disciplines are included and shortly discussed. The same search strategy is applied as in the environmental criteria impacts in subparagraph 3.3.1. This means that keywords and phrases are used, but also synonyms are involved. Several journal articles appeared in the search list, after screening the articles only a few journal articles remained which discuss social impacts in urban planning and thus fit the purpose of this research. Further, these impacts should be categorised into 'main impact criteria' and 'specified criteria' since the journal articles include different types of related impact criteria (e.g. access to housing, gentrification → main impact criteria will be housing). A total number of 13 journal articles were analysed for the purpose of acquiring social impact criteria within the discipline of urban planning. All included journal articles are literature studies which construct an impact criteria list for the purpose of urban planning, for instance the study of Barton (2009) discussed health and well-being related to land-use planning.

In order to have a full 'scope' and 'range' of environmental impact criteria for the discipline of urban planning, 13 studies will included within an environmental impact criteria framework. The thirteen journal articles are found by conducting the search strategy as earlier described.

The wide application of potential environmental impacts can be presented. In fact two examples can be presented by Haapio (2012) and Barton (2009). In the study of Haapio (2012) indicators towards sustainable urban communities are investigated. Assessment tools of buildings became more complex, more requirements are demanded and assessing of buildings is not enough. Therefore, neighbourhoods, built environment, public transportations, and services, should be considered simultaneously. The amount of people living in urban areas is relatively high and expected to be increasing. This urbanisation matters are concerning since the effects on the environment (Haapio, 2012). The following criteria were identified: accessibility, affordable housing, transport (public transport, pedestrian, bicycle ways), resources and energy, business economy and employment (employment, new business telecommuting opportunities), wellbeing (quality of life, social infrastructure, urban context).

Barton (2009) mention: "The focus of this paper is on land use planning for healthy human settlements. It is widely recognised that the spatial planning of human urban activity is affecting quality of life, health and wellbeing (EEA, 2009; WHO, 2009; RTPI, 2009; NICE, 2008)". This paper concentrates in particular on the crucial relationship between spatial variables and physical activity, mental well-being and inequality" (Barton, 2009, p. 115). The following impacts can be noticed: inequalities in housing, facilities and transport; health damage due to air pollution, water pollution and greenhouse emissions; social environment relating to liveability within the streets, safety improving communication.

However, by applying the search strategy and screening it could be said that all the articles are relatable and fit in the scope of this research. As also presented in subparagraph 3.3.1.; here also two examples of the journal articles are given in order to show the relatable but variety of social impacts per study. The two studies show similarities of investigating social impacts regarding urban planning. Given this fact, different social impacts can be observed, for instance Haapio (2012) mention relatively main impact criteria, while Barton (2009) mention relatively specified impact criteria. For instance, Haapio (2012) includes well-being, while Barton (2009) includes liveability, safety, health damage to well-being of individuals. However, this level of detail also depends on the scope of each journal article.

As can be noticed aforementioned, several different social impact criteria are already mentioned by two different studies, while both are related to urban planning -and transitions. After considered 13 journal articles the following table (table 5) can be presented.

By performing a literature study and review of experts (paragraph 4.3) and a more funded impact criteria framework can be constructed regarding urban planning. This need is broadly recognised (e.g. in the study of Arce-Gomez et al., 2015) due to: lacking guidelines and directives for specific branches, lack of influence of social researchers.

*Table 5. Categorised Social Impact Criteria*

| Main Impact Criteria | Specified Impact Criteria |
|---|---|
| Population | Changes in population structure, increase in inward migration, increase in outward migration, moving in and out of an area, Culture of cooperation, balanced demographic distribution, intergeneration ties, cultural diversity, self-organization, aging population, residential density |
| Housing | Requirement for temporary accommodation during construction, increasing demand for permanent housing, joint program houses, house prices, housing affordability, inequalities in housing, houses owned, growth, distribution, displacement, cost for new real estate, gentrification process, target groups for housing, role of private housing, affordable housing, |
| Services | Increase in demand for hospitals, schools, shops, recreation facilities, inequalities in facilities, access to educational institutes, proximity to facilities, life support systems, |
| Health/Well-being | Responsive health systems, health coverage, health access, burden of disease, air pollution, water pollution, greenhouse emissions, liveability within the streets, nuisances (smell, noise, vibration), hazardous, health risks, natural calamity, recreation, livelihood, lifestyle modification, quality of life, number of workspaces, regulation capability (air, climate and water), well-being (quality of life, social infrastructure, urban context) |
| Employment | Local jobs, access to jobs, level of unemployment, number of jobs, income employment, business economy and employment (employment, new business telecommuting opportunities) |
| Safety | Security, crime and safety, Defensible spaces, visibility of security infrastructure, city-wide surveillance networks, biometric borders, surveillance cameras, crime rate, level of crimes, relevant policy, local conflicts, vulnerability, |
| Community | Sense of community, social cohesion, awareness level, rate of face-to-face interactions, place attachment, language proficiency, religious bonds, human behaviour, education, social networks, improving communication, waste generation, waste disposal, cultural, distribution of income, municipalities income, high value area, transport (public transport, pedestrian, bicycle ways) |
| Transport/Accessibility | Providing walkability, use of private car, mean travel time to work, access and activity, traffic and parking access, accessibility for different purposes |
| Local Economy | Offices, income, business activity, local training and skills, Self-sufficiency, urban agriculture, urban green commons (allotment gardens, etc.), structure of the budgetary system, financial support, financial stability and flexibility, insurance and compensation system, diversified livelihoods, product service systems, regional economic balance, taxation and fiscal policies, personal economic security, job diversity of residents, housing capital, employment, tourist attraction, business size, complementary currencies, poverty rate, income level, households below poverty line, income disparity, level of poverty, household incomes, profitability, economic diversity, land owners income, |
| Visual Aspects | Aesthetics, identity, cultural and historic values, significance to visual and cultural identity, experience of area, visual message, physical touch, sense of transition |

### 3.7.2 Filtering and Select Social criteria

In the previous subparagraph a social impact criteria framework was drafted relating to the built environment, based on 13 journal articles. However, not all criteria can or should be involved. It is mentioned that scoping issues will occur when a wide range of criteria is involved; inaccurate predictions are likely to exist. Thus, to select the involved criteria a frequency table is created based on the screened journal articles. Table 6 shows how common a particular social impact criteria is mentioned within the journal articles. By including the common used main impact criteria an idea of urgent social impact criteria within urban planning can be determined. However, this list (after scoping) is not final, since experts will also judge these impact criteria. The final integrated impact criteria framework will presented in paragraph 4.3.. Later in the research the compatibility of the high rise building project will be determined and tested against the integrated impact criteria framework.

*Table 6. Frequency table Social Impacts*

| Main Impact Criteria | Chadwich (2002) | Abu Bakar & Cheen (2013) | Berardi (2013) | Sharifi & Yamagata (2014) | Barton (2009) | Munda (2006) | Canty & Canter (1993) | Burinskien et al. (2017) | Sairinen & Kumpulainen (2006) | Fontana et al. (2013) | Ohl et al. (2007) | Gamboa & Munda (2007) | Pourebrahim et al. (2010) | Haapio (2012) | Frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | X | | X | X | | X | X | | | | X | X | | | 7 |
| Housing | X | X | X | | X | X | | X | X | | | | | | 7 |
| Services | X | | | | X | X | X | X | X | | | | X | | 7 |
| Health/Wellbeing | X | X | | X | X | | X | | | | X | X | | X | 8 |
| Employment | | X | X | | | | | X | | | | X | X | X | 6 |
| Safety | | X | X | X | X | X | | X | | X | X | | | | 8 |
| Community | | X | X | X | | | X | | | | X | | X | X | 7 |
| Transport/Accessibility | | | | X | X | X | | X | X | | | | X | X | 6 |
| Local economy | | | | X | | X | | X | | X | X | X | X | X | 8 |
| Visual aspects | | | | | X | | X | | X | X | X | X | X | | 7 |

Consequently, this subparagraph applies scoping and therefore the social impact criteria will be narrowed down. However, overall the social impact criteria are all commonly mentioned and evenly distributed. It is known that the impact criteria are related, for instance inward and outward mitigation of people could increase the feeling of safety. Also, employment could be assigned to the impact criteria community. However, the social impact criteria are more specified compared to environmental impact criteria. Further, some of the social impact criteria are also encountered in environmental impact criteria, such as: visual aspects and transport.

As can be seen in table 6, criteria transport/accessibility and employment are less used than the remaining criteria. It could be said that transport and accessibility are related, but are also encountered in the environmental impact criteria. Besides, looking separately to these impact criteria the frequency would be even lower. Considering these two arguments, it is evident that transport/accessibility will not be included in the social impact framework. Further, employment is also related to local economy (see table 6). Besides, local economy is common mentioned. Employment will be excluded from this impact criteria framework and assigned to local economy.

The remaining impact criteria are more or less equally mentioned in table 6. The impact criteria are also clearly specified compared to the environmental impact criteria. Although, the environmental impact criteria are tangible and objective, the enlisted social impact criteria could also be relatable to individuals. Considering table 6, the following social impact criteria are common mention: population, housing, services, health/well-being, safety, community and local economy.

Considering the 'common' mentioned impact criteria The following criteria for now can be summed up as follows, ranked by importance (common mentioned):

1. Population
2. Housing
3. Services
4. Health/Wellbeing
5. Safety
6. Community
7. Local economy

It is evident that the EIA and SIA criteria are related, for instance: transport is noted as one of a social impact criteria, however, this can be covered by the 'main impact criteria' pressure on services/facilities. Additionally, an increase in transport will also be affect the environment in terms of air quality and on its turn health.

These involved criteria will later also be judged by external experts in terms of specified criteria related to high rise buildings. Again, this list is thus not definitive and final presented in paragraph 4.3. Here, the integrated impact criteria framework will be used in order to determine the compatibility of high rise building relating to each impact criteria.

## 3.8 Social Impact Criteria integration into Environmental Impact Criteria

As known, the SIA originated from the EIA in the early 1970's and its' use of the SIA is increasingly used among different countries. However, it is also known that due to the increasing complexity of human environments (e.g. city environmental a need is observed for an improved pragmatic impact assessment system. Several renowned authors, such as Vanclay, Sairinen, mentioned that the mainstream EIA system will benefit by including SIA.

The EIA and SIA can become crucial project planning instruments when such are applied in the early phase of the decision making process of a project. These assessment systems provide rich information on the consequences due to a development project. These consequences can be taken into account and be used in the mitigation process for measures. If the EIA as well as the SIA are properly executed it can significantly improve the quality of project proposals and lead to savings on project implementation by reducing the negative impacts (Slootweg, Vanclay, & van Schooten, 2001).

However, how do these social and environmental impacts relate? For instance, Slootweg et al. (2001) mention: "Social change processes can also provoke biophysical changes. Economic developments which increase the number of tourists in a particular area can have serious influence on land use and water quality, which in their turn, can have indirect human impacts through a reduction in agricultural production and subsequently on income level for smallholder farmers" (Slootweg et al., 2001, p. 26). Impact assessment systems are commonly dealing with the identification of cause ← → effect resulting from a development. Ideally, the SIA should be integrated within the EIA procedures, although it still has some shortcomings. In the past decades the SIA has developed in terms of techniques and method to optimise its prediction in order to support public participation, impact mitigation, monitoring and management. However, as the recognition of an integrated impact assessment system is increasing, yet little attention is given to the benefits of the combination and SIA to enhance environmental governance and natural resource management (Rauno Sairinen, Barrow, & Karjalainen, 2010).

An integrated framework would add a new dimension to the EIA as well as the SIA; analytical assistance in the early identification of potential impacts. In most cases an EIA study stops at the level of biophysical changes, for instance impacts on water, air and soil quality. These changes can be translated to explicit issues which are relevant to human society Slootweg et al. (2001).

## 3.9 SIA Conclusion

In fact the composition of the SIA does not significantly differ than from the EIA. More or less the same pitfalls (e.g. lack of knowledge and expertise, inadequate use of methods) are noted as within the EIA, even the process is likely to be the same. The process of the SIA and EIA both starts with the screening process and after the scoping process will be performed. The SIA is clear in the involvement of its' impact criteria and is project dependent. The SIA developed over time . Also the recognition of importance increased and is observed by several countries. The USA and Finland are frontrunners when it comes to the application  and development of the SIA.

It can be seen that the SIA was first more or less neglected, since in 1994 the first guidelines were officially documented and lay down by the Interorganizational Committee on Guidelines and Principles for Social Impact Assessment. As sustainable development (e.g. durability) became increasingly important over the years the SIA evolved as a part of the EIA. This explains why the development and practice of the SIA increased in the past years. However, continuous development of the document and guidelines is necessary.

The strengthening of SIA practice is evidenced by greater recognition of the importance of social issues and a corresponding proliferation of social specialists in lending institutions, governments, project developers and engineering consultancies. Disregard this positive development social practitioners have insufficient influence in shaping project/development alternatives. Despite the increase in social roles within many organizations, the project managers responsible for impact assessments often have little social experience. This also occurs in the built environment and urban development, however, specific indicators are missing within the SIA guidelines. It is mentioned that several benefits come forward when an SIA is involved during a project, for instance: greater certainty for project investments and increased chance of project success; avoidance and reduction of social and environmental risks and conflicts faced by industry and communities etc.

By means of the screening process the following topics need to be clarified within the SIA: relationships to biophysical environment; historical background; political and social resources; cultural, attitudes and social-psychological conditions; population characteristics. Once, the screening process is finalised the scoping process starts. It is mentioned that such processes often overlap, as fuzzy results occur. In order to perform 'well' scoping approach; the methods used by experts are as follows and reviews of existing documentation such as: social science literature, involvement of experts and public participation techniques.

Further, as obtained from literature study on the SIA in depth theory and expertise knowledge is often neglected and is underlined to be important in order to perform a 'well' SIA. Therefore this research has also involved another literature topic study on SIA impact criteria within the urban planning. Several impact criteria for the SIA are identified by different researches, 13 different SIA relating to the built environment are investigated. A topic list is drafted where only, 7 social indicators remained: (1) Population; (2) Housing; (3) Services & facilities; (4) Health and Well-being; (5) Safety; (6) Community and (7) Local economy. Most of the topics discussed are also confirmed by earlier research of a SIA expert Sairinen (2004). In this study it is mentioned that: social impacts of urban plans refer to various factors such as housing quality, services (local) and living environment, gentrification, health, etc..

## 3.10 An Integrated ESIA gap

The main gap of the impact assessments within urban planning is the use and extent of such tools. These tools are used, but are known with some critical and well known continuous flaws in practice. The EIA is a common used assessment tool and in some cases even mandatory, the efficiency of such tool increases due to its' legal powers. However, it should be explained why such gap is existing. In fact, it is mentioned in paragraph 3.9 that an integrated EIA and SIA could be a fertile impact assessment tool. Further, the process steps of the EIA and SIA are more or less the same, since the SIA originates from the EIA. This makes it also easier to combine and even integrate such assessment tools into an single assessment system. Especially, within the boundaries of urban planning where such improved (combined) are a missing element.

Several researchers mention inaccurate and too less information is included within an EIA e.g. due to lacking experience of practitioners. Further, directives and guidelines within the EIA are incomplete and are not satisfying for a branch as the construction industry and urban planning. Further, screening and scoping face some serious difficulties in order to draft a well EIA or EIS and thus long-term solutions. These difficulties are described as: lack in experience of practitioners, different methods are used, no systematic approach is used, mitigation is done by intuition and knowhow.

Probably several benefits will come forward regarding an integrated EIA and SIA. For instance, an improved prediction, therefore better mitigation and reduction of problems and finally a 'compatible' building within the 'to be build area'. But also, some of the impact criteria overlap which could be discussed from both perspectives. Currently, potential impacts are encountered by estimation and intuition, rather than systematic analysis. Further, every single project need to be separately assessed and is done by several different methodologies sometimes even without any argumentation or foundation. This leads on its' turn to inaccurate predictions and even too small or broad scopes of the impact assessment. Based on literature research in chapter 3, it can be mentioned that the gap of the impact assessments for urban planning consists of three major issues: (1) no particular criteria indicators for urban planning exist, while these projects have significant impact on biophysical and human environment; (2) EIA and SIA are performed separately and in most cases an SIA is neglected, while there is multiple evidence for this issue (3) an integrated systematic tool is not yet developed for assessing urban impacts while several studies proved and recommended the importance of it. This is now performed by intuition and know-how resulting in a limited view of impact.

However, also negative consequences could arise due to this combination. For instance: (a) as well in the EIA and SIA a lack of expertise in performing a 'well' impact assessment, imagining a combination of As the SIA is increasingly used (often too less), social practitioners have insufficient influence in shaping project/development alternatives; (b) since the SIA is not legally required by most countries the chances occur that such impact assessment will be of poor quality; (c) since the scope of the integrated impact assessment becomes broader, the time, expenses and involvement of more scientific experts also increases. This will cause difficulties by executing the assessment process.

So to conclude, within the field of urban planning an improved assessment system is needed due increasing urbanisation and complex buildings -and living trends. Therefore, this research provides an integrated impact criteria framework, which leads to a better understanding urban impacts. This impact criteria framework will be used in order to investigate the compatibility of land use functions relating to each environmental impact criteria. By doing so, amend impact predictions can be made which result in improved measures reducing these impacts. This finally leads to area where both biophysical and human environment will benefit. However, since both EIA and SIA deal with methodology a clear structural 'engine' should be developed which is explained in chapter 4.

# 4. Environmental Social Impact Assessment Process

This chapter will discuss and elaborate on the Environmental Social Impact Assessment Process, this means that the type of data input (ESIM Input) for the calculation process (ESIM Calculation Process) are both discussed. This process needs to be discussed for systematic analysing the compatibility of a high rise building in its' case area. The environmental and social impact criteria will be used in order to assess the compatibility of the high rise construction. The compatibility value supported by the possible impacts can be obtained by Environmental Social Impact Model (ESIM) and will thus be developed. The ESIM will explore the compatibility values for the high rise building. The environmental and social impact framework will indicate the compatibility value of the high rise building on each impact criteria within this framework. However, it should be mentioned that not a full impact assessment will be performed. In fact, it will be bounded to screening and scoping process and thus the identification and determine the significance of each impact and compatibility value. The model proposed in this chapter will be performed at building, location and area level. The consequences and impacts due to these developments will be analysed and also visualised by the ESIM. The proposed environmental and social impact criteria in subparagraph 3.3.2 and 3.7.2 will be included within this project in order to construct the compatibility matrixes. However, firstly, an abstract and the background of the methodology will be presented in paragraph 4.1, the following paragraphs in this chapter will gradually go into the details of the approach and methodology. Paragraph 4.1, will describe the overview and background of the ESIM, paragraph 4.2, will elaborate on the purpose, paragraph 4.3 will discuss the integrated impact criteria framework which is judged by experts and will be used for constructing the compatibility matrixes, paragraph 4.4 will mention the data input for the calculations process described in paragraph 4.5, paragraph 4.6 will mention the output, scenario and sensitivity analysis. Paragraph 4.7 will conclude this chapter.

## 4.1 Background & Overview ESIM

**Background:**

The background of the methodology is also shortly described in order to have a better understanding of the reference studies which utilize the same methodology. The impact assessment tool of the thesis of Koops (2012) derived the Compatibility Evaluation Model (CEM) of Taleai, Sharifi, Sliuzas, & Mesgari (2007) could both be mentioned as well-developed studies. In order to further develop the ESIM, the study of Taleai et al. (2007) will be used to model and evaluate the compatibility of multi-land use function combinations such as high rise buildings. The study of Taleai et al. (2007) involve several different methods and tools which consist of: Delphi Methods, spatial decision support tool (MCE-analysis, AHP, OWA). The advantage of this model is the calculations in horizontal and also vertical directions, which is useful for high rise buildings. The study of Taleai et al. (2007) and Koops (2012) is considered as a guide for the methodology of this report.

As also mentioned by Koops (2012), as a part of the study of Taleai et al. (2007) is the Compatibility Evaluation Model, shortly CEM. This model is constructed to predict the possible spatial impacts around different type of land use functions. For instance, the Delphi method is used to indicate whether particular land use functions are conflicting or have a higher compatibility. Further, this means that the compatibility among the different land use types need to be quantified. Since the CEM focus on the negative compatibility and impacts, this research will focus on neutral compatibility matrix. The Delphi method as in Taleai et al. (2007) is also used in study for drafting the compatibility matrix regarding conflicting land use combinations. However, such compatibility matrixes are not related to a particular impact criteria. Contrary, this study research the possible compatibility values between land use functions are related to each impact criteria. The study of Taleai et al. (2007) only considers the compatibility value between land use functions on itself.

In this chapter the use of the ESIM model will be discussed and also the steps developing such model. Further, also the way how the results of the desk research and expert interviews are incorporated into ESIM is discussed, for instance the paragraph 4.3 where the integrated impact criteria framework is discussed with experts. However, paragraph 4.2 will further discuss how the ESIM model will be used related to the methodology of Taleai et al. (2007).

**Overview:**
This paragraph presents an overview and background of the Environmental and Social Impact Model (ESIM). Due to the complexity of the calculations and input of various data, an abstract with flow chart is created in order to give a clear overview of the computation process of the ESIM. Therefore the following flowchart (figure 6) can be presented. Figure 6, represents the steps as discussed in paragraphs 4.4 and 4.5.

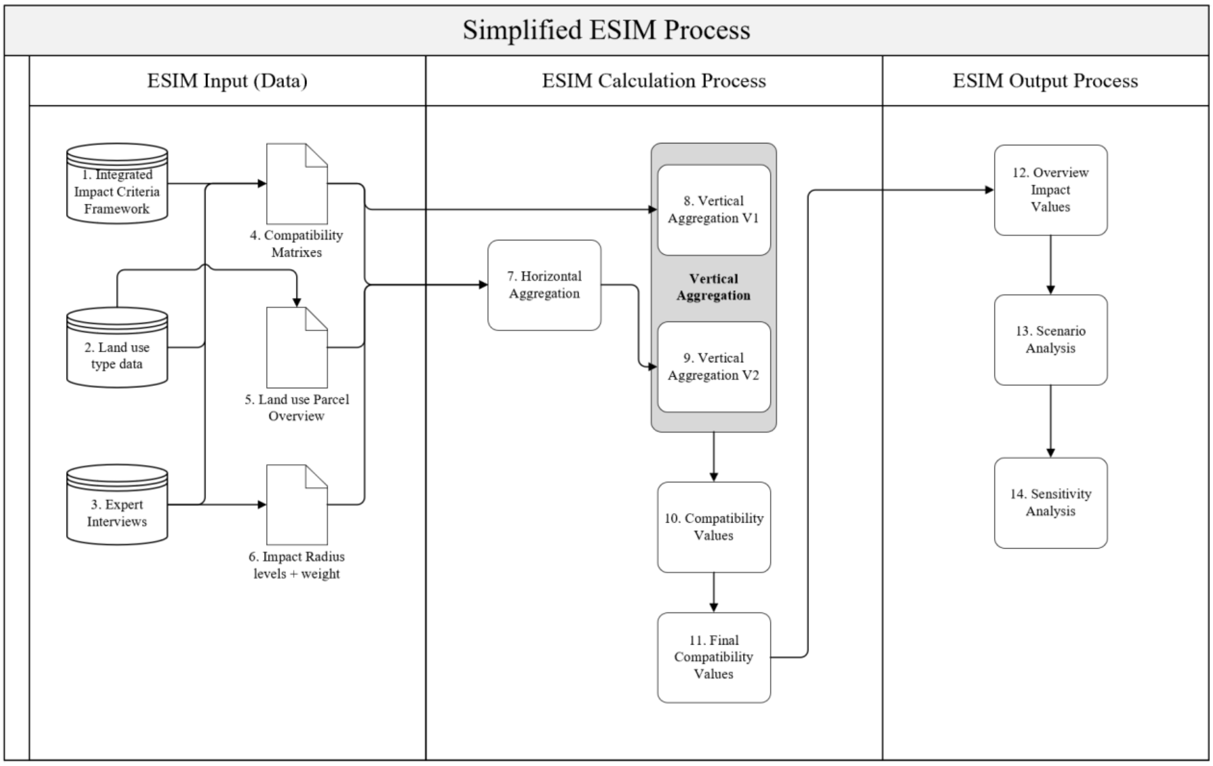



*Figure 6. Simplified ESIM Process Overview*

The flowchart presented in figure 6 represents a simplified ESIM Process Overview and will be applied for the case study and three scenario buildings. All the processes within this overview are labelled with an 'ID' number, for referring purposes. The *first* lane represents the data input for the calculation process. *ID 1* is the integrated impact criteria framework, as a result from the literature study and paragraph 4.3. This is used for constructing the compatibility matrix. *ID 2* indicates the involved land use types and should be identified by using table 7. Here, the type of land use functions are determined for the constructing the compatibility matrix. Further, *ID 3* mention the expert interviews in order to judge the compatibility matrixes. Experts judge this compatibility between land use functions on a five-point scale. After, the five-point scale will be quantified by using the summarised scores in table 9. Thus, *ID 1 till 3* are input for constructing a compatibility matrix as will discussed in subparagraph 4.4.1. *ID 2*, will be used for constructing a land use parcel overview as in *ID 5*. *ID 5* will consider the land use functions and neighbourhood plots around the subject building (high rise building). This will show on which land-plot and floor a particular land use function is located and will be discussed in subparagraph 4.4.2.

*ID 3* is used to determine the impact radius levels weights in *ID 6*. This study is making use of levels of impact and named as: building level (100m), location level (200m) and area level (300m) as presented in *ID 6*, this will be discussed in subparagraph 4.4.2. Also, the land use functions as in *ID 5* are enlisted for each impact level. Therefore, the experts determine the weight of each impact radius level.

In fact *ID 1 till 3* will construct the data objects in *ID 4 till 6*, this data will be used as input for the ESIM calculations discussed in paragraph 4.5.

The next process encounters the horizontal aggregation presented as *ID 7*. It relies on the input of *ID 4 till 6*. Firstly, the land use functions are compared to the horizontal floors of the high rise building and also relies on the division of each impact level (100m-200m-300m). After, compatibility values (input *ID 4*) between a particular land use combination will be used for the horizontal aggregation computation. This means that all the compatibility values for each land use combinations for each impact criteria regarding the subject parcel (high rise building) on each floor level will be aggregated. These aggregated values will be used as an input for the vertical aggregation.

The vertical aggregation exists of two calculation steps; *ID 8 and 9*. Namely, V1 which calculate the compatibility between the floor levels of the subject high rise building. V2 encounters the vertical calculation between floor levels of neighbouring buildings and the subject high rise building. As in *ID 6 and 7*, also V1 and V2 include the impact radius levels in the calculations. However, both vertical calculation steps assume that the compatibility/impact of each floor level in vertical direction declines if the distance in floor level is increasing. After, V1 and V2 will be combined into compatibility values per impact criteria is presented on a particular impact level (100m, 200m, 300m) an also for each floor level, this is presented in *ID 10.* After, the compatibility values, V1 and V2, need to be combined, this is presented as *ID 11*. In this calculation process the compatibility values per impact radius level (100-200-300m) and a weight ($W \leq 1$) is assigned per impact criteria as determined in *ID 6*. This means that the compatibility values for each impact radius level and impact criteria will be aggregated into one single value. In *ID 11* the final compatibility value is calculated for each impact criteria and in fact aggregates the values of *ID 10* into a single compatibility value. *ID 7 till 11* are discussed in paragraph 4.5.

Further, the ESIM will also have an output which presents in a table the compatibility values obtained from *ID 10 and ID 11*. Further, a radar chart will present the compatibility values as obtained by *ID 11*. This all is presented by overview impact values as in *ID 12*. Further, a scenario analysis will be applied, where scenario A, B and C will be compared to the case. This is presented as in *ID 13.* Additionally, two sensitivity analysis will be performed in order to check the robustness of the model, this is presented as *ID 14*. *ID 12 till 14* are discussed in paragraph 4.6.

## 4.2 Purpose of The Environmental Social Impact Model | ESIM

The goal of this research is to develop an extensive tool which can analyse the environmental and social impacts caused by high rise buildings. Among other this, compatibility matrixes will be used for this purpose. Therefore, for what purposes can the ESIM be used and to which extent?

The existing methodology within the EIA and SIA shows that the possible impacts are estimated by the screening and scoping approach. However, these processes have some issues regarding the accuracy of the estimation and also mapping stakeholders' values (e.g. the SIA is developed for measuring and mitigating social impacts contrary stakeholders are often neglected). Consequently, solutions come forward are based on current knowledge and instinctive, rather than an systematic approach and assessed indicators. The ESIM is an extensive impact assessment model which can be helpful in the process of screening and scoping, but can also be used for a mitigation process. ESIM in this scope of research can be used in order to measure the environmental and social impacts caused by high rise buildings within an existing city. In fact, the tool of Koops (2012) is comparable but has a different focus.

Besides, by performing such ESIM an improved understanding will be obtained towards the environmental and social impacts due to certain high rise buildings projects. Hence, ESIM will give an overview of the potential impacts and solutions, further the provided solutions based on intuition will also decline. For instance, in early design phase, potential impacts can be calculated due to the ESIM. On its' turn, scenario analysis can be performed to decrease and even mitigate the potential negative impacts.

The ESIM tool and development of this, relies on two methodologies obtained and deviated from the study of Taleai et al. (2007). In fact, two methodologies have been combined; Analytical Hierarchy Process (AHP) and an aggregation methodology. In the study of Taleai et al. (2007), but also in Koops (2012), the AHP methodology is used for quantifying the compatibility matrixes and compute the weight for each impact criteria per impact radius level. Further, the horizontal and vertical aggregation methods are used to compute the impact compatibility values in horizontal and vertical direction. The relation between the studies will be discussed in subparagraph 4.5.1.

## 4.3 Integrated Impact Criteria Framework

This paragraph is considered as ID 1 in figure 6. As already mentioned in paragraph 4.1, the integrated impact criteria framework is used to construct the compatibility matrixes. The matrixes will encounter the compatibility between land use functions related to each impact criteria. Further, these matrixes will give input to the horizontal aggregation, V1 and V2 calculations. Therefore, the impact criteria used for the matrixes are pivotal within this research. Therefore, this paragraph is firstly discussed as explaining the methodology. However, in chapter 3, around 20 environmental and social impact criteria were obtained and discussed by means of a literature study. After scoping and filtering, 14 environmental and social impact criteria in remained. Scoping is performed due to a limited time frame and pragmatic point of view and therefore not all the initial impact criteria can be included within this study. This paragraph will thus be used as input for paragraph 4.4.

To continue, in subparagraph 3.3.2 and 3.7.2 the impact criteria are selected by means of 'common mentioned main impact criteria' within the journal articles. The common mentioned impact criteria remained and is reviewed for overlapping criteria. As mentioned in chapter 3, the integrated impact criteria framework would be presented in paragraph 4.3. After judgment of experts the integrated impact criteria framework would be final. After this process, the environment and social impact criteria remained as presented in figure 7. Additionally, experts mention possible impacts as a consequence of constructing high rise buildings within a certain area.

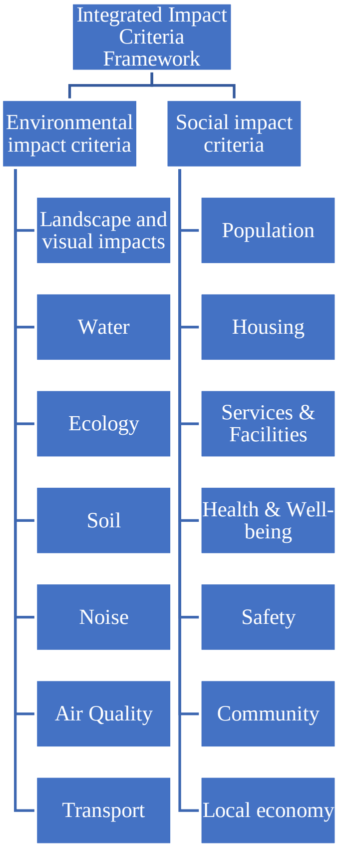



*Figure 7. Work breakdown structure environmental social impacts*

The fourteen impact criteria were presented to several experts and asked which were likely to be included within this research. It was mentioned that pollution should be excluded and noise should be included. It was argued that pollution could be also considered as water pollution, soil pollution, air quality pollution. Noise however, was judged as an important factor within and around a building. Therefore, figure 7 presents the included impact criteria within the ESIM. Further, additional context is provided for each impact criteria following the hierarchy as in figure 7. It will also include specified impact criteria and judgment from experts related high rise buildings (projects).

As mentioned is *landscape and visual* impacts a commonly notated impact criteria which also is strongly judged by the experts. Landscape and Visual impacts can be related to the design and its' consequences such as:

- Shading, which could affect individuals on that location as well other buildings and green areas.
- Strong air flow due to high rise buildings;
- Loss of human dimensions, individuals can feel disorientated within due to particular building design. For instance; urban form (compact, dispersed, poly-centric), density of buildings, urban size, variability and spatial heterogeneity;
- City image distortion due to inconsistent design, e.g. ratio of high and low rise buildings.

*Water* impacts criteria is defined as the quality of water but also consumption and water storage capacity. Because of high rise building projects is it likely to assume that areas will be paved (e.g. due to increase in transport, pavement etc.). On its turn, it could have impact of groundwater recharge due to surface run-off; water quantity and quality; water consumption, releases to water.

*Ecology* is defined as the conservation of nature and reduce harm to nature, flora and fauna. Due to high rise buildings and thus compacting on within a urban area less space is left for ecological purposes. Therefore, microclimates could affected, biodiversity could harmed, erosion consequences.

*Soil* impact criteria encounters the soil contamination due to high rise building construction projects related to urban transitions. Such building activities but also human activities could affect filter capacity, harm to soil organisms, increasing land surface temperatures etc.

*Noise* impact criteria refers to the level of noise and noise hinder within the city area. Consequently, noise should be reduced to a acceptable level to the inhabitants of a particular area. It is mentioned that noise could cause serious health damage in various ways.

*Air quality* refers to the balance of 'healthy air' within a certain area and thus do not exceed the limits regarding certain 'toxic' substances. The purpose for the inclusion is to prevent further degradation of air quality within the city and reduce the amount of $CO_2$ , dust, nitrogen dioxides, greenhouse emissions (VOC, CFC), odour and also $SO_2$.

The impact criteria *transport* refers to the fact that transport issues could occur relating to the fact that a huge amount of people are living on the same occupied area. It is likely to assume that several transport modes will be used increasingly within a small area. It is self-evident that this will create problems due to: high frequency schedule public transportation, walking trails that link with public transportation routes, principle arterial miles per square mile, vehicle ownership, transport pollution.

*Population* refers to changes in population structure but also increase in, in and outward migration. This impact criteria could be affected by other criteria, but is an important factor which determines the liveability of humans within an area. Further, it also affects the feeling of density and maybe even the feeling of safety within an area. For example cultural diversity and population diversity is important to the liveability and success of an urban environment.

As these seven environmental impact criteria are discussed, the seven remaining social criteria are elaborated upon. *Housing* refers to the fact that housing inequalities could rise, due to construction developments regarding high rise buildings. This phenomenon can occur as a consequence of gentrification, therefore the affordability of certain dwellings is decreasing and initial population structures also changes, which could be hazardous to liveability of an area.

*Services and facilities* refers to the eventually pressure on the facilities and services in a neighbourhood. It is likely to assume that due to an increase of individuals in a particular area more facilities should be created. Due to this pressure, also facilities and services need to remain accessible. Several different facilities and services can be identified such as: education, facilities, hospitals,

*Health and well-being* of people concerns the personal damage to people which could be a consequence of environmental and social interventions. Again, this impact criteria is related to multiple other aspects, but should be discussed separately due to its' importance on affecting humans. Therefore several specified criteria could be mentioned such as: acceptance by neighbourhood, social cohesion, hinder of noise, health systems, health coverage, burden of disease, liveability within the streets, recreation, livelihood, lifestyle modification, quality of life, regulation capability (air, climate and water), well-being (quality of life, social infrastructure, urban context). But also environmental impacts can harm this main impact criteria; air quality (health), water quality.

*Safety* concerns as it mention the feeling of safety of people and also the actual measurable safety within an area. Safety is a very important aspect to liveability of individuals and therefore a separate issue to discuss. Therefore, several impact criteria can be mentioned: Security; crime and safety; Defensible spaces; visibility of security infrastructure; surveillance cameras; local conflicts; vulnerability.

*Community* this impact criteria refers to possible consequences on the community, as well positively as negatively. As a result of high rise buildings, people could live anonymous within their building, further, the location and area could also be affected by a lower social cohesion due to this development. However, this will be judged within the compatibility matrixes.

*Local economy* impact criteria refers to the potential economic consequences due to construction high rise buildings. It could be plausible to assume that for example shops or bars face additional competition. However, also positive effects could occur where attraction of people due to e.g. office building provide additional job opportunities.

## 4.4 ESIM Inputs

The ESIM relies on the input of different data sources as will be discussed in the subparagraphs of paragraph 4.4. This paragraph can be related to the ID 1 till 6 in figure 6. On its turn these data sources will give input to the calculation process as described in paragraph 4.5. This paragraph will thus not discuss the calculation method of the ESIM. However, first 4.4.1. elaborates on the land use compatibility. Here the construction of the compatibility matrixes is discussed related to the impact criteria. Therefore, it is also mentioned: which land use functions will be compared; the judgment of the compatibility by experts; quantifying the compatibility matrix. Second, 4.4.2. will elaborate on the case study data and how this will be used in this research. Additionally, to this a scenario -and sensitivity analysis will be applied.

### 4.4.1 Compatibility Matrix Assessment

This subparagraph are considered as ID 2 till 4 in figure 6. In order to assess the land use compatibility, this study uses a compatibility matrix as also used in the study of Taleai et al. (2007). The first step for constructing such compatibility matrix is to identify which land use functions will be compared. However, the compatibility matrix is slightly adapted to the scope of this research, in such way that land use compatibilities matrix are related to the impact criteria. The matrix in Taleai et al. (2007) only compared the compatibility between land use functions, not to any impact criteria. Further, the land use functions which are compared in the matrixes are adapted to the Dutch Planning system. In this case it means that land use functions are included which are commonly located within a city centre, e.g. industrial settings are thus ignored.

To continue on the comparison of land use functions, this study is bounded to a city centre area. This means that a certain vision and urban development programme will be drafted for a certain area. By means of a research, the municipality decides which functions and combinations will be constructed in the area. To already refer to the case study in Den Haag, high rise buildings and several other land use combinations (e.g. office, retail & catering, services) will mainly constructed near public transport hubs in the Central Innovation District (CID) (Gemeente Den Haag, 2018). These public transport hubs are located within a dense city centre area. It can be seen that only several land use functions are located within a relative small area, fur the purpose and scope of this research only the characteristic city centre land use functions will be involved. Also considering the land use functions of the area in figure 8, it can be mentioned that the land use functions within the study area is rather monotone.


*Figure 8. Land use functions case study Beatrix Area Den Haag – multi layer GIS map*

Considering the land use functions in figure 8 and the CID policy document of municipality Den Haag it is clear that a limited amount of land use functions are situated within a city centre area. Therefore, table 7 can be constructed and provides the land use functions included within this study. This table will be used in order to draft the compatibility matrix. The purpose of such 'compatibility matrix' is to assess to what extent every particular land use function combination is compatible. The compatibility between land use functions can be defined as the degree to which a combination of two land use functions results in a certain environmental-social impact. In fact, the synergy between of 'functional diversity' can be showed (Koops, 2012).

*Table 7. Land use functions input for compatibility matrix*

| | Functions | Theme | Specific functions |
|---|---|---|---|
| 1 | Residential | Diverging types of housing | Single family and multi-family housing |
| 2 | Offices | Provision of services and commercial activities | Business purposes in all sizes |
| 3 | Retail and catering | Sale, rent or supply of goods for personal use, this means also commercial provision of food and beverages | Supermarkets, bakeries, butcher, coffee corners, restaurants, pubs. |
| 4 | Services and facilities | Provided services for public use, this means also organisations which support the share of knowledge and skills, but also healthcare provision | Banks, barbers, schools, medical centres, hospitals, dentist, museums, theatres. |
| 5 | Urban green areas | Public green areas for relaxation, land marks and city function | Green area with water, park, gardens, etc. |
| 6 | Transportation | Movement of individuals by rails, road or water | Public transport, parking spaces (lots and garages), bicycle storages. |

Once the land use functions are determined, the relation to the impact criteria will be explained. This study will incorporate 14 environmental and social impact criteria, as presented in paragraph 4.3. Each environmental social impact criteria need to be stressed by a compatibility matrix. This gives insight into the environmental-social compatibility resulting from land use function combinations. This is related to a single environmental or social impact criteria. It should be noticed that data collection varies from the reference study. In the study of Taleai et al. (2007) the Delphi method is used. This thesis relies on external of experts in different branches (consultancy, governmental, engineering).

Since the compatibility matrixes are a pivotal part of the research, elaboration on expert judgement is required. Before the compatibility matrixes were filled in, additional guidance and questions were given to the experts. First, the experts were guided by instruction in order to reduce false or unwanted information. The experts are asked to fill in the matrix considering the project in ideal/optimal circumstances. Since, it could be argued that compatibility for instance depends on the design or quality of the building. Furthermore, experts are asked to consider a city centre area, since this is the scope of the research. Furthermore, experts were asked that current regulations or other technical aspects shouldn't be involved within their decision making.

After this guidance, the experts are asked to fill in the table to consider the compatibility between two land use functions regarding a single impact criteria. Besides, synonyms are used in order to describe the purpose, for instance: what will be the synergy between land use functions relating to a particular impact criteria? Further, experts were told that compatibility between land use functions could be negative, but also positive. Given this information, experts could completed such matrixes without doubting or multi-interpretation issues. The obtained dataset as a result from the filled in tables from experts is project dependent. This means that the environmental and social impact criteria do rely on project characteristics, such as city centre areas or high rise building projects.

After the experts were guided and asked to fill in the compatibility matrixes as noted above, a five point scale was introduced to indicate the 'strength' of the compatibility. However, as the focus is only on a single aspect it will result in improved predictive assessments. The separate judgments will enable that experts do not have to concern other related impact criteria at the same moment. The environmental-social impact in relation to a single environmental or social aspects of pair-wise function combinations have been assessed by experts specialised in the field of urban development.

The urban experts need to judge the impact matrix by a five point scale. This five point scale is also used by Taleai et al. (2007) and Koops (2012) and can be noted as follows:

- Highly Positive Impact (HPI): intermingling of those land uses which lead to high positive impacts in regard to a particular environmental and social aspect.
- Moderate Positive Impact (MPI): intermingling of those land uses which lead to moderate positive impacts in regard to a particular environmental and social aspect.
- Neutral Impact (NI): intermingling of those land uses which lead to negligible impacts in regard to a particular environmental and social aspect.
- Moderate Negative Impact (MNI): intermingling of those land uses which lead to moderate negative impacts in regard to a particular environmental and social aspect.
- Highly Negative Impact (HNI): intermingling of those land uses which lead to high negative impacts in regard to a particular environmental and social aspect.

In order to support the above described process, table 8 can be presented. This table give an example of a filled in compatibility matrix by an expert, regarding the landscape/visual impact.

*Table 8. Compatibility Matrix Landscape/Visual Impact*

| **Compatibility Matrix Landscape Visual Impact** | | | | | | |
|---|---|---|---|---|---|---|
| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
| Residential | MPI | | | | | |
| Offices | MPI | MPI | | | | |
| Retail and catering | NI | NI | MNI | | | |
| Services and facilities | NI | NI | MPI | NI | | |
| Urban green areas | NI | NI | NI | NI | HPI | |
| Transportation | NI | NI | NI | NI | MNI | NI |

As the compatibility matrix and thus the qualitative assessment (compatibility matrixes) are finished by the experts; quantifying of such matrixes is needed. This is also performed by the study of Koops (2012). Therefore, it is noticed by Taleai et al. (2007) that the Analytical Hierarchy Process (AHP) and structured pair-wise comparison are used in order to quantify the compatibility of the environmental and social impact criteria. The AHP methodology is a theory of measurement by means of pair-wise comparisons and relies on the input of experts to derive priority scales. These scales measure intangibles in relative terms. The comparisons are made using a scale of absolute judgments that notice how strong one element dominates another with respect to a given attribute (Saaty, 2008). A short description of the AHP Methodology can be found in Appendix A. To be clear, no expert is involved for this quantification process.

As earlier mentioned in order to quantify the compatibility matrixes regarding the environmental and social impact criteria a structured pair-wise comparison is used. This is also performed in the study of Taleai et al. (2007). This is due to inconsistency issues which could occur with regular pair-wise comparisons. A structured pairwise comparison is executed by two following steps. Firstly, the involved impact criteria need to be ranked in order and after, adjacent criteria will be compared based on the previously ranks. Because the structured pair-wise comparison assumes an already ranked order, the adjacent criteria can be considered as a weak or strong impact. This is because the most and least important impact criteria are not compared, but only the adjacent ones, however multiple comparisons are thus made for pair-wise comparisons. This is not the case for structured pair-wise comparisons, as performed in this research Taleai et al. (2007). The following table (table 9) can be created in order to quantify the levels of the impact criteria.

*Table 9. Quantification of Compatibility Matrix*

| Compatability Level | | HPI | MPI | NI | MNI | HNI | Geometric mean | Standardised score |
|---|---|---|---|---|---|---|---|---|
| HPI | Highly Positive Impact | 1 | 3 | 5 | 7 | 9 | 3,94 | 0,50 |
| MPI | Moderate Positive Impact | 0,33 | 1 | 3 | 5 | 7 | 2,03 | 0,26 |
| NI | Neutral Impact | 0,20 | 0,33 | 1 | 3 | 5 | 1,08 | 0,14 |
| MNI | Moderate Negative Impact | 0,14 | 0,20 | 0,33 | 1 | 3 | 0,51 | 0,07 |
| HNI | Highly Negative Impact | 0,11 | 0,14 | 0,20 | 0,33 | 1 | 0,26 | 0,04 |

Considering table 9, the strength of between the compatibility levels (HPI-MPI-NI-MNI-HNI) are indicated between 1 till 9. However, table 9 can be related to the AHP matrix, however, as mentioned structured pair-wise comparison is performed and assumes an already ranked order. Therefore, only the change from HPI to MPI is considered, and the a change from MPI to NI is judged, from NI to MNI, etc. So therefore, it is indicated in table 9 that a change from HPI to MPI; MPI is more important by a strength difference of 2. Further, a change from MPI to NI is more important by strength difference of 2. By continuing this process, a matrix can be formed as in table 9. Further, the matrix in table 9 is a so called, reciprocal matrix. Further, as can be seen the 'strength' between each criteria is equally divided. A change from HPI to MPI is equal, also a change from MPI to NI is equal.

To further explain the table, the numbers in table 9 represent the strength between the compatibility levels in horizontal and vertical direction. The depicted table (table 9), should be read from number 1 towards another number below and right hand side. For instance, a difference between a high positive impact and high negative impact is a factor 9; a difference in high positive impact and moderate positive impact is a factor 3; a difference in strength between moderate positive impact and neutral impact is a factor 3, this can be seen in horizontal direction 1 – 3 and in vertical direction 1 – 0,33. The compatibility levels will be quantified by calculating standardized scores and represent the weights for each of the levels. These standardized scores will be used in the horizontal and vertical aggregation. By a strength difference of 2, a more dominant value is assigned between the difference of compatibility levels. This is done since the impact caused by high rise buildings are significant.

However, this study divides the compatibility levels equally. The study of Taleai et al. (2007) uses values as a step of 1 and does not encounters specific type of project. Further, Taleai et al. (2007) focus on the negative compatibility rather on the positive. This can be seen since the strength between HPI-MPI is only by 1, while negative compatibility NI-MNI-HPI is divided by a strength of 2.

After, considering table 8 and the quantifying process (table 9), a quantified compatibility matrix can be presented. This example is depicted below in table 10 to show the quantified compatibility matrix, in this case landscape/visual impact is shown.

*Table 10. Quantified Compatibility Matrix Landscape/Visual Impact*

| **Quantification Landscape and Visual Impact** | **Residential** | **Offices** | **Retail and catering** | **Services and facilities** | **Urban green areas** | **Transportation** |
|---|---|---|---|---|---|---|
| Residential | 0,26 | | | | | |
| Offices | 0,26 | 0,26 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,07 | | | |
| Services and facilities | 0,14 | 0,14 | 0,26 | 0,14 | | |
| Urban green areas | 0,14 | 0,14 | 0,14 | 0,14 | 0,50 | |
| Transportation | 0,14 | 0,14 | 0,14 | 0,14 | 0,07 | 0,14 |

The purpose of this research among other things is to visualise the compatibility related to the impact criteria due to constructing high rise buildings in urban areas. As mentioned, the emphasises will be placed upon an equal but stronger approach compared to the study Taleai et al. (2007). This is done since high rise buildings could cause multiple significant impacts, positively or negatively such as: job opportunities, increasing use of public transport, traffic jams. Again, the compatibility of land use functions are used in order to define the strength of such impacts.

### 4.4.2 Data Case Study

This subparagraph are considered as ID 2, 5 and 6 in figure 6. The input for this research relies on the data which is related to the project characteristics. This provides data input the horizontal aggregation, as also the compatibility matrix. Several steps are needed in order to provide a satisfying case study dataset. The first step is to identify all the parcels within the case study area and obtain which functions are on these parcel, by providing a parcel map, as depicted in figure 9. Further, the case study data also define impact radius levels. In the ESIM three impact radius levels can be noted: building level (100m), location level (200m) and area level (300m), this layers can be seen in figure 9. Experts are asked to which extent a particular impact criteria is more important per impact radius level, by means of an AHP methodology (analysis in paragraph 6.3). These impact radius level per impact criteria will also be visualised and presented in further calculations and the output of the ESIM. Contrary to the study of Taleai et al. (2007), this research includes the ‘area level’ within the radius of 300 meters from the subject building.

By introducing impact radius levels a better estimation and improved prediction of the consequences can be proposed. The indirect impacts between neighbouring parcels are not taken in consideration. So, only the direct impacts related to the high rise building and land use functions on building, location and area level. The compatibility value for each impact level will therefore also differ; an expert could mention that air quality for the area is more important than on building radius level. The calculation process will be further discuss this matter in the next paragraph.

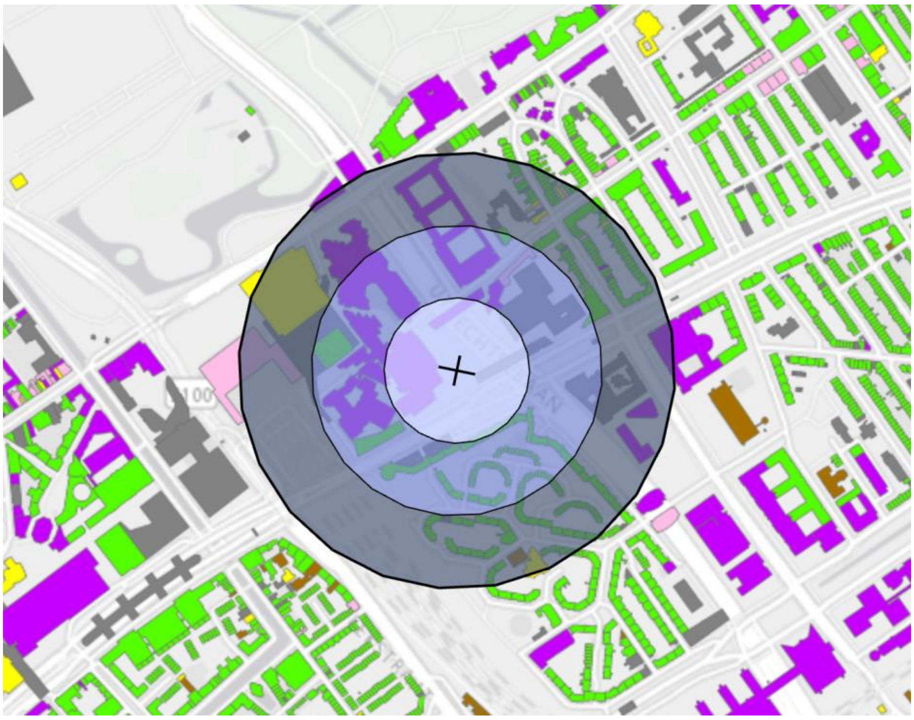


*Figure 9. Case area Parcel Map*

After this, the data need to be restructured. Land uses for each floor level at each parcel in the project area have to allocated in the land use table. Note that only direct influence due to high rise buildings will be included and thus calculated. This means that indirect influences (e.g. influence of neighbouring parcels) are excluded within this approach. It is self-evident that several types of land-use functions exist on the same floor level.

In the vertical direction, land uses are classified on the typical design of buildings, namely a plinth, centre and top section. As a typical character of Dutch cities the plinth of a building has a commercial function, where on top (centre) residential functions are situated. Additionally, a basement land use function is added in contrast to the initial land use division. The floor classification in the initial way is visualised in figure 10, different types of function should be assigned as in table 7.

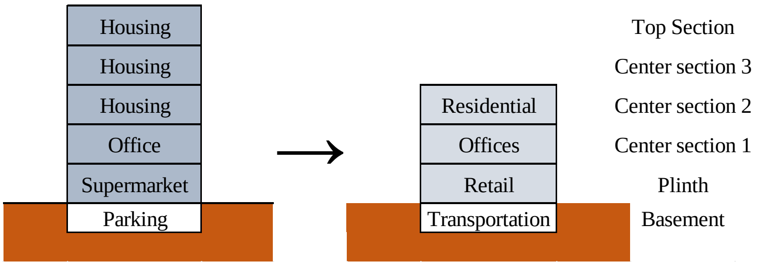



*Figure 10. Floor classification horizontal and vertical (Source: Koops, 2012)*

All the land uses as surrounding parcels have to be assigned as mentioned in table 7. This will result in land use function table. This encounters the horizontal aggregation to obtain the environmental and social compatibility values based on the land use combinations of the case data. The surrounding land use plots can be adjacent, opposite directed and diagonal to the parcel of the subject building. Therefore, a neighbourhood parcel is not always directly attached to the parcel of the subject building (Taleai et al., 2007).

Further, scenario analysis and sensitivity analysis will be applied for this study. The scenario analysis will include scenario building A, B and C and will be compared to the case. Further, two sensitivity analysis will be applied in order to test the robustness of the model and results. However, this should be considered as output of ESIM and will be further elaborated in subparagraph 4.6.2 and 4.6.3.

## 4.5 ESIM Calculation Process

The inputs described in paragraph 4.4 will be included within the computation of the environmental social impact. This basically forms the 'engine' of the ESIM. By incorporating the identified and obtained surrounding neighbourhood and parcels, impact criteria compatibility values and finally the compatibility matrices as input, the environmental and social compatibility values are computed for each floor of the high rise building. This calculation process will be repeated for the scenario and sensitivity analysis. To underline, compatibility values will be calculated in order to present the environmental and social impact. These values obtained from the compatibility matrixes are mentioned as measure unit for the impact level considering the compared land use functions. This paragraph first introduces in subparagraph 4.5.1 the computation model of the reference study of Taleai et al. (2007). Second, subparagraph 4.5.2 the incorporation of the impact radius levels are discussed. Third, subparagraph 4.5.3 mention the horizontal aggregation.

Fourth, 4.5.4 discusses the vertical aggregation. Five, 4.5.5 the final compatibility values will be explained and relies on the input of subparagraph 4.5.3 and 4.5.4. Six, subparagraph 4.5.6 elaborates on aggregation of the impact radius level values into a single value.

The computation process performed in this research is in fact largely retrieved from the study of Taleai et al. (2007) and Koops (2012). Some small adjustments are made in order to steer the computational process to the purpose and scope of this research. These adjustments will be further explained within this chapter and further paragraphs.

### 4.5.1 Background Calculation Process

In the study of Taleai et al. (2007), first, the neighbouring land use functions are determined. After, the Delphi method is applied in order to construct and show the compatibility between the land use functions. In order to quantify this matrix an AHP and pair-wise comparison is executed. The MA-WOA is used for the proposed methodology applies horizontal aggregation, this aggregates values of between the floor level of the subject building and area floor level. These values will be provided by the neighbouring land use at several floors of these adjacent parcels. Horizontal aggregation thus 'aggregates' all the values obtained from the compatibility matrixes. This process results in a single compatibility value for each impact criteria. After this, aggregation in vertical direction is applied to compute compatibility values, between the floor levels of the subject building and the vertical floor levels of the subject building and neighbouring floor levels. This vertical aggregation consists of two aggregation processes V1 & V2. Aggregation of V1 aggregates the compatibility values between the floors of the building itself. V2 relies on the input of the horizontal aggregation values of the building, location or area, and is calculated as the compatibility values between the parcel plots and the subject building (V1).

The last computing step aggregates the three obtained compatibility scores for the different impact radius levels (building, location and area level) into one single value and should perform as the final compatibility score for the high rise building

### 4.5.2 Building, Location and Area Impact

The environmental and social impact radius levels will be aggregated into a single environmental-social impact compatibility value. As noted earlier, three different impact radius levels are included and will thus be considered: building (100m), location (200m) and area level (300m).

First the radius around the subject building is determined. After, it is counted how many land use functions are situated within the impact radius level. Considering the subject floor and the floor of the neighbour land use function the compatibility value from the matrix is noted. This process is repeated for each impact criteria, each neighbouring plot and each impact radius level. After, the horizontal aggregation will be performed.

### 4.5.3 Horizontal Aggregation

This subparagraph is considered as ID 7 in figure 6. This process is noted as 'Horizontal Aggregation' and is inputted by the compatibility matrixes. Horizontal aggregation is needed in order to perform vertical aggregation. The horizontal aggregation aggregates the environmental-social impact values from the neighbouring parcels on subject building, which are located at the same level. This process generate one single value compared to the subject floor's land use function.

However, the process is schematically presented in figure 11 and uses a hypothetical example showing a subject parcel and floor. A comparison should firstly be made with the neighbouring land use functions on plinth level, in this example it results in a set of seven environment-social values.

These values need to be aggregated by executing the horizontal aggregation method. The numbers are obtained from the values in the compatibility matrixes regarding an environmental or social impact. The process is repeatedly performed for each floor level and finally results in fourteen impact criteria compatibility values per floor level. However, it depends neighbouring plots how many floor levels exist, in fact it can be seen as building height. This process performs aggregation in horizontal and diagonal direction on the subject land use function.

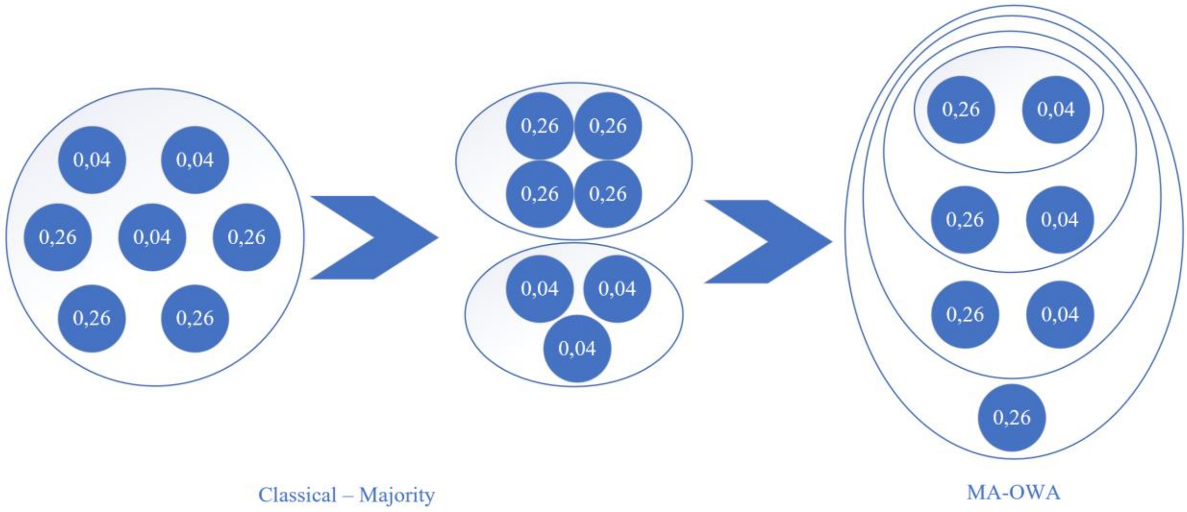



*Figure 11. Horizontal Aggregation example Scenario A plinth level and safety impact - Representation of the classical and MA-OWA aggregation (adopted from fig. 7 in Taleai, Sharifi, Sliuzas, & Mesgari, 2007, p.384).*

The Majority Additive Ordered Weighting Averaging gives basis for the aggregation method. The arithmetic mean is modified and operates for the MA-OWA. This aggregation need to be performed as follows: (1) selecting a single component of each group and aggregate the components; (2) 1 should be subtracted from the cardinality of each group and nullify those groups with a cardinality of 0; (3) the obtained results from the aggregated first two steps, a new group is created with a cardinality of 1 and last (4) previous steps should be repeated until only one group is left. This is presented as the last step in figure 11. As a result an aggregation value is created which represents the majority and indicates the influence of the minority and thus creates a more precise aggregation value (Taleai et al., 2007).

The horizontal aggregation methodology should be computed as follows (Taleai et al., 2007): Firstly, the $A_i$ should be identified by obtaining environment and social impact criteria compatibility values. This can be done by considering the land use function combinations from the environmental-social impact matrix. The extent of the set relies on the amount of neighbours around the subject building. Considering figure 11, for each floor level it will result in a set of seven values. These numbers are obtained from scenario A and involves the case study area.

Consequently if, $A_i = (a_{1i}, a_{2i}, \ldots, a_{ni})$ is a group of environmental and/or social impact values from floor level *i* offering to a particular subject floor and $a$ji ∈ [0.04, 0.04, 0.04, 0.26, 0.26, 0.26, 0.26], then the horizontal aggregate value can be described as:

$$F_i\ (a_{1i},\ a_{2i}, \ldots, a_{ni}) = \sum_{j=1}^{n} w_j \cdot b_j = \sum_{j=1}^{n} f_j(b_1, b_2, \ldots, b_n) \cdot b_j \qquad [1]$$

Where $w_j \in [0,1]$ , $\sum_{j=1}^{n} wj = 1$ and i is the floor level. Additionally, *bj* is the jth largest of the Ai and:

$$w_j = f_j\ (b_1, \ldots, b_n) = \frac{1}{\prod_{k=g_j}^{n} h_k(b_1, \ldots, b_n)} \qquad [2]$$

The function $g_j$ indicates when the $b_j$ element is used in the aggregation process. The function $h_k$ indicates the amount of elements in each step in the aggregation process. Therefore, the following can be noted:

$$h_k(b_1, \ldots, b_n) = \begin{cases} \sum_{j=1}^{n} p_{kj} & if\ k = 1 \\ \sum_{j=1}^{n-k+1} p_{kj} + 1 & otherwise \end{cases}$$

$$p_{kj} = \begin{cases} 1 & if\ j = 1 \quad and \quad k \geq 1 \quad and \quad b_j = b_k \\ 1 & if\ j + k - 1 < n \quad and \quad b_j = b_{j+k-1} \quad and \quad b_j \neq b_{j-1} \\ 0 & otherwise \end{cases}$$

However, the equation and constraints noted above should not be considered within the range of this study. The equation simply presents whether a particular horizontal floor is within the boundary of influence relating to the subject parcel. Since this study relies on impact level calculations within 100m (building level), 200m (location level) and 300m (area level) radius.

To give an computation example, consider figure 12 as a set of horizontal values obtained from the compatibility matrix and land use functions related to the subject parcel, which is retail & catering land use function.

Figure 14 represents a set of impact values on floor $F_i$ (0.04, 0.04, 0,04, 0.26, 0.26, 0.26, 0.26). By performing horizontal aggregation, the following example can be drafted:

$\frac{0.04+0.26}{2} =$ A = 0.15

$\frac{A+0.04+0.26}{3} =$ B = 0.15

$\frac{B+0.04+0.26}{3} =$ C = 0.15

$\frac{C+0.26}{2} =$ D = 0.205

This results that the impact value for a particular impact criteria on a certain floor level would be $F_i$ = 0.205.

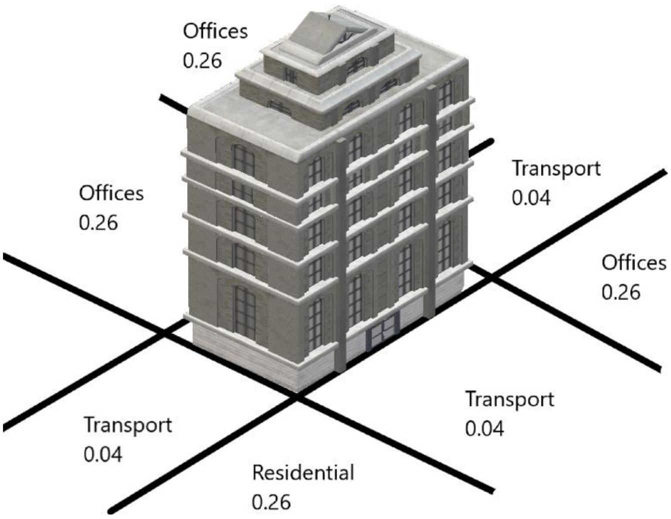



*Figure 12. Example horizontal aggregation level (Source: Taleai et al. 2007)*

### 4.5.4 Vertical Aggregation

This subparagraph is considered as ID 8 and 9 in figure 6. The vertical aggregation process calculates the compatibility between the floors in vertical direction, regarding each impact criteria. The horizontal aggregation process will generate fourteen environmental and social impact values for each floor level. It reflect the possible environmental-social impact related to the near located land use functions. Each generated floor level value, considers that neighbouring land use function exist of different floor levels. The results from the horizontal aggregation will be used as input for the vertical aggregation process. This means that the following step (vertical aggregation) aggregate the certain floor values of the subject building environmental-social value. The next considerations are involved, as also described by Taleai et al. (2007):

1. The weight of the aggregated floor values computed by the horizontal aggregation method for each neighbouring floor is decreasing as the floor distance between neighbourhood floor and subject floor increases.
2. The amount of neighbouring land use functions involved in order to generate aggregated values prior to this stage need to be considered.

Since the vertical aggregation encounters the compatibility between floor levels, the weight factors of the floor distance between neighbourhood floors and subject floor should be identified. Again, the AHP method will be used for this. As in table 9, the same principle for vertical aggregation will be used as presented in table 11 and shows the importance of each floor distance in contrast to other floors. To identify the weight, an assumption was applied that an increase by one unit distance between the subject floor and the other land use functions results in a decrease by one level in importance. Weight determination is performed by a computation of the distance between the neighbourhood floor and subjective floor ($d*$).

*Table 11. Vertical Aggregation Weights Determination*

| Criteria | d*=0 | d*=1 | d*=2 | d*=3 | d*=4 | d*=5 | Geometric mean | Eigenvector | ωd |
|---|---|---|---|---|---|---|---|---|---|
| d*=0 | 1 | 2 | 3 | 4 | 5 | 6 | 2,99 | 0,38 | ω1 |
| d*=1 | 0,5 | 1 | 2 | 3 | 4 | 5 | 1,98 | 0,25 | ω2 |
| d*=2 | 0,33 | 0,5 | 1 | 2 | 3 | 4 | 1,26 | 0,16 | ω3 |
| d*=3 | 0,25 | 0,33 | 0,5 | 1 | 2 | 3 | 0,79 | 0,10 | ω4 |
| d*=4 | 0,20 | 0,25 | 0,33 | 0,5 | 1 | 2 | 0,50 | 0,06 | ω5 |
| d*=5 | 0,17 | 0,2 | 0,25 | 0,33 | 0,5 | 1 | 0,33 | 0,04 | ω6 |

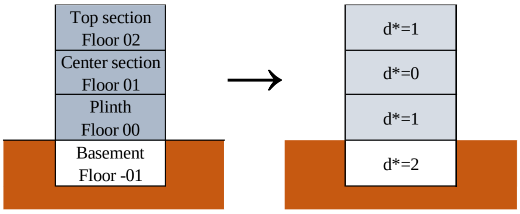


*Figure 13. Distance Determination Vertical Aggregation (Source: Koops, 2012)*

The first step of the vertical aggregation is the computation process of the building itself. This means that the compatibility of the floors of the subject building are determined, regarding to each impact criteria. The study of Taleai et al. (2007) describes this aggregation computation as V1. The computation process for the building environmental and social impact value varies because only a single impact value should be aggregated and is horizontal aggregation obviate. The method for vertical aggregation computing on building level varies therefore as well:

$$F_{\text{subj. building}} = \frac{\Sigma_{i=1}^{n} w_{d*_i} \cdot F_i}{\Sigma_{i=1}^{n} w_{d*_i}} \qquad [3]$$

Here $a_i$ is the environmental-social compatibility value for the land use function on floor level *i* compared with the land use function on the subjective floor.

The following step is the computation of the vertical aggregated values between the adjacent parcels and building (varies due to scenario's A, B, C). The study of Taleai et al. (2007) describes this equation as V2. The weighted average factor is sued to generate vertical aggregated environmental-social compatibility value.

The vertical aggregation method (V2) can be defined as follows:

$$F_{\text{building, location, area}} = \frac{\Sigma_{i=1}^{n} w_{d*_i} \cdot (A_i/T) \cdot F_i}{\Sigma_{i=1}^{n} w_{d*_i} \cdot (A_i/T)} \qquad [4]$$

$A_i$ is the amount of adjacent types of land use functions applied in the horizontal aggregation process of floor level $i$, and $T = \sum_{i=1}^{n} A_i$. The weight factor $w_{d*i}$ for the floor environmental social compatibility value (Fi) mandatory for the level of aggregation process. Where,

$$d *_i = |N_s - N_i| \qquad [5]$$

where d* defines the distance between the neighbouring floor and subjective floor, Ns represents the floor number of the subject land use, N*i* the floor number resulting from the horizontal aggregation process.

Two vertical aggregation calculations will be executed where equation 3 determines the compatibility value impact of the subject building between its' floors. Equation 4 determines the compatibility impact between the subject building and adjacent land use functions on each floor. Finally the V1 and V2 will be combined and show the final compatibility level per impact criteria.

### 4.5.5 Compatibility Value

This subparagraph is considered as ID 10 in figure 6. After the calculation of V1 and V2, the final compatibility value per: floor, impact criteria and impact radius level, can be calculated. The following equation will be used in order to calculate the compatibility value ‘$F_{ESIM}$’.

$$F_{ESIM} = \sqrt[((w_1/w_2)\cdot N_1+N_2)]{(V_1)^{(w_1/w_2)} \cdot (V_2)^{N_2}} \qquad [6]$$

Obviously, V1 and V2 are the compatibility values as calculated in the vertical aggregation. N1 and N2 are the amount of land use functions involved for the calculation of V1 and V2. The W1 and W2 can be obtained from table

*Table 12. Weights for calculating Final Compatibility Value (Taleai et al., 2007)*

| Criteria | Subject Parcel | Neighbourhood Parcel | Geometric mean | Standardized Score | Weight |
|---|---|---|---|---|---|
| Subject Parcel | 1 | 2 | 1,414 | 0,67 | *W1* |
| Neighbourhood Parcel | 0,5 | 1 | 0,707 | 0,33 | *W2* |
| Sum | | | 2,121 | | |

The weight value’s W1 and W2 are indicating the weight of the subject parcel and neighbourhood parcel related to the compatibility value. In this case more weight is placed on the subject parcel, since high rise buildings in this study do have serious impact on the area. However, the deviation between such parcels is only one, since also the influence on the neighbourhood parcels are important.

### 4.5.6 Final Compatibility Value

This subparagraph is considered as ID 11 in figure 6. The compatibility values as described in subparagraph 4.5.5. result in three environmental-social impact compatibility values on the levels of: building, location and area for a particular environmental or social impact criteria. However, the separate values need to be integrated into a single environmental social impact value for the subject environmental-social aspect ($F_{ESA}$). It is mentioned that scale levels will give an improved representation of the environmental and social impacts in the total area. Besides, it is plausible that different scale levels will generate different outputs and thus varies to environmental and social impacts.

Therefore, the next equation should be used in order to calculate the environmental-social compatibility value for a certain environmental or social impact, as Koops (2012) defines it as follows:

$$F_{ESA} = \frac{\Sigma_{i=1}^{n} w_x \cdot F_x}{\Sigma_{i=1}^{n} w_x} \qquad [7]$$

$W_x$ represents the ‘weight’ of the scale level value, $F_x$ is the environmental-social impact value on scale level $x$. The ‘weight’ factors for each scale level and each environmental-social compatibility value will be generated by an expert in the field of urban planning.

This computation process need to be repeated for: each environmental-social aspect; each parcel; each floor; this result in a complete summary of environmental-social impact values for each floor and parcel divided into environmental and social aspects (Koops, 2012).

## 4.6 ESIM Output

The ESIM will provide decision makers several outputs for reducing and mitigating potential impact, this will be explained in this paragraph. The outputs of the tool will indicate the final impact compatibility values of the scenarios by means of tables and other visualisation. These outputs can be used in order to relate to the compatibility of the land use functions within the ‘to be build area’. The biophysical and human environmental conditions will be optimised by using such tools rather than current knowhow and intuitive solutions. This is achieved by means of creating understanding on land use function combinations affecting environmental and social aspects in several manners. Further analysis are made by compare results on a variety of environmental and social impact criteria. First, the ESIM Overview Impact values will be discussed in subparagraph 4.6.1. Second, subparagraph 4.6.2. discuss the scenario analysis which will be utilised by the standards of paragraph 4.5. Third, subparagraph 4.6.3 will describe how the sensitivity analysis will be applied for the purpose of this research.

### 4.6.1 ESIM Overview Impact Values

The first output produces a total overview of the environmental-social criteria compatibility values for each floor level on each parcel in a particular urban environment, however this case relies on a city centre area. This means that ESIM shows which environmental and social impacts account to a floor on a parcel. Also the underlying scores are presented, which can be distinguished into environmental and social separately.

*Table 13. Example ESIM Overview Impact Values Scenario C*

| **Scenario C** | | | | | | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Floor Level** | **Floor Section** | **Floor Name** | **Average Value** | **Average Environmental** | **Average Social** | | | | | | | | | | | | | | |
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,19 | 0,16 | 0,22 | 0,14 | 0,14 | 0,17 | 0,14 | 0,13 | 0,20 | 0,17 | 0,39 | 0,13 | 0,11 | 0,27 | 0,13 | 0,28 | 0,25 |
| 3 | Centre 3 | Residential | 0,20 | 0,16 | 0,23 | 0,15 | 0,15 | 0,19 | 0,14 | 0,13 | 0,22 | 0,17 | 0,39 | 0,13 | 0,12 | 0,29 | 0,18 | 0,28 | 0,25 |
| 2 | Centre 2 | Offices | 0,19 | 0,17 | 0,22 | 0,10 | 0,16 | 0,20 | 0,14 | 0,13 | 0,27 | 0,18 | 0,39 | 0,12 | 0,12 | 0,29 | 0,18 | 0,21 | 0,24 |
| 1 | Centre 1 | Retail & Catering | 0,19 | 0,18 | 0,21 | 0,14 | 0,15 | 0,21 | 0,14 | 0,13 | 0,26 | 0,20 | 0,37 | 0,14 | 0,10 | 0,25 | 0,14 | 0,23 | 0,23 |
| 0 | Plinth | Urban Green | 0,20 | 0,20 | 0,20 | 0,12 | 0,20 | 0,35 | 0,14 | 0,11 | 0,27 | 0,23 | 0,40 | 0,10 | 0,12 | 0,29 | 0,07 | 0,21 | 0,20 |
| -1 | Basement | Parking | 0,17 | 0,17 | 0,18 | 0,12 | 0,17 | 0,11 | 0,14 | 0,09 | 0,21 | 0,34 | 0,40 | 0,13 | 0,11 | 0,15 | 0,06 | 0,19 | 0,20 |

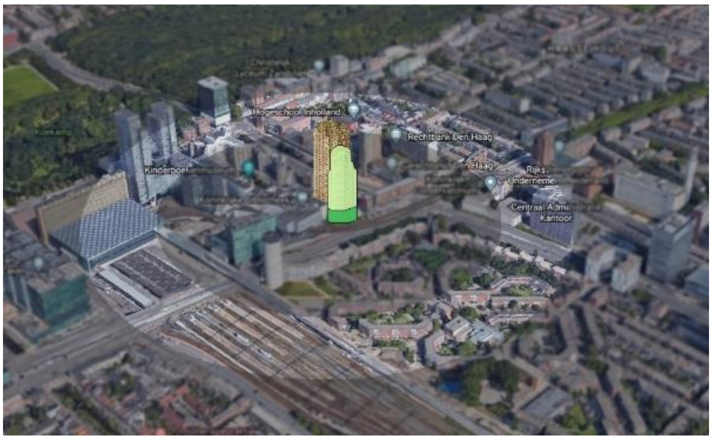



*Figure 14. 3D Area Compatibility Visualisation (Source: Taleai et al., 2007)*

As shown in figure 14, the outputs of the ESIM can be used in order to draft impact maps and provide visualised insights in the severity of the environmental and social compatibility values. The compatibility values regarding the impact criteria should also be assigned by thresholds, as this method is also likely to be used within the EIA and SIA.

The following environmental and social impact thresholds can be defined as follows:

- High Positive Impact: $0.50 \leq F \leq 0.35$
- Moderate Positive Impact: $0.35 \leq F \leq 0.20$
- Neutral Impact: $0.20 \leq F \leq 0.10$
- Moderate Negative Impact: $0.10 \leq F \leq 0.07$
- Highly Negative Impact: $0.07 \leq F \leq 0.04$

By obtaining the numbers from the impact table, such impact compatibility maps can be drafted by for example Revit. The maps can show whether the land use functions could have a positive or negative impact on the environmental and social impacts. Insight can directly be seen as a result of functional intermingling. As alternatives will be compared, improved insight is gained in alternative scores on the building, location and area level on the project.

### 4.6.2 Scenario Analysis

This subparagraph is considered as ID in figure 6. Since the purpose of the ESIM is to show different potential environmental and social compatibilities, the alternatives are presented as land use scenario's (scenario analysis). The scenario's will be included within assessment of the ESIM system. The ESIM include three scenarios and will be compared to the case. The scenarios (A, B, C) of high rise building types within a city centre: A) parking garage, retail & catering and offices; B) parking garage, parking, services & facilities, offices and a urban green roof, C) parking garage, services & facilities, retail & catering, offices, residential and services & facilities ; The case will include a parking garage and subparagraphs of residential purposes. By performing such scenario analysis robustness of the model will be checked and finally the decision making process will be improved.

Common applied functions in high rise buildings will be shortly discussed. High rise buildings become more common within Dutch urban areas. In the past such buildings were only dedicated to centre areas. Ever since the eighties high rise buildings in the Netherlands gain foothold, where city Rotterdam takes the lead. Cities such as Den Haag and Amsterdam developed their high rise buildings near to (public)transportation hotspots. (Zandbelt et al., 2008). As previously mentioned in table 8 and noticed in the study of van Hellenberg Hubar (2009) on high rise buildings and the previously mentioned CID document a Scenario A and Case scenario are commonly applied within high rise buildings and will be presented in figure 15. Scenario B and C are more extreme buildings in order to vary the output of the results.

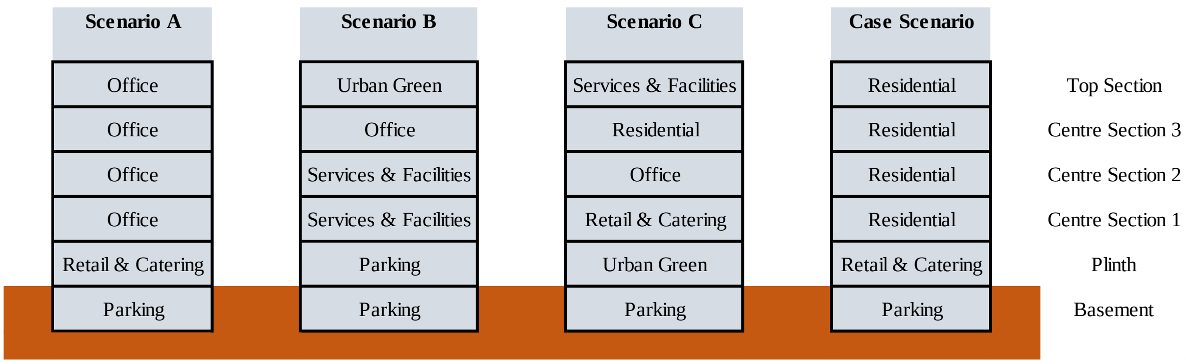



*Figure 15.Land use function scenario's High Rise Buildings*

As a result three scenarios and a case building can be proposed and using as an input for the ESIM. Scenario A will contain office subparagraphs, a catering & retail plinth and a parking garage. Scenario B will include urban rooftop, office subparagraph, two services & facilities subparagraphs, an office plinth and a parking garage. Scenario C will contain services & facilities, a residential subparagraph, office subparagraph, retail & catering, urban green plinth, in the basement a parking garage will be situated. The case scenario will include a retail & catering and further residential functions.

### 4.6.3 Sensitivity Analysis

This subparagraph is considered as ID 14 in figure 6. An sensitivity analysis will be performed on the scenario analysis by means of alter the strength of the difference between compatibility levels impact and summarised scores of table 9. It is expected that some of the results could differ. However, such results shouldn't alter too much, such that different results appear compared to the initial model. By doing so, decision makers will obtain insight in the possible effects due to urban transitions and the construction projects as high rise buildings. This knowledge is essential in order to contribute to a sustainable living environment.

Since the calculations rely on the input from such compatibility impact values, it will contribute towards an improved prediction of model and robustness of this. By performing such sensitivity analysis also the strength between positive and negative compatibility will be visualised. Therefore, the initial input from table 9 will be altered and the weight numbers from Taleai et al. (2007) and Koops (2012) will be used. The study of Taleai et al. (2007) embraces a more negative approach, while Koops (2012) focus more on a negative approach, this can be seen in table 14 and 15. By doing such sensitivity analysis, this study provides insights for equal, positive and negative focus on strength between HPI-MPI-NI-MNI-HNI impacts.

*Table 14. Compatibility levels quantification  (Taleai et al., 2007)*

| Compatability Level | | HPI | MPI | NI | MNI | HNI | Geometric mean | Standardised score |
|---|---|---|---|---|---|---|---|---|
| HPI | Highly Positive Impact | 1 | 2 | 3 | 5 | 7 | 2,91 | 0,43 |
| MPI | Moderate Positive Impact | 0,5 | 1 | 2 | 4 | 6 | 1,89 | 0,28 |
| NI | Neutral Impact | 0,33 | 0,5 | 1 | 3 | 5 | 1,20 | 0,18 |
| MNI | Moderate Negative Impact | 0,2 | 0,25 | 0,33 | 1 | 3 | 0,55 | 0,08 |
| HNI | Highly Negative Impact | 0,14 | 0,17 | 0,2 | 0,33 | 1 | 0,27 | 0,04 |

*Table 15. Compatibility levels quantification (Koops, 2012)*

| Compatability Level | | HPI | MPI | NI | MNI | HNI | Geometric mean | Standardised score |
|---|---|---|---|---|---|---|---|---|
| HPI | Highly Positive Impact | 1 | 3 | 5 | 6 | 7 | 3,63 | 0,51 |
| MPI | Moderate Positive Impact | 0,33 | 1 | 3 | 4 | 5 | 1,82 | 0,25 |
| NI | Neutral Impact | 0,2 | 0,33 | 1 | 2 | 3 | 0,83 | 0,12 |
| MNI | Moderate Negative Impact | 0,17 | 0,25 | 0,5 | 1 | 2 | 0,53 | 0,07 |
| HNI | Highly Negative Impact | 0,14 | 0,2 | 0,33 | 0,5 | 1 | 0,34 | 0,05 |

The tables 14 and 15 provide the quantification of the compatibility matrixes by using the standardised scores. In table 14, it can be seen that the strength between the positive impacts alters by one, the negative impacts alter by two which indicate that there is focus on the negative impacts. In table 15, the opposite occurs where the strength between the positive impacts alter by 2 and the negative by just one, which indicate that there is focus on the positive impacts.

## 4.7 Conclusion

In chapter 4 the Environmental Social Impact Model is discussed. Paragraph 4.1 discussed the background and overview of the ESIM. Paragraph 4.2 mentioned the purpose of such comprehensive model. Paragraph 4.3 discussed the integrated impact criteria framework which is used for assessing the compatibility matrixes. Paragraph 4.4 mentioned the input of the calculation process described in paragraph 4.5. After, paragraph 4.6 discussed the output of the ESIM. The paragraphs are discussed sequentially.

The development of the ESIM involved a combination of two methodologies namely: AHP method and aggregation methodology (MA-OWA) which is introduced by study of Taleai et al. (2007). For this study little adjustments are made as this is based on the thesis of Koops (2012). It can be said that the described methodology is based on the study of Taleai et al. (2007) and Koops (2012).

The existing methodology within the EIA and SIA shows that the possible impacts are estimated by the screening and scoping approach. However, these processes have some issues regarding the accuracy of the estimation and also mapping stakeholders' values. Consequently, this means that solutions are based on knowhow and intuition, rather than systematic assessed indicators.

Hence, ESIM will give an overview of the potential impacts and solutions, further the provided solutions based on intuition will also decline. As afore mentioned the study of Taleai et al. (2007) is suitable for using and fits to the purpose of this research. This is because Taleai et al. (2007) developed a urban decision tool which contains, MCE-analysis, AHP and MA-OWA. This included impact calculations on horizontal and vertical level which makes this appropriately for impact calculations on high rise buildings. The model shows were future and possible conflicts could occur to due intermingling of land use types. As part of it, the Delphi method is also used for drafting the compatibility matrix regarding conflicting land use intermingling. However, this method is adjusted due to the time limit of the research this means that the included environmental and social impact criteria are separately judged by experts. Further, the amount of land use functions are limited and related to common functions within a city centre area.

A total of fourteen environmental and social impact criteria are included within this research. After some additional literature study and judgement of experts, fourteen environmental and social impact criteria are included. Each environmental social impact criteria need to be stressed by a compatibility matrix (derived from the Delphi Method). This gives insight into the environmental-social impact resulting from combining land use functions, relating to a single environmental or social impact criteria. The experts were asked several questions to fill in such compatibility matrix.

However, as concerned the qualitative assessment by the experts need to be quantified. Therefore, the Analytical Hierarchy Process (AHP) and structured pair-wise comparison are used in order to quantify the land use compatibility matrixes regarding each environmental and social impact criteria.

The second input for this research relies on the data which is related to the project characteristics. Several steps are needed in order to provide a satisfying dataset (e.g. identifying parcels, obtain land use functions). The last step in preparation process of the case study data is to define impact radius levels. In the ESIM three scale levels can be noticed: building level, location level and area level. As the area impact radius level is not considered in the study of Taleai et al. (2007) this research approach this dimension within the radius of 300 meters from the initial object. The levels are used for presenting the compatibility values.

The majority additive-ordering weighing averaging (MA-OWA) and AHP method are the theoretical foundation for the purpose of developing an aggregation method in the study of Taleai et al. (2007). Here, the proposed methodology first aggregates the compatible values of each floor level (horizontal aggregation). These values will be provided by the neighbouring land use at several floors of these adjacent parcels. Horizontal aggregation thus 'aggregates' all the obtained values which belong to the same floor and output a single value for a separate neighbouring floor and resulting in a single compatibility value for each floor. The next step contains the vertical directed aggregation to compute a unique value, on its turn this indicates aggregated compatibility value based on the values obtained by the land use functions placed at the different floors (vertical) of the neighbouring parcels.

The ESIM will provide decision makers several outputs for reducing and mitigating potential impact and impact reduction can be significantly improved. The outputs of the tool will indicate the final impact values of the scenarios by means of tables, graphical representations and visualisation. These outputs can be used in order to relate to the compatibility of the land use functions within the 'to be build area'. On its turn, the biophysical and human environmental conditions will be optimised by using such tools rather than current knowhow and intuitive solutions. This is achieved by means of creating understanding on land use function combinations affecting environmental and social aspects in several manners. However, as the EIA and SIA, also ESIM relies on the input of external stakeholders. In this research the involvement of such stakeholders is limited, however this is encountered by include experts from municipality, consultancies (spatial economics, economics, environment, urban planning, social studies) and environmental backgrounds.

# 5. ESIM Application

In this chapter the ESIM will be applied by means of the previous discussed chapter 4. First, the case study will be introduced where the ESIM will be applied upon. Second, the case characteristics will be discussed. Third, the compatibility matrixes will be analysed, since the judge of the experts are related to the case study and these matrixes are a result when applying the ESIM. Fourth, the function compatibility will be discussed, here the horizontal aggregated compatibility values are discussed. Fifth, the scenario alternatives will be highlighted again, in order to refresh. Sixth, the ESIM output and results will be discussed, here the case will be compared to the scenario alternatives. Also the sensitivity analysis will be discussed. Finally, the most suitable building will be presented. The ESIM is a tool which can predict and estimate the potential compatibility of the building within a particular environment. In this report the compatibility scores will be showed for each floor level of the high rise building on each environmental and social impact criteria. Seventh, the conclusion will be presented. In previous paragraphs the methodology and data were discussed, however this chapter will actually perform the ESIM. The initial scope of the research is to involve also the social impacts. By doing so, a better understanding and estimation of the consequences of high rise constructions can be given. The model shows the compatibility of the building within a city centre environment and by including different scenario's an optimal division of floor levels can be proposed. The ESIM and the scenario analysis are performed within the case study area and a realistic illustration of the outcomes can be presented.

## 5.1 Case Study

The case study is a project which involves two high rise towers considering Dutch standards. The 'Grotius Torens' are situated in the city centre of Den Haag and will have around 600 apartments in different segments, the plinth of the building provides space for commercial purposes. The height of one building is 100m and the other 120. The high rise residential buildings are located in a dense area, near to public transport hubs, office buildings and retail & catering. In fact, the hotspots of the city are walkable from the Grotius Torens. The two buildings are named Grotius Toren I and Grotius Toren II, building I contains 39 levels and building II 32, where building I has a surface of 32084m² and building II 18043m².

*Figure 16. Grotius Torens I&II and Area (Source: Google Earth, 2019)*

The area around the Grotius Torens can be described diverse and alive. Several different and typical city centre land use functions can be noticed. There is a mix of living, shopping, working and transportation in this area. Therefore, this area has a typical character of a city centre and dense area. In some places of the area mid -and low-rise buildings are situated and typical dwellings. However, by constructing a high rise building of +100m the current urban environment could be unbalanced referring to several impact criteria.

## 5.2 Case Characteristics

The ESIM depends on the input of the parcels in the case area, for instance to calculate the horizontal aggregation of the scenario's. The case area is divided into three impact radius levels of 100m, 200m and 300m. By using Google Earth and Sketchup the impact circles can be drawn and after the parcels are labelled by parcel id's. Each id's is assigned to a particular land use functions, but also the levels of the parcels and buildings are identified. Within the radius of 300m, 68 parcel are identified and can be found in Appendix C is depicted in figure 17.

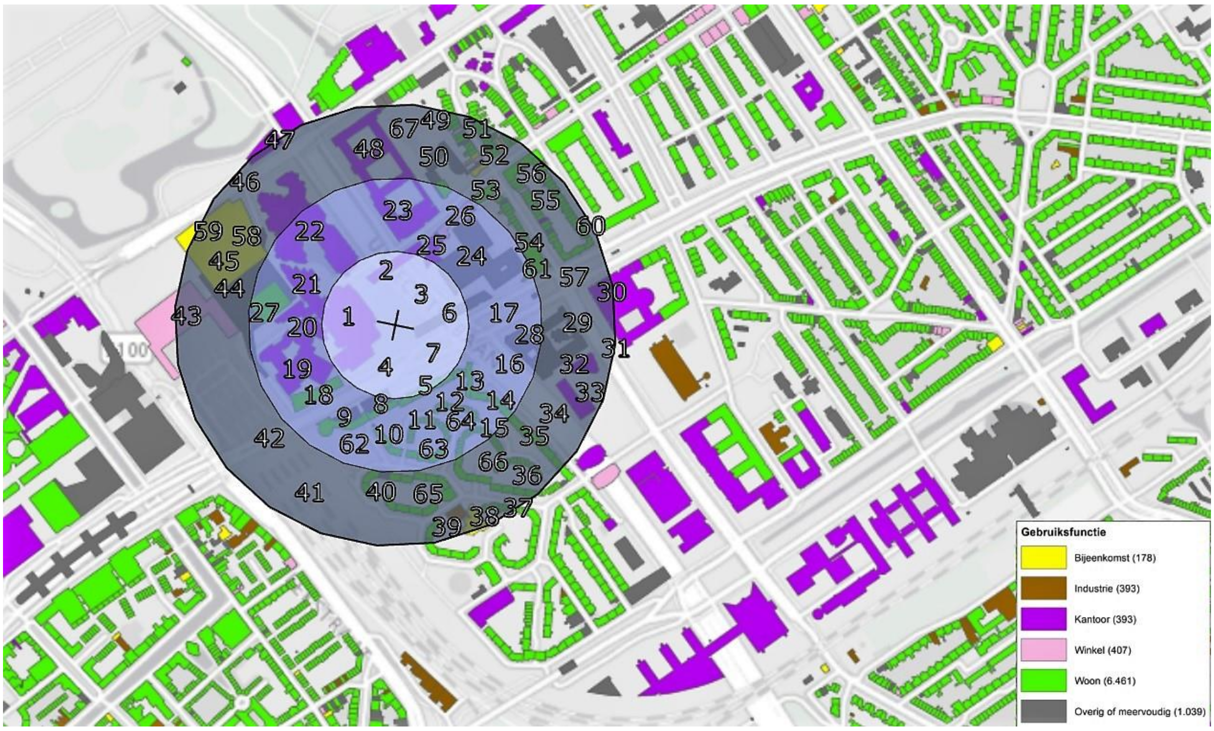



*Figure 17. Parcel ID Overview Case Area*

By using land use functions map, Google Earth and Sketchup it was easy to identify the height and specific functions of each parcel. After, the parcels were further detailed into a particular level and an overview is created of parcel id and level identification. As can be seen in figure 17, the most common functions within all impact levels are office and residential functions. The remaining functions can be identified as, retail & catering, urban green, transportation (public transport, parking, etc.). An overview of the parcel id plots are also shown in Appendix C.

## 5.3 Compatibility Matrixes Analysis

Since the compatibility matrixes are dependent on the case characteristics, this paragraph continues on the data collection and analysis for the input (paragraph 4.4) of the ESIM calculations as presented in paragraph 4.5.At first the data collection for constructing an environmental social compatibility matrix is discussed. The experts filled in the compatibility matrixes towards the case area. Those matrixes will be used in order to quantify the compatibility value for each impact criteria on each floor, for instance at the horizontal aggregation. The matrixes will be shortly discussed and analysed in order to see what to what extent a particular environmental or social impact criteria is affected due to a certain land use combination. Besides of this, the weight levels of each impact criteria will also be addressed, then it becomes clear at what impact level radius (100-200-300m) a particular environmental or social impact criteria has the highest weight. The chapter is concluded by remarking the data collection and analysis of this.

**Compatibility Matrixes Collection:**

In total 18 typical urban land use combinations were judged by each expert. Experts with different backgrounds and studies were involved for assessing the compatibility matrixes. Not only, matrixes were filled in by experts but also additional information was asked e.g. potential specified impacts relating to a particular main impact criteria, for instance: main impact criteria was landscape/visual impact, experts added specific impacts as shading and wind hinder due to high rise buildings. Further, experts from different branches were involved to encounter a full scope of knowledge. These branches, consist of an consultancy office, municipality and environmental advisory. In the next paragraph the data is reviewed for consistency, irrationality, therefore it can be seen if the matrixes are encountered by logical reasoning. By doing so, the reliability of the outcomes will be enhanced.

**Compatibility Matrixes Review:**

The collected data as described in subparagraph 4.4.1 is used to construct and quantify fourteen impact criteria matrixes. The experts filled in whether a particular land use combination relating to a particular environmental or social impact criteria considering the five-point scale. Each impact criteria will be shortly discussed in order to provide insight of scores. However, not all matrixes will presented in this paragraph but will be shown in Appendix B. In Appendix B, the remaining compatibility matrixes are shown towards each discussed impact criteria.

*Landscape and Visual Impact*

Considering table 16, it can be observed that addition of urban green areas will positively influence the area since it is known that such land use functions will stimulate the impact on landscaping and visual aspects.

*Table 16. Quantification Matrix Landscape and Visual Impact*

| Quantification Landscape and Visual Impact | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,26 | | | | | |
| Offices | 0,26 | 0,26 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,07 | | | |
| Services and facilitie: | 0,14 | 0,14 | 0,26 | 0,14 | | |
| Urban green areas | 0,14 | 0,14 | 0,14 | 0,14 | 0,50 | |
| Transportation | 0,14 | 0,14 | 0,14 | 0,14 | 0,07 | 0,14 |

Further, some combinations will also have positive influence on the environment, since some combinations will not disturb the current area, a combination of residential and residential land use functions will probably not affect human dimensions. Also a mix of office and dwellings according to experts will not disturb the area, but could contribute on visual aspect. Further, the mix of transportation and urban green areas will result in a negative impact, this is plausible result.

In dense build urban areas, human dimensions could decrease where orientation and feeling of the 'human dimension' will get lost, this means that for instance the design of the plinth should be carefully designed and idealistic the building should be constructed from street level (Zandbelt et al., 2008).

*Water impact*
In the matrix regarding water impact it can be seen that these mentioned phenomenon's are particularly common, when for instance urban green areas is mixed with residential functions. This results in a positive impact (0,50) since impacts are related to human conditions. There are negative impacts (0,07) which accounts for the mix of offices to residential which indicates a probably increase of pavement around the area and results in a higher negative impact on water. Detailed overview of compatibility table can be found in Appendix B.

*Ecology Impact*
As can be seen in the matrix in Appendix B, urban green areas will positively affect the impact on ecology. This means when urban green areas are mixed with other land use functions it could be said that this will stimulate or positive affect the impact criteria ecology. Further, the matrix shows that all other land use mixes will negatively affect the ecology. Especially, land use function transportation will negatively affect ecology in combination with other land use functions, here the lowest impact value (0,04) is assigned to.

*Soil Impact*
As can be observed in the compatibility matrix, in Appendix B, it can be seen that addition or a mix of different land uses have a neutral impact (0,14), it is assumed that the city area is already paved and do not need further adaption. However, only addition of urban green areas will lead to a positive impact (0,5) towards soil impact. Detailed overview of compatibility table can be found in Appendix B.

*Noise Impact*
This compatibility matrix as presented in Appendix B. Here, transport and residential land use functions indicates highly negative impact (0,04), which is plausible since additional transport will negatively impact human living conditions. Also, this is indicated relating to office and a moderate negative impact is observed (0,07).

*Air Quality Impact*
In the compatibility matrix in Appendix B, it can be seen that especially accommodations such as offices and residential purposes face negative impacts. Others, have neutral impacts, such as retail and catering. Urban green areas bring positive impacts, further Dutch cities embrace sustainable transportation and due to this land use function it is also assumed that moderate positive impacts will occur. Except transportation in combination on urban green areas.

*Transport Impact*
A negative impact (0,07) is observed when residential functions are added to existing residential functions. This means that additional people will living within a particular area and thus the demand and pressure on transport grows. This also is the case for offices and residential functions, were more commuters will make use of transport functions. Furthermore, when for instance the same land use functions are combined it is estimated that more pressure will occur on transport (retail & catering + retail & catering). It is self-evident that when transport is added to residential functions a positive impact occurs (0,50). Detailed overview of compatibility table can be found in Appendix B.

*Population Impact*
The strengthening of residential functions is assumed to be positive (0,5) for the area, giving the fact that high rise buildings in city centres (e.g. Den Haag) should contain 30% of social housing and therefore stimulates population and cultural diversity. This also is the case adding other land use functions to residential areas, where more diversity is created and a vibrant area will be achieved, a positive impact (0,5) is thus expected. Except for offices to offices, a negative impact is expected since a monotone culture will arise. Other land use combinations have impacts which are relatively positive (0,26) or neutral (0,14). Detailed overview of compatibility table can be found in Appendix B.

*Housing Impact*
In the compatibility matrix in Appendix B, it is observed that most of the additional land use functions will have a neutral impact. However, it is expected that retail & catering will have a positive impact (0,26) on residential function. Adding urban green areas will have a negative impact (0,07) since there is less space to be built for houses, which will increase housing prices and thus affordability. It could be argued that high rise buildings will be a solution for this type of aspect. Also addition on services & facilities on retail & catering is positively addressed (0,26) by an expert and prevent that a particular area will deteriorate and housing in as a broad concept will benefit. This is also the case for transportation.

*Services Impact*
As seen in the compatibility matrix in Appendix B, the overall judgment of experts indicate that mixes of land use functions will result in a neutral impact. Also here, urban green areas will consume space which could be used for other land use functions and thus have negative impacts (0,04). Further, it is assumed that the more people will migrate to a city area, more services should be situated and therefore has a positive impact (0,50), this also applies for offices which has a slightly lower positive impact (0,26).

*Health & Well-being Impact*
Considering the compatibility matrix in Appendix B, results and impacts seems plausible. For instance, the mix of residential and residential will result in a negative effect (0,07) where social cohesion will decrease and therefore also quality of life. This is also the case if more offices will be constructed within the area, a more monotone area will be created and negative consequences (0,07) are foreseen. However, an addition of catering, retail and services is estimated to have a positive impact (0,26) on the area, since these for instance will provide additional healthcare and/or leisure activities. Addition of urban green areas to residential functions and office functions will result into a positive effect (0,5), this is more or less self-evident. Transportation is assumed to be negatively (0,07) since this could decrease air quality and further could cause noise and danger.

*Safety Impact*
Looking at the compatibility matrix in Appendix B, intermingling offices in an residential area would have positive (0,50) impact on the human environment. Here it is assumed that more buzz is created within the area and more people will moving in and out the area, it is expected that crowded area will increase the feeling of safety amongst people. This is also the case for retail & catering in mix with residential and office land use functions, again it is assumed that more people will move in the area and crowding as a result, a moderate positive impact (0,26) is estimated. Additional urban green areas such as parks will decrease the feeling of safety and would have a negative impact (0,26). Further, transportation will also decrease the feeling of safety (0,04).

*Community Impact*
Especially the residential, retail, services, urban green areas and transportation land use functions do show a positive impact on community in a particular area. It is argued that for instance more people within an area will increase social cohesion, for instance experts mention that in the Netherlands it is common to have a neighbourhood association which is beneficial for social interactions. This is also the case for retail & catering, where people do have options to meet (e.g. in pubs, restaurants) and thus increase social interactions. Also urban green areas will contribute to this phenomenon and transportation could is beneficial in such way that more convenience is provided to the neighbourhood. However, a mix of offices within a residential area will have a negative impact as also transportation on green urban areas. Detailed overview of compatibility table can be found in Appendix B.

*Local Economy Impact*
The compatibility matrix in Appendix B, regarding local economy on the environment is shows relatively positive impacts. Especially a mix of residential and office functions indicates a positive impacts regarding economic opportunities for the area. As noted by an expert that more people within a particular area, will increase economic situation overall, contributing by numbers of people who seek for jobs, shop and will visit bars and restaurants and thus result in a positive impact (0,50). Further, offices will contribute moderately positive by providing jobs, but also employees who contribute knowledge and visit local restaurants (0,26). Further, additional retail & catering, services & facilities will attract more people into a particular area and benefit (0,26) on their behalf of the economic situation. Transport will positively influence retail & catering and services & facilities, since more people and a wider range of people could visit such places and thus have a moderately positive impact (0,26).

*Criteria Weight Impact*
As discussed in the methodology impact radius levels are used for the calculation of compatibility values. Therefore, each impact criteria is also assessed by an expert. Each expert is asked to what extent a particular impact criteria encounters more 'weight' by impacting a certain land use function.

In fact, a regular AHP method is conducted in order to determine the weight of the impact criteria for the impact radius levels (building, location, area). Questions related to decision making are asked, for instance: comparing A to B which is more importance, and indicate this importance by a number between 1-9. Further, the 'intensity' the value (1-9) is defined and explained to the experts. This will also contribute towards an improved consistency ratio. This calculation process as an AHP can be seen Appendix A. The weights as presented in table 17 will be used at the last calculation step of the ESIM, in order to aggregate the impact radius level compatibility values into a single value, as discussed in subparagraph 4.5.6.

*Table 17. ESIM Impact Criteria Weights*

| Level | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services/ facilities | Health/ Well-being | Safety | Community | Local economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building | 0,2 | 0,11 | 0,08 | 0,18 | 0,12 | 0,1 | 0,12 | 0,1 | 0,18 | 0,07 | 0,07 | 0,1 | 0,1 | 0,1 |
| Location | 0,6 | 0,18 | 0,73 | 0,71 | 0,65 | 0,26 | 0,48 | 0,26 | 0,71 | 0,28 | 0,28 | 0,64 | 0,64 | 0,64 |
| Area | 0,2 | 0,71 | 0,19 | 0,11 | 0,23 | 0,64 | 0,4 | 0,64 | 0,11 | 0,65 | 0,65 | 0,26 | 0,26 | 0,26 |
| Total W ≤ 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Land Use Compatibility Overview:**
In previous paragraph (52) the matrixes were separately discussed and impact compatibility values per land use function were discussed regarding a single environmental and social impact criteria. As this step is performed a total overview of all matrixes should be presented 1) by providing an overview of positive impacts and 2) by providing an overview of negative impacts. By doing so, insight is obtained into the total environmental and social impact for each land use function combination.

*Positive Compatibility*

Positive compatibility exists of two degrees of impact, highly positive impact and a moderate positive impact. In table 18, all positive impacts are included and an overview is given. For instance, land use functions retail & catering and offices are estimated to have a positive impact for six compatibility matrixes.

*Table 18. Overview Positive Compatibility*

| | **Residential** | **Offices** | **Retail and catering** | **Services and facilities** | **Urban green areas** | **Transportation** |
|---|---|---|---|---|---|---|
| Residential | 5 | | | | | |
| Offices | 5 | 3 | | | | |
| Retail and catering | 6 | 6 | 1 | | | |
| Services and facilities | 4 | 5 | 7 | | | |
| Urban green areas | 8 | 8 | 5 | 5 | 6 | |
| Transportation | 4 | 4 | 6 | 5 | 2 | 3 |

Given this example, table 18 can be further discussed and conclusions can be drafted:

1. No function combinations show a positive impact regarding all fourteen impact criteria.
2. There are two most suitable land use combinations which are residential and office functions combined with urban green areas, in table 18 it can be seen that eight of the fourteen compatibility matrixes are positively judged.
3. In fact three land use functions show a matching compatibility, which are residential functions, urban green areas and offices.
4. The remaining land use functions also indicate some positive impacts, but seems to be less compatible within the area.

*Negative Compatibility*

The overview of the negative compatibilities in table 19, is based on the same principle as table 18. However, table 19 indicates the estimated negative impacts and more or less incompatible land use functions. Here the amount of highly and moderately negative impacts are presented.

*Table 19. Overview Negative Compatibility*

| | **Residential** | **Offices** | **Retail and catering** | **Services and facilities** | **Urban green areas** | **Transportation** |
|---|---|---|---|---|---|---|
| Residential | 5 | | | | | |
| Offices | 4 | 5 | | | | |
| Retail and catering | 2 | 2 | 2 | | | |
| Services and facilities | 2 | 2 | 2 | 3 | | |
| Urban green areas | 3 | 2 | 3 | 3 | 1 | |
| Transportation | 4 | 4 | 3 | 3 | 6 | 2 |

Given the above mentioned conclusions can be drafted based on table 19:

1. Transportation is the most incompatible land use function, this seems plausible since this could cause, increasing traffic flows, reduce air quality, increase noise hinder. Further, table 16 also indicate less positive compatibility compared to other land use functions;
2. A saturation or addition of the land use functions as residential and office will more or less result in incompatibility regarding the impact criteria. However, on average table 16 indicates that residential and office land use functions are compatible towards other land use functions;
3. The most negative impact is caused by transportation and urban green areas. This seems likely since such combination cause ecological damage, decreases air quality etc.;
4. Retail & catering and facilities & services show both a relatively low amount of negative impacts. It can be said that these land use functions could be mixed with other land use functions without altering or damaging the area severely.

Overall, urban green areas are indicated to have the most positive impact on the environment. This seems likely since for instance parks, lawns, and green surfaces increase the liveability and health in an urban environment and could e.g. encounter social interactions, leisure and physical activities. A saturation of residential and office land use functions could cause some issues, also this seems plausible since for instance additional individuals on a particular area could cause traffic jams and put pressure on public transport. This is also the case for office land use functions. The most incompatible land use combination can be addressed to transportation and urban green areas. As explained this combination is also likely. However, for each project type the values could differ and cannot be seen as a point of reference.

**To conclude:**
It can be observed that urban green areas would have a positive impact on the area and shows the highest compatibility. In fact three land use functions show a matching compatibility, which are residential functions, urban green areas and offices. However, the impact criteria are judged as equally important and will vary once a real project is performed and multiple stakeholders are involved.

Both office and residential land use functions show both positive as well negative impacts within the area. These land use functions do not show a high compatibility for constructing within an area and attention should be paid on the possible negative consequences. Although residential and office land use functions are not an optimum for compatibility, it is realistic that such functions will be constructed within a particular area. Therefore additional attention should be paid to negative consequences which could come forward due to these land use functions.

## 5.4 Function Compatibility

This paragraph relates to the horizontal aggregation, where the horizontal compatibility values are obtained. As described earlier in the methodology, a particular function combination related to a certain impact criteria will result in an impact number. In order to execute the ESIM, the function combinations for each scenario should related to each parcel should be indicated and enlisted in order to obtain the horizontal aggregation values. However, by giving already an overview of the impact values related to the case building a first glimpse of the compatibility can be indicated.

Considering the compatibility matrix, a relative mono function will probably result in a high compatibility on the environmental or social aspect. A mix of land use functions will probably result in a diverse and balanced compatibility scores on environmental and social aspects. The introduction (chapter 1) shortly discussed that a new approach in urban planning in the Netherlands is desirable. This new approach is called 'METRO-mix' and mention that a diverse land use function intermingling is essential in order to maintain a liveable urban environment also regarding current living trends.

This is also one of the reasons why scenario analysis is applied within this report, besides testing the robustness and finding more interesting results when applying only mono function buildings. Two example are given, where Scenario A facilitates offices and Scenario C facilities mix of functions. Note that this example only shows the direct result of function intermingling towards horizontal impact and not the end result.

*Table 20.Example Horizontal  Scenario Impact*

| | **Landscape** | **Water** | **Ecology** | **Soil** | **Noise** | **Air Quality** | **Transport** | **Population** | **Housing** | **Services & Facilities** | **Health & Well-being** | **Safety** | **Community** | **Local Economy** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario A | 0,14 | 0,14 | 0,04 | 0,14 | 0,14 | 0,25 | 0,14 | 0,50 | 0,26 | 0,14 | 0,26 | 0,26 | 0,26 | 0,26 |
| Scenario C | 0,14 | 0,50 | 0,50 | 0,50 | 0,14 | 0,49 | 0,14 | 0,50 | 0,07 | 0,04 | 0,50 | 0,07 | 0,44 | 0,26 |

On average mono functions such as office or residential buildings results in a more relatively high social compatibility, but lower environmental compatibility. It can be observed that such environmental aspects have neutral impacts, but does not necessarily mean that attention should be ignored. When applying a diverse and mix of land use functions the impact criteria are more equal and balanced on average. On average Scenario A shows a higher social compatibility and lower environmental compatibility, where Scenario B shows on average higher environmental However, the application of the results relies on the scope and vision of the municipality or other governmental party.

However, it can be seen that on average a mono function scenario contribute towards an lower environmental, but higher social compatibility compared to a diverse function scenario. Therefore, it cannot be said which scenario has the best fit for a particular area, since this could rely on the scope and vision of the municipality. Eventually, by combining the land use functions an optimal scenario can be found.

## 5.5 Scenario Alternatives

For executing the ESIM four alternatives are constructed and tested. The case scenario is leading and therefore scenario A, B and C are compared to the case. The case and scenario A are situated with mono functions and scenario B, C can be defined as more extreme and hypothetical buildings. By applying such scenario analysis a better understanding of the compatibility values of each floor and the building itself can be initiated. By analysis the results of each scenario an optimal building division can be found. The scenario alternatives will be shortly discussed.

Scenario A:
This scenario is a typical office building, where on -1 subparagraph is assigned to parking, the plinth (subparagraph 0) for retail & catering and the remaining subparagraphs 1, 2, 3 and 4 are facilitated for offices. This scenario could likely be constructed in an city centre area, especially such as described above.

Scenario B:
This scenario is a more extreme and hypothetical scenario. The basement and plinth are assigned for parking, subparagraph 1 and 2 are realised for services & facilities, the third subparagraph is assigned to offices and the top floor (4) for urban green. This building is somewhat hypothetical and can be judged as expensive.

Scenario C:
Also this scenario is a relatively extreme scenario where a mix of several land use functions is situated. The mix of different land use functions at different floor levels will contribute towards better insights in compatibility of the high rise building. However, again at -1 parking is situated, plinth facilitates urban green, centre subparagraph 1 retail & catering, centre subparagraph 2 Offices, centre subparagraph 3 residential and top floor services & facilities.

## 5.6 ESIM Output & Results

Once the ESIM calculated the scenario's a comparison can be made and the most suitable or optimal building in the case area can be selected. The weights of the impact criteria are equally divided. The presented values in table 21 indicate of each scenario and case the compatibility compared to the plots within the case area. It can be seen that the scenario C has the best overall/average score, however, this is close to the case. However, the case average is relatively high since the residential floors contribute towards a high social compatibility. Considering the overall score of scenario C, it exceeds other scenarios and is a well-balanced building regarding the compatibility scores.

*Table 21. Overall Final Compatibility Scores Scenario's*

| | **Landscape** | **Water** | **Ecology** | **Soil** | **Noise** | **Air Quality** | **Transport** | **Population** | **Housing** | **Services & Facilities** | **Health & Well-being** | **Safety** | **Community** | **Local Economy** | **Average** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario A | 0,18 | 0,14 | 0,05 | 0,14 | 0,14 | 0,20 | 0,16 | 0,37 | 0,21 | 0,18 | 0,17 | 0,21 | 0,19 | 0,26 | 0,19 |
| Scenario B | 0,17 | 0,15 | 0,07 | 0,16 | 0,10 | 0,22 | 0,37 | 0,42 | 0,14 | 0,15 | 0,11 | 0,09 | 0,23 | 0,19 | 0,18 |
| Scenario C | 0,14 | 0,25 | 0,29 | 0,31 | 0,14 | 0,30 | 0,16 | 0,26 | 0,11 | 0,24 | 0,21 | 0,11 | 0,31 | 0,23 | 0,22 |
| Case | 0,18 | 0,11 | 0,06 | 0,15 | 0,14 | 0,18 | 0,16 | 0,49 | 0,22 | 0,23 | 0,18 | 0,23 | 0,24 | 0,30 | 0,21 |

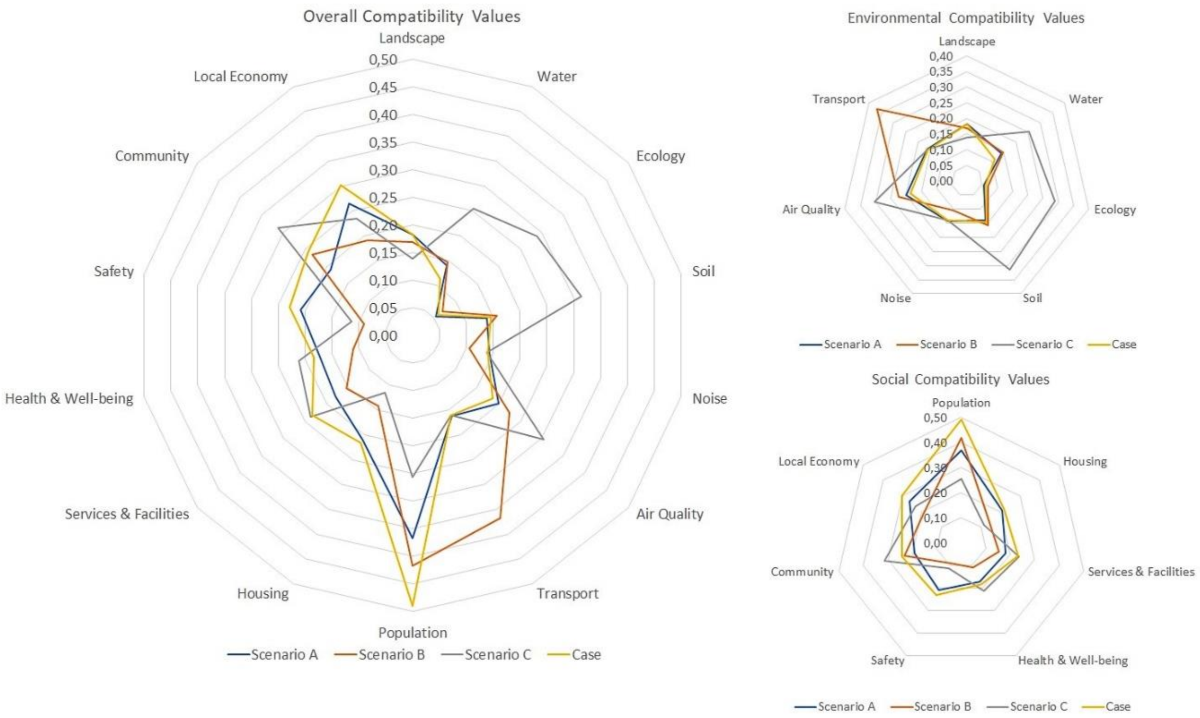



*Figure 18. Compatibility Values Scenario A, B and C & Case*

The graph presented in figure 18 shows the overall score, but also the scores of the environmental and social compatibility separately. By doing so, better insight is obtained between the scores of the scenario's. It could occur that on average a scenario scores poorly on environmental, but high on social and on average it therefore scores relatively high. However, at the same time another scenario scores 'quite' good on both aspects, but the average score is lower. By only looking at the average compatibility score a one sided interpretation can be obtained, therefore the environmental and social compatibility scores should be involved when discussing the results. The results in figure 18, can be related to the compatibility scores in table 21.

The mono functions as scenario A and Case, score relatively high on the social impacts. Further, it can be seen that the mixed functions (especially scenario C) have a moderate high compatibility on all the impact criteria, compared to the monofunctional buildings. Therefore, figure 18, provides insight into particular environmental or social impact criteria. Here, also outliers can be mentioned, as for instance the case scenario scores high on population, while scenario B scores high on transport and scenario C scores higher on the environmental impact criteria.

The results in table 21 show that Scenario C is the most compatible building for the case area, with an average compatibility score of 0,22. This scenario scores relatively 'good' on several impact criteria. When considering figure 18, it can be seen that scenario C scores on several compatibility scores higher than all the other scenario's and also the case. Also in the environmental overview scenario C outsources the other scenarios. Scenario C, scores on most of the impact criteria relatively high and can therefore be noted as the most important. Further, the mono function buildings (scenario A and case) show a high compatibility related to the social aspects, but score low on the environmental aspects. However, considering the compatibility scores in Appendix C and results in chapter 6 it can be seen that such mono functions will have a neutral to low compatibility on environmental aspects, but are estimated to have higher compatibility on social aspects and will for instance increase the economic situation in a particular area. Scenario B has the lowest average compatibility value, however, this scenario is more or less the same as scenario C. The lower scores of scenario can be explained by the fact that more parking is facilitated within the building.

Besides of the base analyses, it is also vital to perform analysis by alter the compatibility values in the compatibility matrix (see table 14 and 5) and can be mentioned as a sensitivity analysis. Therefore, a positive and negative approach can be utilised. It is interesting to analyse how Sensitivity analysis 1 (based on table 14) and Sensitivity 2 (based on table 15) will relate to the 'base' analyses.

The same table as in the base scenario (table 21) can be created for both sensitivity analyses. The sensitivity analyses do have a more negative (sensitivity 1) and positive approach (sensitivity 2) than the base scenario. The following results can presented and form table 22 and a full overview can be found in Appendix E and F.

*Table 22. Overall Compatibility Scores Sensitivity 1 & 2*

| | **Landscape** | **Water** | **Ecology** | **Soil** | **Noise** | **Air Quality** | **Transport** | **Population** | **Housing** | **Services & Facilities** | **Health & Well-being** | **Safety** | **Community** | **Local Economy** | **Average Compatibility** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sensitivity 1 | | | | | | | | | | | | | | | |
| Scenario A | 0,22 | 0,18 | 0,06 | 0,19 | 0,18 | 0,22 | 0,17 | 0,33 | 0,23 | 0,21 | 0,19 | 0,23 | 0,22 | 0,29 | 0,21 |
| Scenario B | 0,21 | 0,19 | 0,07 | 0,20 | 0,14 | 0,25 | 0,33 | 0,37 | 0,18 | 0,19 | 0,13 | 0,10 | 0,26 | 0,22 | 0,20 |
| Scenario C | 0,18 | 0,27 | 0,28 | 0,34 | 0,18 | 0,30 | 0,19 | 0,24 | 0,13 | 0,24 | 0,22 | 0,13 | 0,32 | 0,26 | 0,23 |
| Case | 0,22 | 0,15 | 0,07 | 0,19 | 0,18 | 0,21 | 0,19 | 0,43 | 0,25 | 0,24 | 0,22 | 0,26 | 0,26 | 0,31 | 0,22 |
| Sensitivity 2 | | | | | | | | | | | | | | | |
| Scenario A | 0,16 | 0,12 | 0,06 | 0,13 | 0,12 | 0,20 | 0,15 | 0,38 | 0,20 | 0,16 | 0,17 | 0,21 | 0,18 | 0,26 | 0,18 |
| Scenario B | 0,15 | 0,13 | 0,07 | 0,14 | 0,10 | 0,23 | 0,38 | 0,43 | 0,12 | 0,14 | 0,10 | 0,09 | 0,22 | 0,17 | 0,18 |
| Scenario C | 0,12 | 0,26 | 0,32 | 0,35 | 0,12 | 0,30 | 0,14 | 0,24 | 0,11 | 0,24 | 0,22 | 0,11 | 0,31 | 0,21 | 0,22 |
| Case | 0,19 | 0,10 | 0,07 | 0,13 | 0,12 | 0,15 | 0,15 | 0,49 | 0,23 | 0,26 | 0,21 | 0,23 | 0,24 | 0,30 | 0,20 |

Both sensitivity analyses do show more or less the same results as the base scenario. In both analyses Scenario C seem to be the most suitable option for in the area. Again, Scenario C does not outsource all impact criteria, but has an acceptable compatibility score on the overall environmental -and social impact criteria. In fact, all the scenarios to show more or less the same results as in the base scenario. Also the ranking scores of each impact criteria are the same. By providing reasoning to the sensitivity analyses it can be said that Scenario C it the most suitable building for the case area.

*Table 23. Overview Compatibility Score Scenario C*

| Scenario C | | | | | | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Floor Level** | **Floor Section** | **Floor Name** | **Average Value** | **Average Environmental** | **Average Social** | | | | | | | | | | | | | | |
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,19 | 0,16 | 0,22 | 0,14 | 0,14 | 0,17 | 0,14 | 0,13 | 0,20 | 0,17 | 0,39 | 0,13 | 0,11 | 0,27 | 0,13 | 0,28 | 0,25 |
| 3 | Centre 3 | Residential | 0,20 | 0,16 | 0,23 | 0,15 | 0,15 | 0,19 | 0,14 | 0,13 | 0,22 | 0,17 | 0,39 | 0,13 | 0,12 | 0,29 | 0,18 | 0,28 | 0,25 |
| 2 | Centre 2 | Offices | 0,19 | 0,17 | 0,22 | 0,10 | 0,16 | 0,20 | 0,14 | 0,13 | 0,27 | 0,18 | 0,39 | 0,12 | 0,12 | 0,29 | 0,18 | 0,21 | 0,24 |
| 1 | Centre 1 | Retail & Catering | 0,19 | 0,18 | 0,21 | 0,14 | 0,15 | 0,21 | 0,14 | 0,13 | 0,26 | 0,20 | 0,37 | 0,14 | 0,10 | 0,25 | 0,14 | 0,23 | 0,23 |
| 0 | Plinth | Urban Green | 0,20 | 0,20 | 0,20 | 0,12 | 0,20 | 0,35 | 0,14 | 0,11 | 0,27 | 0,23 | 0,40 | 0,10 | 0,12 | 0,29 | 0,07 | 0,21 | 0,20 |
| -1 | Basement | Parking | 0,17 | 0,17 | 0,18 | 0,12 | 0,17 | 0,11 | 0,14 | 0,09 | 0,21 | 0,34 | 0,40 | 0,13 | 0,11 | 0,15 | 0,06 | 0,19 | 0,20 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,24 | 0,24 | 0,24 | 0,15 | 0,30 | 0,28 | 0,34 | 0,16 | 0,32 | 0,14 | 0,23 | 0,13 | 0,32 | 0,18 | 0,12 | 0,40 | 0,28 |
| 3 | Centre 3 | Residential | 0,25 | 0,25 | 0,24 | 0,16 | 0,31 | 0,30 | 0,34 | 0,15 | 0,34 | 0,14 | 0,23 | 0,13 | 0,34 | 0,18 | 0,15 | 0,40 | 0,28 |
| 2 | Centre 2 | Offices | 0,24 | 0,25 | 0,23 | 0,13 | 0,32 | 0,31 | 0,35 | 0,15 | 0,37 | 0,14 | 0,23 | 0,13 | 0,33 | 0,18 | 0,14 | 0,35 | 0,27 |
| 1 | Centre 1 | Retail & Catering | 0,22 | 0,24 | 0,21 | 0,14 | 0,28 | 0,29 | 0,33 | 0,14 | 0,33 | 0,14 | 0,20 | 0,12 | 0,28 | 0,15 | 0,12 | 0,34 | 0,24 |
| 0 | Plinth | Urban Green | 0,24 | 0,28 | 0,20 | 0,13 | 0,36 | 0,40 | 0,42 | 0,13 | 0,38 | 0,15 | 0,16 | 0,08 | 0,35 | 0,13 | 0,08 | 0,35 | 0,23 |
| -1 | Basement | Parking | 0,23 | 0,26 | 0,20 | 0,14 | 0,36 | 0,26 | 0,36 | 0,13 | 0,37 | 0,19 | 0,16 | 0,10 | 0,36 | 0,10 | 0,08 | 0,36 | 0,25 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,19 | 0,19 | 0,19 | 0,15 | 0,14 | 0,28 | 0,32 | 0,14 | 0,20 | 0,13 | 0,28 | 0,11 | 0,10 | 0,33 | 0,10 | 0,24 | 0,17 |
| 3 | Centre 3 | Residential | 0,20 | 0,20 | 0,19 | 0,15 | 0,14 | 0,29 | 0,33 | 0,14 | 0,21 | 0,12 | 0,28 | 0,11 | 0,10 | 0,34 | 0,11 | 0,24 | 0,17 |
| 2 | Centre 2 | Offices | 0,20 | 0,20 | 0,19 | 0,13 | 0,14 | 0,30 | 0,34 | 0,14 | 0,23 | 0,13 | 0,28 | 0,10 | 0,10 | 0,35 | 0,11 | 0,22 | 0,17 |
| 1 | Centre 1 | Retail & Catering | 0,20 | 0,21 | 0,19 | 0,14 | 0,14 | 0,33 | 0,36 | 0,14 | 0,24 | 0,14 | 0,29 | 0,10 | 0,08 | 0,35 | 0,10 | 0,24 | 0,16 |
| 0 | Plinth | Urban Green | 0,22 | 0,24 | 0,19 | 0,13 | 0,15 | 0,42 | 0,43 | 0,13 | 0,26 | 0,15 | 0,31 | 0,09 | 0,07 | 0,39 | 0,08 | 0,24 | 0,15 |
| -1 | Basement | Parking | 0,19 | 0,21 | 0,18 | 0,13 | 0,14 | 0,28 | 0,36 | 0,13 | 0,24 | 0,18 | 0,31 | 0,09 | 0,07 | 0,31 | 0,07 | 0,23 | 0,15 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,22 | 0,22 | 0,22 | 0,15 | 0,24 | 0,26 | 0,30 | 0,15 | 0,27 | 0,14 | 0,27 | 0,13 | 0,23 | 0,23 | 0,12 | 0,34 | 0,25 |
| 3 | Centre 3 | Residential | 0,23 | 0,22 | 0,23 | 0,16 | 0,25 | 0,28 | 0,30 | 0,15 | 0,29 | 0,14 | 0,27 | 0,13 | 0,25 | 0,23 | 0,15 | 0,34 | 0,25 |
| 2 | Centre 2 | Offices | 0,22 | 0,23 | 0,22 | 0,12 | 0,25 | 0,29 | 0,31 | 0,14 | 0,32 | 0,15 | 0,27 | 0,12 | 0,24 | 0,23 | 0,14 | 0,30 | 0,25 |
| 1 | Centre 1 | Retail & Catering | 0,21 | 0,22 | 0,20 | 0,14 | 0,23 | 0,28 | 0,30 | 0,14 | 0,30 | 0,15 | 0,25 | 0,12 | 0,20 | 0,21 | 0,12 | 0,30 | 0,23 |
| 0 | Plinth | Urban Green | 0,23 | 0,26 | 0,20 | 0,13 | 0,29 | 0,39 | 0,37 | 0,13 | 0,33 | 0,17 | 0,24 | 0,09 | 0,25 | 0,21 | 0,08 | 0,30 | 0,21 |
| -1 | Basement | Parking | 0,21 | 0,23 | 0,19 | 0,13 | 0,28 | 0,23 | 0,31 | 0,12 | 0,31 | 0,22 | 0,24 | 0,10 | 0,25 | 0,15 | 0,07 | 0,30 | 0,22 |

Further, it is interesting to see the compatibility scores of each scenario per building level and per floor. However, in this case only the results and interpretation of scenario C will be discussed, since this is on average the most suitable scenario for the case area. The remaining base scenarios are depicted in Appendix D. The table above (table 23) shows the compatibility scores of each impact level and also each floor level.

By doing so, a better estimation and insight is obtained and thus provided by ESIM. The impact of scenario C differs per impact level, however this can be explained by the fact that in each impact level several different functions are situated which are have a higher or lower compatibility value with the floor level of the subject building. As the results in table 21 and figure 18 show, is that scenario C is suitable at most of the impact criteria. Looking at the results, scenario C has neutral impacts but at most times moderate positive impacts. This is also the case for each floor. By performing ESIM for the compatibility values for each floor level and each impact criteria become clear. As a result, adaption and improved measures can be implemented for the building in order to increase the compatibility value for the area. However, as discussed previously the weight for each impact criteria can be changed depending on the vision and policy of a governmental party and therefore another compatibility value or even suitable building could appear.

As a part of this report the compatibility values will be visualised for each floor and each impact level. Therefore, a 3D map is created to show the compatibility of the subject building of each floor for each impact level. By providing such 3D maps, better and clear insight is obtained between the subject building and its' area for that particular area, as can be seen in figure 19.


*Figure 19. Compatibility Visualisation Scenario C*

Figure 19 shows the compatibility of the impact radius levels of the high rise building in the case area. The left building shows that on building level there is a neutral compatibility for all floor levels. The second building shows on location level there is also a neutral compatibility for all floor levels. The third building on the right, shows that here is on area level a moderate positive impact for plinth level and neutral compatibility for the remaining floor levels.

## 5.7 Conclusion

Chapter 5 discussed the results of the ESIM. The base scenario and sensitivity 1& 2 were also discussed and compared. It could be seen that Scenario C in the base scenario as well as in the sensitivity analyses was the most suitable scenario. It was observed that the case scores were close to the scenario C, but this can be explained by the fact that the case scenario showed high compatibility scores on social impact criteria. However, by discussing the paragraph 5.7 two sub-questions can be answered:

*D. To which extent does a functional combination in a high rise building contribute to the environmental and social impacts?*

*E. Which functional combination of a high rise building results in the less environmental and social impacts by means of scenario analysis?*

As a result of the ESIM, it showed that mono functional building do actually differ significantly from those buildings facilitating several different land use functions. The results indicate that mono functions such as office buildings or residential buildings do have a high compatibility on the social aspects. However, the environmental compatibility is much lower compared to the mixed functions. At one hand a concentration of mutual functions in the same area causes environmental damage.

While, at the other hand social impacts benefit from mono functions, since for example offices could increase the economic situation, or residential buildings could for instance provide a wider range of dwellings type. A mix of land use functions contribute towards a more balanced compatibility. It does not have high compatibility values on particular impact criteria, but scores relatively 'good' at the overall impact criteria. As a result the 'mixed' buildings score quite good on environmental compatibility compared to the mono functions. However, the social compatibility values of the 'mixed' buildings are lower compared to the mono functions. It is already described that for instance a concentration of residential functions will improve the housing environment. Further, the mix of land use functions in a building have a wider range of compatibilities. Therefore, a relative moderate compatibility score can be noted in the results.

Relating to sub-question E, scenario C is the most suitable scenario for the case area. The mix of functions provide a wide range of suitable compatibility values. The biggest contribution to the environmental compatibility is caused by urban green on the plinth. Further, the contribution of the social impacts is supported by the offices, residential functions, retail and services & facilities. Besides of this, it can be seen that there is not a concentration of one or two functions which increases the overall compatibility values of most of the impact criteria. However, most suitable is relative, since a land use vision or municipality could assign weights to a particular impact criteria.

For instance, if the social impacts are more important than the environmental impacts, the case scenario or scenario A would be a suitable alternative. However, when environmental aspects are more important scenario B and C would be more suitable. Therefore, the sub-questions can be answered, but in practice it depends on the weights of the impact criteria which scenario or division of land use functions is most beneficial for the area.

Hence, the ESIM provides a detailed insight into the compatibility values of each floor and also each impact level (radius). Therefore, improved predictions and accurate consequences can be obtained due to this tool. Each impact has a compatibility score, therefore measures can be undertaken to improve the possible consequences. Besides, by further analyses the relation between impact criteria can be investigated, it is possible that certain impact criteria are related. Further, the ESIM tool is project dependent, for instance if only residential functions are located in the area air quality, transport and other social aspects could differ.

# 6. Conclusion

The current practice and literature shows that social aspects are more or less neglected and too less attention is paid to when developing urban plans. Furthermore, a comprehensive supportive assessing tool is missing and decisions are made on intuition and current knowhow. Additionally to this, current urban planning is becoming complex due to increasingly demanding urban environments, urban and related social trends. For instance urbanisation is increasing and therefore cities do need to construct high rise buildings. This is examples are for instance indicated within the National Governmental document 'Metro-Mix'. A need is observed to combine a relatively pragmatic assessment tool. This could include EIA aspects as well as SIA aspects, this phenomenon is also noted in the literature study. A strength is observed that an EIA could include a SIA in order to improve predictions of potential impacts. Since (urban) sustainability is an increasingly consciously matter, for instance the ESIM tool could help to obtain more insight into urban impacts due to high rise buildings projects. Due to this improved insight, a long term and well functionating urban living environments could be created.

However, the EIA and SIA are relatively broad and can be used for multiple project types. No specific guidelines do exist for each separate project type. This can be explained by the fact that each project is more or less exclusive and is situated within a unique area. Here, experts are asked to make an overview of the potential impacts due to the project and will later on be critically judged. This can be described as 'screening and scoping' process within an EIA or SIA. In fact in the screening process the potential impacts are enlisted by intuition and knowhow. Later on in the scoping process, the potential impacts are ranked by importance and scoped/filtered by experts. Only the urgent potential impacts are finally included within the scoping process and besides a detailed overview of impacts on the area is made. However, the practice shows that the 'experts' face difficulties when performing the screening and scoping process, due to lacking experience of practitioners. Further, directives and guidelines within the EIA are incomplete and are not satisfying for a branch as the construction industry and urban planning. This results in an incomplete and inaccurate results.

Given the above mentioned issues, this report performed a study to construct the environmental and social framework related to the urban environment. Later on, experts are asked to note their specific concerns related to the proposed impact criteria obtained from the literature study. However, the literature study for each impact assessment system involved 13 journal articles. In total 20 main impact criteria were enlisted and after applying filtering only 14 main impact criteria remained. For each impact assessment system seven impact criteria were used in this report. As mentioned experts gave their review regarding impact criteria related to high rise building projects. This report also included social impacts and typical potential consequences were mentioned such as: impact on housing due to gentrification, possible increase of services and facilities and its' transport issues, affection on population by mitigation or crowding, safety issues etc. However, also on the environmental impacts regarding high rise building issues were noted for instance; landscape/visual impact due to shadow and wind hinder, transport issues due to concentration of people on a relative small area. Therefore, external review of experts is necessary in order to construct a specific impact criteria list regarding high rise buildings. As mentioned, guidelines in the EIA and SIA are relatively broad, therefore literature study and external review is necessary to construct a well-developed impact criteria list.

For analysing the environmental and social impacts the methodology of Taleai et al. (2007) is largely used and the methodology is guided by the study of Koops (2012). This study proposes to use a majority additive-ordered weighing averaging (MA-OWA). Compared to OWA, MA-OWA indicates also a influence of the minority rather than only the majority, this means that more accurate results appear. In the study of Taleai et al. (2007) Delphi method is used in order to check the compatibility of land use functions, however, in this report compatibility matrixes are used in order to obtain the compatibility of land use functions related to a single environmental or social impact criteria. These matrixes are judged by several experts.

After, the horizontal aggregation values could be obtained, which indicate the horizontal floor level compatibility of the subject building related to the case area plots around the building. This horizontal aggregation counts as input for the vertical aggregation values. Finally, the compatibility values per floor level and per building scenario alternative can be presented. In this report three different scenarios were used (A, B, C) and a case scenario. Scenario A and Case scenario were typical high rise building as can be found in city areas; office and a residential buildings with a typical plinth and parking in basement. Compared to the mixed buildings (B and C) are typical phenomenon was visible in the results. The monofunctional buildings (A and Case) showed a significant difference in social compatibility, however a poor environmental compatibility when comparing to the mixed buildings (B and C). This can be explained by the fact that for instance a mix of dwellings will increase the housing situation in the area or an office building is expected to have a positive effect on the feeling of safety and increasing economic situation. The mixed buildings do contribute towards a quite ‘well’ compatibility value overall. However, in the results it can be seen that addition of urban green in the plinth floor level, does positively affect the environmental compatibility values.

As mentioned will the mixed land use functions in high rise buildings affect the compatibility values positively at an overall value. Especially, scenario C with urban green at the plinth will contribute towards a positive compatibility environmental value, where other functions such as: retail & catering, offices, residential functions and services contribute towards a positive social compatibility. However, this building is practically not profitable and would thus not be constructed on regular basis. Hence, a mix of functions will result suitable building in the case area, however it is important that urban green will be added in or closely around the building. Further, will mix of different functions contribute towards a positive social compatibility. As mentioned, mono functions will only contribute to a high social compatibility and relatively lower environmental compatibility. However, a most suitable building is not real existing, since this depends on the weights of each impact criteria. For instance, when too much expensive dwellings and facilities are located within a particular area, gentrification process could be initiated. This results that the current urban environment will change and have a significant impact regarding social aspects and therefore the case scenario is the most suitable. It could also be that the emphasis is on the environmental impact criteria and scenario C is the most suitable building. However, this is not involved in the scope of this research.

The above noted answers the sub-questions and therefore now the main question can be answered. The ESIM includes also social impact criteria besides of the environmental impact criteria obtained from the EIA, SIA and in depth literature study and review of experts. The methodology used from Taleai et al. (2007) allows to test and perform systematically the comprehensive tool in order to measure the compatibility value of high rise building relating to its’ area. By doing such analysis, in depth insight is created for optimising the function division of floors within the high rise building. Therefore, building characteristics can be adapted in early design phase to its’ area and increase the compatibility values of each impact criteria. Besides, appropriate measures can be undertaken in order to reduce the biggest concerns of the stakeholders. As mentioned a ‘most suitable building’ depends on the perspectives of the stakeholders and/or governmental parties. This indeed depends on the scope and weighing of impact criteria of the municipality to create a long term durable living environment. For instance, when too much expensive dwellings and facilities are located within and around the high rise building, gentrification process could be initiated. This results that the current urban environment will change and have a significant impact regarding some social aspects.

By using the ESIM and thus involving also social impact criteria rather than only environmental impact criteria a better prediction and estimation of the potential impacts on the urban area can be made. Especially, when it is known that these two type of impact criteria are strongly related. This could for instance be useful to developed a sustainable long term well functional urban environment.

# 7. Discussion

As known is the ESIM a comprehensive tool which systematically analysis to potential impacts on the urban environment, as well on the environmental as on the social domain. The current screening and scoping is currently too limited and the ESIM provides more insight into the potential impacts. Several studies note that an increasing use of social impacts into an pragmatic assessment system such as the EIA is needed. The SIA follows the same process steps as the EIA and an integration of both assessment systems seems feasible, since both could maintain the pragmatic application of it. It is discussed that due to increasing complexity of urban environments a SIA would improve the prediction of potential impacts. This is also the case for high rise buildings, which can be judged as complex building with an significant impact on the area. Besides, social and environmental impacts are related and such inclusion would indeed improve such predictions of potential effects.

To continue on the inclusion of social impacts, this study involved several experts with each their own background. However, it would be better to involve social experts who detailed knowledge about the social impacts. For instance the impact on health & well-being is an example where a social expert could be involved. This will definitely increase the reliability of the data and results. Further, the included impact criteria are described relatively broad. It could be interesting to see which specific impact criteria are affected by high rise buildings and the urban environment. Also the available literature is somewhat minimal when considering the impact caused by high rise buildings. However, therefore also experts should be involved by judging such impact criteria.

The ESIM encountered a few land use types in the compatibility matrixes. In order to have an even more accurate prediction, only a few specific land use functions should be involved. In the study of Taleai et al. (2007) a detailed overview of possible land use combinations are described. For instance, the compatibility matrixes could include the dwelling types as social housing, expensive housing, semi attached housing etc. could be involved to have precise prediction rather than judge residential as a whole. This could also apply for offices, where small offices, mid-size offices large size offices could be included with. By doing so, the impacts for several types of specific land use functions are obtained and a more detailed overview of the results can be presented.

However, as discussed in the conclusion a mix of land use functions within a high rise building an optimal setting. An overall positive compatibility value can be noticed. An optimal setting is of course depended on the vision and involvement of other stakeholders. This report did not encounter the involvement of stakeholders, but did included some experts of different types of companies to have a wider range of interests. Therefore, inclusion of weights per impact criteria would be a recommendable addition for this study. For instance as in the conclusion described, reference projects can be given where social impacts are underestimated, such as the Bijlmer wijk in Amsterdam and Schilderswijk in Den Haag. Here, too much focus on one particular dwelling type (social housing) was initiated. Consequently, this resulted in a deteriorated area with high crime levels and poor economic situations. So, given the above described scenario a higher weight could be assigned to the impact criteria ‘housing’. By assigning weight to impact criteria other results could appear and another building type would be more suitable in a particular area.

Further, Python was used in order to calculate the input for the final results. However, Python is compatible with several other programmes such as QGIS, by combining these programmes, more accurate data and results can be obtained.

It can be said that ESIM is succeeded in predicting the potential compatibility and impact values of the fourteen impact criteria. Considering the above mentioned discussing points, several improvements should be added to the tool in order to have even more precise data and results. Hence, insight is obtained for each floor and each impact criteria by applying ESIM. Combining environmental and social impacts in such tool an improved prediction can be made of the final compatibility value.

# References


Ahmad, B., & Wood. (2002). A comparative evaluation of the EIA systems in Egypt , Turkey and Tunisia. *Environmental Impact Assessment Review*, *22*, 213–234. https://doi.org/10.1016/S0195-9255(02)00004-5

Alshuwaikhat, H. M. (2005). Strategic environmental assessment can help solve environmental impact assessment failures in developing countries. *Environmental Impact Assessment Review*, *25*, 307–317. https://doi.org/10.1016/j.eiar.2004.09.003

Arce-Gomez, A., Donovan, J. D., & Bedggood, R. E. (2015). Social impact assessments: Developing a consolidated conceptual framework. *Environmental Impact Assessment Review*, *50*, 85–94. https://doi.org/10.1016/j.eiar.2014.08.006

Arslan, G., & Sev, A. (2014). High-Rise Residential Environments. *3rd International Environment and Design Congress*, 1–12. Retrieved from https://www.academia.edu/11057600/SIGNIFICANT_ISSUES_IN_AND_AROUND_HIGH-RISE_ENVIRONMENTS

Barton, H. (2009). Land use planning and health and well-being. *Land Use Policy*, *26*(1), 115–123. https://doi.org/10.1016/j.landusepol.2009.09.008

Becker, H. A. (2001). Social impact assessment. *European Journal of Operational Research*, *128*(2), 311–321. https://doi.org/10.1016/S0377-2217(00)00074-6

Bocquier, P. (2014). World urbanization prospects: An alternative to the UN model of projection compatible with the mobility transition theory. In *Demographic Research* (Vol. 12). https://doi.org/10.4054/DemRes.2005.12.9

Burdge, R. J., & Vanclay, F. (1996). Social impact assessment: A contribution to the state of the art series. *Impact Assessment*, *14*(1), 59–86. https://doi.org/10.1080/07349165.1996.9725886

Burinskien, M., Bielinskas, V., Podviezko, A., Gurskiene, V., & Maliene, V. (2017). Evaluating the Significance of Criteria Contributing to Decision-Making on Brownfield Land Redevelopment Strategies in Urban Areas. *Sustainability*, *9*(759), 1–17. https://doi.org/10.3390/su9050759

Canter, L. W., & Canty, G. A. (1993). Impact significance determination-Basic considerations and a sequenced approach. *Environmental Impact Assessment Review*, *13*(5), 275–297. https://doi.org/10.1016/0195-9255(93)90020-C

Chadwick, A. (2002). Socio-economic Impacts: Are They Still the Poor Relations in UK Environmental Statements? *Journal of Environmental Planning and Management*, *45*(1), 3–24. https://doi.org/10.1080/09640560120100169

Dendena, B., & Corsi, S. (2015). The Environmental and Social Impact Assessment: a further step towards an integrated assessment process. *Journal of Cleaner Production*, *108*, 965–977. https://doi.org/10.1016/j.jclepro.2015.07.110

Dietz, T., Rosa, E. A., & York, R. (2009). Environmentally Efficient Well-Being: Rethinking Sustainability as the Relationship between Human Well-being and Environmental Impacts. *Human Ecology Review*, *16*(1), 114–123. Retrieved from https://www.jstor.org/stable/24707742

Donnelly, A., Dalal-Clayton, B., & Hughes, R. (1998). *A Directory of Impact Assessment Guidelines* (Second). Retrieved from https://books.google.nl/books?hl=nl&lr=&id=SVsEYo9h924C&oi=fnd&pg=PA4&ots=Ka2i16JcUX&sig=SZKt7Wdo6hb1LPdkunpDLrnKaVM&redir_esc=y#v=onepage&q&f=false

Esteves, A. M., Franks, D., & Vanclay, F. (2012). Social impact assessment : the state of the art. *Impact Assessment and Project Appraisal*, *30*(1), 34–42. https://doi.org/10.1080/14615517.2012.660356

Gemeente Den Haag. (2018). *Policy Campus Centraal: Gebiedsagenda Overkluizing Utrechtsebaan*.

Gemeente Rotterdam, & Waterschap Hollandse Delta. (2013). *Herrijking Waterplan Rotterdam: Werken aan water voor een aantrekkelijke en klimaatbestendige stad*. Retrieved from https://www.rotterdam.nl/wonen-leven/waterplan-2/

George, C., & Kirckpatrick, C. (2007). *Impact Assessment and Sustainable Development: European Practice and ExperienceTitle*. Retrieved from https://books.google.nl/books?hl=nl&lr=&id=XzNmAwAAQBAJ&oi=fnd&pg=PA15&dq=sustainable+development+faber+2005&ots=IjSlm9tJZN&sig=ob_Tbocj9ziIzIml89ovhIBqYdQ#v=onepage&q=sustainable development faber 2005&f=false

Gifford, R. (2014). The Consequences of Living in High-Rise Buildings. *Architectual Science Review*, *50*(April), 2–17. https://doi.org/https://doi.org/10.3763/asre.2007.5002

Giyasov, B., & Giyasova, I. (2018). The Impact of High-Rise Buildings on the Living Environment. *High-Rise Construction 2017 (HRC 2017)*, *33*(E3S Web Conf.), 1–7. https://doi.org/https://doi.org/10.1051/e3sconf/20183301045

Haapio, A. (2012). Towards sustainable urban communities. *Environmental Impact Assessment Review*, *32*(1), 165–169. https://doi.org/10.1016/j.eiar.2011.08.002

Hansen, E., & Wood. (2016). Understanding EIA scoping in practice: A pragmatist interpretation of effectiveness. *Environmental Impact Assessment Review*, *58*, 1–11. https://doi.org/10.1016/j.eiar.2016.01.003

Hayati, H., & Sayadi, M. H. (2012). Impact of tall buildings in environmental pollution. *Environmental Skeptics and Critics*, *1*(1), 8–11.

He, J., Bao, C. K., Shu, T. F., Yun, X. X., Jiang, D., & Brwon, L. (2011). Framework for integration of urban planning, strategic environmental assessment and ecological planning for urban sustainability within the context of China. *Environmental Impact Assessment Review*, *31*(6), 549–560. https://doi.org/10.1016/j.eiar.2010.09.002

Hobma, F. A. M., & Jong, P. (2016). *Planning and development law in the Netherlands*.

Horton, F., & Reynolds, D. (1971). Effects of Urban Spatial Structure on Individual Behavior. *Economic Geography*, *47*(1), 36–48. https://doi.org/http://dx.doi.org/10.2307/143224

Huesca-pérez, M. E., Sheinbaum-pardo, C., Köppel, J., Elena, M., Sheinbaum-pardo, C., & Köppel, J. (2018). From global to local : impact assessment and social implications related to wind energy projects in wind energy projects in Oaxaca , Mexico. *Impact Assessment and Project Appraisal*, *36*(6), 479–493. https://doi.org/10.1080/14615517.2018.1506856

Koomen, E., Stillwell, J., Bakema, A., & Scholten, H. J. (2007). Modelling Land-Use Change: Progress and Applications. In *GeoJournal* (Vol. 90). https://doi.org/10.1007/978-1-4020-5648-2

Koops, J. (2012). *A functionalistic approach for assessing sustainability impacts in an urban environment*.

Lawrence, D. P. (2007). Impact significance determination-Back to basics. *Environmental Impact Assessment Review*, *27*(8), 755–769. https://doi.org/10.1016/j.eiar.2007.02.011

Li, D. H. W., Yang, L., & Lam, J. C. (2013). Zero energy buildings and sustainable development implications e A review. *Energy*, *54*, 1–10. https://doi.org/10.1016/j.energy.2013.01.070

Lockie, S. (2001). SIA in review SIA in review : setting the agenda for impact. *Impact Assessment and Project Appraisal*, *19*, 277–287. https://doi.org/10.3152/147154601781766952

Loomis, J. J., & Dziedzic, M. (2018). Evaluating EIA systems effectiveness: A state of the art. *Environmental Impact Assessment Review*, *68*, 29–37. https://doi.org/10.1016/j.eiar.2017.10.005

Mahmoudi, H., Renn, O., Vanclay, F., Hoffmann, V., & Karami, E. (2013). A framework for combining social impact assessment and risk assessment. *Environmental Impact Assessment Review*, *43*, 1–8. https://doi.org/10.1016/j.eiar.2013.05.003

Mcdonald, R. I., Green, P., Balk, D., Fekete, B. M., Revenga, C., & Todd, M. (2011). Urban growth, climate change, and freshwater availability. *PNAS*, *108*(15), 6312–6317. https://doi.org/https://doi.org/10.1073/pnas.1011615108

Montano, M., & Pereira de Souza, M. (2015). *Environmental impact assessment as a tool for urban environmental planning and management in Brazil – a case of a mid-sized city*. Retrieved from https://www.researchgate.net/publication/268375549

Morgan, R. K. (2012). Environmental impact assessment : the state of the art. *Impact Assessment and Project Appraisal*, *30*, 5–14. https://doi.org/10.1080/14615517.2012.661557

Munda, G. (2006). Social multi-criteria evaluation for urban sustainability policies. *Land Use Policy*, *23*(1), 86–94. https://doi.org/10.1016/j.landusepol.2004.08.012

Noble, B. F. (2000). Strengthening EIA through adaptive management: a systems perspective. *Environmental Impact Assessment Review*, *20*, 97–111. https://doi.org/10.1016/S0195-9255(99)00038-4

Nuissl, H., Haase, D., Lanzendorf, M., & Wittmer, H. (2009). Land Use Policy Environmental impact assessment of urban land use transitions — A context-sensitive approach. *Land Use Policy*, *26*, 414–424. https://doi.org/10.1016/j.landusepol.2008.05.006

OECD. (2006). *Applying Strategic Environmental Assessment: Good Practice Guidance for Development Cooperation. DAC Guidelines and Reference Series*. https://doi.org/10.1787/9789264026582-en

Peche, R., & Rodríguez, E. (2009). Environmental impact assessment procedure: A new approach based on fuzzy logic. *Environmental Impact Assessment Review*, *29*(5), 275–283. https://doi.org/10.1016/j.eiar.2009.01.005

Pinho, P., McCallum, S., & Cruz, S. S. (2010). A critical appraisal of EIA screening practice in EU Member in states. *Impact Assessment and Project Appraisal*, *28*(2), 91–107. https://doi.org/10.3152/146155110X498799

Robinson, J. B., Biggs, D., Francis, G., Legge, R., Lerner, S., Slocombe, D. S., & Van Bers, C. (1996). *Life in 2030: Exploring a Sustainsable Future for Canada*. Retrieved from https://books.google.nl/books?hl=nl&lr=&id=DNRTCgAAQBAJ&oi=fnd&pg=PA26&dq=characteristics+of+sustainable+society&ots=WoatlLTz8m&sig=dwFjwt7_2Uwy0PD2_3B7TJXec24#v=onepage&q=characteristics of sustainable society&f=false

Runhaar, H., van Laerhoven, F., Driessen, P., & Arts, J. (2013). Environmental assessment in The Netherlands: Effectively governing environmental protection? A discourse analysis. *Environmental Impact Assessment Review*, *39*, 13–25. https://doi.org/10.1016/j.eiar.2012.05.003

Saaty, T. L. (2008). Decision making with the Analytic Hierarchy Process. *International Journal Services Sciences*, *1*(1), 83–98. https://doi.org/10.1504/ijssci.2008.017590

Sairinen, R. (2004). Social impact assessment in urban planning. *Sustainable City III: Urban Regeneration and Sustainability*, *18*, 423–430.

Sairinen, Rauno, Barrow, C., & Karjalainen, T. P. (2010). Environmental conflict mediation and social impact assessment: Approaches for enhanced environmental governance? *Environmental Impact Assessment Review*, *30*(5), 289–292. https://doi.org/10.1016/j.eiar.2010.04.011

Schmidt, M., Glasson, J., Emmelin, L., & Helbron, H. (2008). *Environmental Protection In The European Union 3: Standards and Thresholds for Impact Assessment*.

https://doi.org/10.1007/978-3-540-31141-6

Sharifi, A., & Yamagata, Y. (2014). Resilient Urban Planning : Major Principles and Criteria ScienceDirect Resilient urban planning : Major principles and criteria. *Energy Procedia*, *61*, 1491–1495. https://doi.org/10.1016/j.egypro.2014.12.154

Slootweg, R., & Kolhoff, A. (2003). A generic approach to integrate biodiversity considerations in screening and scoping for EIA. *Environmental Impact Assessment Review*, *23*, 657–681. https://doi.org/10.1016/S0195-9255(03)00114-8

Slootweg, R., Vanclay, F., & van Schooten, M. (2001). Function evaluation as a framework for the integration of social and environmental impact assessment. *Impact Assessment and Project Appraisal*, *19*(1), 19–28. https://doi.org/10.3152/147154601781767186

Snell, T., & Cowell, R. (2006). Scoping in environmental impact assessment: Balancing precaution and efficiency? *Environmental Impact Assessment Review*, *26*(4), 359–376. https://doi.org/10.1016/j.eiar.2005.06.003

Taleai, M., Sharifi, A., Sliuzas, R., & Mesgari, M. (2007). Evaluating the compatibility of multi-functional and intensive urban land uses. *International Journal of Applied Earth Observation and Geoinformation*, *9*(4), 375–391. https://doi.org/10.1016/j.jag.2006.12.002

The Interorganizational Committee Guidelines and Principles for Assessment Social Impact. (1994). Guidelines and Principles for Social Impact Assessment. In *Impact Assessment*. https://doi.org/10.1080/07349165.1994.9725857

van Hellenberg Hubar, S. (2009). *Duurzaamheid flexibilliteit en kosten van Hoogbouw - Literatuurstudie* (Technische Universiteit Delft). Retrieved from https://repository.tudelft.nl/islandora/object/uuid:951d7b03-a0e9-4e1f-824a-909c8c6705fc/datastream/OBJ2/download

Vanclay, F. (2003). SIA principles Assessment. *Impact Assessment and Project Appraisal*, *21*. https://doi.org/10.3152/147154603781766491

Ward, P. M., Aguilar, A. G., & Smith Sr, C. B. (2003). Globalization , regional development , and mega-city expansion in Latin America : Analyzing Mexico City's peri-urban hinterland. *Cities*, *20*(1), 3–21. https://doi.org/https://doi.org/10.1016/S0264-2751(02)00092-6

Weston, J. (2000). EIA, decision-making theory and screening and scoping in UK practice. *Journal of Environmental Planning and Management*, *43*(2), 185–203. https://doi.org/10.1080/09640560010667

Weston, J. (2011). Screening for environmental impact assessment projects in England: What screening? *Impact Assessment and Project Appraisal*, *29*(2), 90–98. https://doi.org/10.3152/146155111X12913679730593

Wood. (2003). *Environmental Impact Assessment in Developing Countries*. (November), 1–28. Retrieved from https://pdfs.semanticscholar.org/df7c/ea0f4f56d43b5f7dba92707a3bd924752f8c.pdf

Wood. (2014). *Environmental Impact Assessment* (Second). https://doi.org/10.4324/9781315838953

Wood, Glasson, J., & Becker, J. (2006). EIA scoping in England and Wales: Practitioner approaches, perspectives and constraints. *Environmental Impact Assessment Review*, *26*(3), 221–241. https://doi.org/10.1016/j.eiar.2005.02.001

Zandbelt, D., van den Berg, R., Bokkers, T., & Witteman, B. (2008). *Een studie naar Nederlandse hoogbouwcultuur*. Retrieved from https://www.stichtinghoogbouw.nl/download/hoogbouwbeleid.pdf

# Appendix A

In all practices, even daily, all individuals are fundamental decision makers. Everything a person does whether it is consciously or unconsciously is a result of a decision making process. The decision making process encounters several criteria and sub-criteria in order to rank the alternatives of a particular decision. Not only priorities need to be created for each alternative in relation to the criteria or sub-criteria, also for the criteria in terms of a higher goal, if such depending on each alternative, then in terms of the alternatives self. Criteria could be noticed as intangible and have no measurement reference in terms of guiding tot rank an alternative; creating priorities for the criteria to weight such priorities of the alternatives and add over all the criteria and obtaining the strived overall ranks of the alternatives is known as a challenging task (Saaty, 2008).

Saaty (2008) argues that decision making in an organised way in order to generate priorities, the decision need to be decomposed into the four steps (Saaty, 2008, p. 85):

1. Define the problem and determine the kind of knowledge sought.
2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

In order to perform the comparisons, scale numbers need to be assigned which indicate how many times more important one aspect is over another aspect regarding the criterion or property with respect to which such are compared (Saaty, 2008, p. 85).

**AHP Calculation process:**

This process is shortly and well described from Koops (2012). Therefore, this AHP calculation process is copied and quoted from Koops (2012) and mention: “Consider n elements to be compared, C1 … Cn and denote the relative ‘weight’ (or priority or significance) of Ci with respect to Cj by aij and form a square matrix A=(aij) of order n with the constraints that aij = 1/aji, for i ≠ j, and aii = 1, all i. Such a matrix is said to be a reciprocal matrix. (Coyle,G. 2004)” (Koops, 2012, p. 52).

Koops (2012) mention: “The weights are consistent if they are transitive, that is aik = aijajk for all i, j, and k. Such a matrix might exist if the aij are calculated from exactly measured data. Then find a vector ω of order n such that Aω = λω . For such a matrix, ω is said to be an eigenvector (of order n) and λ is an eigenvalue. For a consistent matrix, λ = n . (Coyle,G. 2004)” (Koops, 2012, p. 52).

Koops (2012) mention: “For matrices involving human judgment, the condition aik = aijajk does not hold as human judgments are inconsistent to a greater or lesser degree. In such a case the ω vector satisfies the equation Aω= λmaxω and λmax ≥ n.” (Koops, 2012, p. 52).

Koops (2012) mention: “The difference, if any, between λmax and n is an indication of the inconsistency of the judgments. If λmax = n then the judgments have turned out to be consistent. Finally, a Consistency Index can be calculated from (λmax -n)/(n-1). That needs to be assessed against judgments made completely at random and Saaty has calculated large samples of random matrices of increasing order and the Consistency Indices of those matrices. A true Consistency Ratio is calculated by dividing the Consistency Index for the set of judgments by the Index for the corresponding random matrix. Saaty suggests that if that ratio exceeds 0.1 the set of judgments maybe too inconsistent to be reliable.

In practice, CRs of more than 0.1 sometimes have to be accepted. A CR of 0 means that the judgments are perfectly consistent. (Coyle,G. 2004).” (Koops, 2012, p. 52).

Koops (2012) mention: “**Eigenvector:** There are several methods for calculating the eigenvector. Multiplying together the entries in each row of the matrix and then taking the nth root of that product gives a very good approximation to the correct answer. The nth roots are summed and that sum is used to normalize the eigenvector elements to add to 1.00. In the matrix below, the 4th root for the first row is 0.293 and that is divided by 5.024 to give 0.058 as the first element in the eigenvector. (Coyle,G. 2004). The table below (table 24) gives a worked example in terms of four attributes to be compared which, for simplicity, we refer to as A, B, C, and D” (Koops, 2012, p. 53).

*Table 24. Eigenvector calculation example (Source: Koops, 2012)*

| | A | B | C | D | N^th root of product values | Eigenvector |
|---|---|---|---|---|---|---|
| A | 1 | 1/3 | 1/9 | 1/5 | 0.293 | 0.058 |
| B | 3 | 1 | 1 | 1 | 1.316 | 0.262 |
| C | 9 | 1 | 1 | 3 | 2.279 | 0.454 |
| D | 5 | 1 | 1/3 | 1 | 1.136 | 0.226 |
| Total | | | | | 5.024 | 1.000 |

Koops (2012) mention: “The eigenvector of the relative importance or value of A, B, C and D is (0.058,0.262,0.454,0.226). Thus, C is the most valuable, B and D are behind, but roughly equal and A is very much less significant.” (Koops, 2012, p. 53).

Koops (2012) mention: “**Consistency:** The next stage is to calculate λmax so as to lead to the Consistency Index and the Consistency Ratio. (Coyle,G. 2004). We first multiply on the right the matrix of judgments by the eigenvector, obtaining a new vector. The calculation for the first row in the matrix is:

(1*0.058)+(1/3*0.262)+(1/9*0.454)+(1/5*0.226) = 0.240

and the remaining three rows give 1.116, 1.916 and 0.928. This vector of four elements (0.240,1.116,1.916,0.928) is, of course, the product Aω and the AHP theory says that Aω= λmaxω so we can now get four estimates of λmax by the simple expedient of dividing each component of (0.240,1.116,1.916,0.928) by the corresponding eigenvector element. This gives 0.240/0.058=4.137 together with 4.259, 4.22 and 4.11. The mean of these values is 4.18 and that is our estimate for λmax. If any of the estimates for λmax turns out to be less than n, or 4 in this case, there has been an error in the calculation, which is a useful sanity check.” (Koops, 2012, p. 53).

Koops (2012) mention: “The Consistency Index for a matrix is calculated from (λmax -n)/(n-1) and, since n=4 for this matrix, the CI is 0.060. The final step is to calculate the Consistency Ratio for this set of judgments using the CI for the corresponding value from large samples of matrices of purely random judgments using the table below, derived from Saaty’s book, in which the upper row is the order of the random matrix, and the lower is the corresponding index of consistency for random judgments. (Coyle,G. 2004)

*Table 25. Consistency Index (Source: Koops, 2012)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.51 | 1.48 | 1.56 | 1.57 | 1.59 |

For this example, that gives 0.060/0.90=0.0677. Saaty argues that a CR > 0.1 indicates that the judgments are at the limit of consistency though CRs > 0.1 (but not too much more) have to be accepted sometimes. In this instance, we are on safe ground. A CR as high as, say, 0.9 would mean that the pair-wise judgments’ are just about random and are completely untrustworthy” (Koops, 2012, pp. 53).

# Appendix B

Overview impact criteria compatibility matrixes

**Compatibility Matrix Landscape Visual Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MPI | | | | | |
| Offices | MPI | MPI | | | | |
| Retail and catering | NI | NI | MNI | | | |
| Services and facilities | NI | NI | MPI | NI | | |
| Urban green areas | NI | NI | NI | NI | HPI | |
| Transportation | NI | NI | NI | NI | MNI | NI |

**Quantification Landscape and Visual Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,26 | | | | | |
| Offices | 0,26 | 0,26 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,07 | | | |
| Services and facilities | 0,14 | 0,14 | 0,26 | 0,14 | | |
| Urban green areas | 0,14 | 0,14 | 0,14 | 0,14 | 0,50 | |
| Transportation | 0,14 | 0,14 | 0,14 | 0,14 | 0,07 | 0,14 |

**Compatibility Matrix Water Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MNI | | | | | |
| Offices | MNI | NI | | | | |
| Retail and catering | MNI | NI | NI | | | |
| Services and facilities | MNI | NI | NI | NI | | |
| Urban green areas | HPI | MPI | NI | NI | HPI | |
| Transportation | NI | NI | NI | NI | NI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,07 | | | | | |
| Offices | 0,07 | 0,14 | | | | |
| Retail and catering | 0,07 | 0,14 | 0,14 | | | |
| Services and facilities | 0,07 | 0,14 | 0,14 | 0,14 | | |
| Urban green areas | 0,50 | 0,26 | 0,14 | 0,14 | 0,50 | |
| Transportation | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 |

## Compatibility Matrix Ecology Impact

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MNI | | | | | |
| Offices | NI | MNI | | | | |
| Retail and catering | HNI | HNI | MNI | | | |
| Services and facilities | MNI | MNI | MNI | MNI | | |
| Urban green areas | HPI | HPI | HPI | HPI | HPI | |
| Transportation | HNI | HNI | HNI | HNI | HNI | MNI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,07 | | | | | |
| Offices | 0,14 | 0,07 | | | | |
| Retail and catering | 0,04 | 0,04 | 0,07 | | | |
| Services and facilities | 0,07 | 0,07 | 0,07 | 0,07 | | |
| Urban green areas | 0,50 | 0,50 | 0,50 | 0,50 | 0,50 | |
| Transportation | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |

## Compatibility Matrix Soil Impact

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | NI | | | | | |
| Offices | NI | NI | | | | |
| Retail and catering | NI | NI | NI | | | |
| Services and facilities | NI | NI | NI | NI | | |
| Urban green areas | HPI | HPI | HPI | HPI | HPI | |
| Transportation | NI | NI | NI | NI | NI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,14 | | | | | |
| Offices | 0,14 | 0,14 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,14 | | | |
| Services and facilities | 0,14 | 0,14 | 0,14 | 0,14 | | |
| Urban green areas | 0,50 | 0,50 | 0,50 | 0,50 | 0,26 | |
| Transportation | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 |

**Compatibility Matrix Noise Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | NI | | | | | |
| Offices | NI | NI | | | | |
| Retail and catering | NI | NI | NI | | | |
| Services and facilities | NI | NI | NI | NI | | |
| Urban green areas | NI | NI | NI | NI | NI | |
| Transportation | HNI | MNI | NI | NI | HNI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,14 | | | | | |
| Offices | 0,14 | 0,14 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,14 | | | |
| Services and facilities | 0,14 | 0,14 | 0,14 | 0,14 | | |
| Urban green areas | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | |
| Transportation | 0,04 | 0,07 | 0,14 | 0,14 | 0,04 | 0,14 |

**Compatibility Matrix Air Quality Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MNI | | | | | |
| Offices | MNI | MNI | | | | |
| Retail and catering | NI | MPI | NI | | | |
| Services and facilities | NI | MPI | MPI | MNI | | |
| Urban green areas | HPI | HPI | MPI | MPI | HPI | |
| Transportation | MPI | MPI | MPI | MPI | HNI | HPI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,07 | | | | | |
| Offices | 0,07 | 0,07 | | | | |
| Retail and catering | 0,14 | 0,26 | 0,14 | | | |
| Services and facilities | 0,14 | 0,26 | 0,26 | 0,07 | | |
| Urban green areas | 0,50 | 0,50 | 0,26 | 0,26 | 0,50 | |
| Transportation | 0,26 | 0,26 | 0,26 | 0,26 | 0,04 | 0,50 |

**Compatibility Matrix Transport Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MNI | | | | | |
| Offices | MNI | MNI | | | | |
| Retail and catering | NI | NI | MNI | | | |
| Services and facilities | NI | NI | MNI | MNI | | |
| Urban green areas | NI | NI | NI | NI | NI | |
| Transportation | HPI | HPI | HPI | HPI | HPI | HPI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,07 | | | | | |
| Offices | 0,07 | 0,07 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,07 | | | |
| Services and facilities | 0,14 | 0,14 | 0,07 | 0,07 | | |
| Urban green areas | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | |
| Transportation | 0,50 | 0,50 | 0,50 | 0,50 | 0,50 | 0,50 |

**Compatibility Matrix Population Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | HPI | | | | | |
| Offices | MPI | MNI | | | | |
| Retail and catering | HPI | HPI | NI | | | |
| Services and facilities | HPI | HPI | MPI | NI | | |
| Urban green areas | HPI | HPI | MPI | MPI | NI | |
| Transportation | HPI | HPI | HPI | HPI | MPI | MPI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,50 | | | | | |
| Offices | 0,26 | 0,07 | | | | |
| Retail and catering | 0,50 | 0,50 | 0,14 | | | |
| Services and facilities | 0,50 | 0,50 | 0,26 | 0,14 | | |
| Urban green areas | 0,50 | 0,50 | 0,26 | 0,26 | 0,14 | |
| Transportation | 0,50 | 0,50 | 0,50 | 0,50 | 0,26 | 0,26 |

**Compatibility Matrix Housing Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | NI | | | | | |
| Offices | NI | NI | | | | |
| Retail and catering | MNP | NI | NI | | | |
| Services and facilities | NI | NI | MPI | NI | | |
| Urban green areas | MNI | MNI | MPI | MNI | MPI | |
| Transportation | NI | NI | MPI | NI | NI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,14 | | | | | |
| Offices | 0,14 | 0,14 | | | | |
| Retail and catering | 0,26 | 0,14 | 0,14 | | | |
| Services and facilities | 0,14 | 0,14 | 0,26 | 0,14 | | |
| Urban green areas | 0,07 | 0,14 | 0,07 | 0,07 | 0,26 | |
| Transportation | 0,14 | 0,14 | 0,26 | 0,14 | 0,14 | 0,14 |

**Compatibility Matrix Services Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | HPI | | | | | |
| Offices | MPI | MPI | | | | |
| Retail and catering | NI | NI | NI | | | |
| Services and facilities | NI | NI | NI | NI | | |
| Urban green areas | HNI | HNI | HNI | HNI | MNI | |
| Transportation | NI | NI | NI | NI | NI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,50 | | | | | |
| Offices | 0,26 | 0,26 | | | | |
| Retail and catering | 0,14 | 0,14 | 0,14 | | | |
| Services and facilities | 0,14 | 0,14 | 0,14 | 0,14 | | |
| Urban green areas | 0,04 | 0,04 | 0,04 | 0,04 | 0,07 | |
| Transportation | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 |

**Compatibility Matrix Health & Well-being Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MNI | | | | | |
| Offices | NI | MNI | | | | |
| Retail and catering | MPI | MPI | MPI | | | |
| Services and facilities | MPI | MPI | MPI | NI | | |
| Urban green areas | HPI | HPI | NI | NI | NI | |
| Transportation | MNI | MNI | MNI | MNI | MNI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,07 | | | | | |
| Offices | 0,14 | 0,07 | | | | |
| Retail and catering | 0,26 | 0,26 | 0,26 | | | |
| Services and facilities | 0,26 | 0,26 | 0,26 | 0,14 | | |
| Urban green areas | 0,50 | 0,50 | 0,14 | 0,14 | 0,14 | |
| Transportation | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,14 |

**Compatibility Matrix Safety Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | NI | | | | | |
| Offices | HPI | NI | | | | |
| Retail and catering | MPI | MPI | NI | | | |
| Services and facilities | NI | NI | NI | NI | | |
| Urban green areas | MNI | MNI | MNI | MNI | NI | |
| Transportation | HNI | HNI | HNI | HNI | HNI | MNI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,14 | | | | | |
| Offices | 0,50 | 0,14 | | | | |
| Retail and catering | 0,26 | 0,26 | 0,14 | | | |
| Services and facilities | 0,14 | 0,14 | 0,14 | 0,14 | | |
| Urban green areas | 0,07 | 0,07 | 0,07 | 0,07 | 0,14 | |
| Transportation | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,07 |

**Compatibility Matrix Community Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | MPI | | | | | |
| Offices | MNI | NI | | | | |
| Retail and catering | MPI | MPI | NI | | | |
| Services and facilities | HPI | MPI | MPI | NI | | |
| Urban green areas | HPI | MPI | MPI | MPI | NI | |
| Transportation | MPI | MPI | MPI | MPI | MNI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,26 | | | | | |
| Offices | 0,07 | 0,14 | | | | |
| Retail and catering | 0,26 | 0,26 | 0,14 | | | |
| Services and facilities | 0,50 | 0,26 | 0,26 | 0,14 | | |
| Urban green areas | 0,50 | 0,26 | 0,26 | 0,26 | 0,14 | |
| Transportation | 0,26 | 0,26 | 0,26 | 0,26 | 0,07 | 0,14 |

**Compatibility Matrix Local Economy Impact**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | HPI | | | | | |
| Offices | MPI | MPI | | | | |
| Retail and catering | MPI | MPI | NI | | | |
| Services and facilities | MPI | MPI | MPI | NI | | |
| Urban green areas | MPI | MPI | NI | NI | NI | |
| Transportation | NI | NI | MPI | MPI | NI | NI |

**Quantification**

| | Residential | Offices | Retail and catering | Services and facilities | Urban green areas | Transportation |
|---|---|---|---|---|---|---|
| Residential | 0,50 | | | | | |
| Offices | 0,26 | 0,26 | | | | |
| Retail and catering | 0,26 | 0,26 | 0,14 | | | |
| Services and facilities | 0,26 | 0,26 | 0,26 | 0,14 | | |
| Urban green areas | 0,26 | 0,26 | 0,14 | 0,14 | 0,14 | |
| Transportation | 0,14 | 0,14 | 0,26 | 0,26 | 0,14 | 0,14 |

# Appendix C

| Parcel nr | -1 | 0 | 1 | 2 |
|---|---|---|---|---|
| 1 | | Offices | Offices | |
| 2 | | Offices | Offices | |
| 3 | | Transportation | | |
| 4 | | Transportation | | |
| 5 | | Residential | | |
| 6 | | Offices | Offices | |
| 7 | | Transportation | | |
| 8 | | Residential | Residential | |
| 9 | | Residential | Residential | |
| 10 | | Residential | | |
| 11 | | Residential | | |
| 12 | | Residential | | |
| 13 | | Residential | | |
| 14 | | Residential | | |
| 15 | | Residential | | |
| 16 | | Transportation | | |
| 17 | | Transportation | | |
| 18 | | Residential | Residential | |
| 19 | | Offices | Offices | |
| 20 | | Offices | | |
| 21 | | Offices | Offices | |
| 22 | | Offices | Offices | |
| 23 | | Offices | | |
| 24 | | Services & Facilities | Services & Facilities | |
| 25 | | Offices | Offices | |
| 26 | | Retail & Catering | | |
| 27 | | Residential | Residential | |
| 28 | | Services & Facilities | | |
| 62 | | Urban green areas | | |
| 63 | | Urban green areas | | |
| 64 | | Urban green areas | | |
| 29 | | Residential | Residential | |
| 30 | | Offices | Offices | Offices |
| 31 | | Transportation | | |
| 32 | | Offices | Offices | |
| 33 | | Offices | Offices | Offices |
| 34 | | Transportation | | |
| 35 | | Residential | | |
| 36 | | Residential | | |
| 37 | | Residential | | |
| 38 | | Services & Facilities | | |
| 39 | | Services & Facilities | | |
| 40 | | Residential | | |
| 41 | | Transportation | | |
| 42 | | Transportation | | |
| 43 | | Transportation | | |
| 44 | Transportation | | | |
| 45 | | Services & Facilities | Services & Facilities | |
| 46 | | Transportation | | |
| 47 | | Offices | | |
| 48 | | Offices | Offices | |
| 49 | | Residential | | |
| 50 | | Services & Facilities | | |
| 51 | | Retail & Catering | | |
| 52 | | Services & Facilities | | |
| 53 | | Residential | | |
| 54 | | Residential | | |
| 55 | | Offices | | |
| 56 | | Retail & Catering | | |
| 57 | | Transportation | | |
| 58 | | Retail & Catering | Retail & Catering | |
| 59 | | Offices | Offices | Offices |
| 60 | | Residential | | |
| 61 | | Retail & Catering | | |
| 65 | | Urban green areas | | |
| 66 | | Urban green areas | | |
| 67 | | Urban green areas | | |

# Appendix D

## Output ESIM base scenario

**Scenario A**

| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,16 | 0,14 | 0,18 | 0,21 | 0,14 | 0,06 | 0,14 | 0,14 | 0,14 | 0,17 | 0,22 | 0,17 | 0,16 | 0,12 | 0,16 | 0,19 | 0,26 |
| 3 | Centre 3 | Office | 0,17 | 0,14 | 0,19 | 0,21 | 0,14 | 0,06 | 0,14 | 0,14 | 0,14 | 0,18 | 0,23 | 0,17 | 0,21 | 0,12 | 0,16 | 0,19 | 0,26 |
| 2 | Centre 2 | Office | 0,17 | 0,14 | 0,20 | 0,14 | 0,14 | 0,06 | 0,14 | 0,14 | 0,16 | 0,19 | 0,26 | 0,17 | 0,20 | 0,13 | 0,17 | 0,20 | 0,25 |
| 1 | Centre 1 | Office | 0,18 | 0,15 | 0,20 | 0,19 | 0,14 | 0,05 | 0,14 | 0,13 | 0,18 | 0,22 | 0,31 | 0,17 | 0,19 | 0,14 | 0,17 | 0,21 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,16 | 0,24 | 0,15 | 0,14 | 0,04 | 0,14 | 0,14 | 0,24 | 0,30 | 0,47 | 0,19 | 0,15 | 0,20 | 0,19 | 0,25 | 0,26 |
| -1 | Basement | Parking | 0,20 | 0,18 | 0,22 | 0,15 | 0,14 | 0,04 | 0,14 | 0,12 | 0,24 | 0,43 | 0,47 | 0,20 | 0,17 | 0,11 | 0,08 | 0,25 | 0,22 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,19 | 0,15 | 0,23 | 0,22 | 0,15 | 0,06 | 0,16 | 0,15 | 0,17 | 0,15 | 0,33 | 0,21 | 0,19 | 0,16 | 0,24 | 0,18 | 0,29 |
| 3 | Centre 3 | Office | 0,19 | 0,15 | 0,23 | 0,22 | 0,15 | 0,06 | 0,16 | 0,15 | 0,18 | 0,15 | 0,34 | 0,22 | 0,22 | 0,16 | 0,24 | 0,18 | 0,29 |
| 2 | Centre 2 | Office | 0,19 | 0,15 | 0,24 | 0,18 | 0,15 | 0,06 | 0,15 | 0,15 | 0,18 | 0,15 | 0,36 | 0,22 | 0,21 | 0,16 | 0,24 | 0,18 | 0,28 |
| 1 | Centre 1 | Office | 0,18 | 0,14 | 0,22 | 0,19 | 0,13 | 0,05 | 0,14 | 0,14 | 0,17 | 0,15 | 0,35 | 0,20 | 0,19 | 0,15 | 0,22 | 0,17 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,19 | 0,14 | 0,23 | 0,16 | 0,14 | 0,05 | 0,14 | 0,14 | 0,22 | 0,16 | 0,45 | 0,22 | 0,16 | 0,15 | 0,23 | 0,16 | 0,26 |
| -1 | Basement | Parking | 0,19 | 0,16 | 0,23 | 0,17 | 0,15 | 0,05 | 0,15 | 0,14 | 0,24 | 0,20 | 0,49 | 0,24 | 0,18 | 0,12 | 0,17 | 0,17 | 0,26 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,17 | 0,13 | 0,22 | 0,19 | 0,14 | 0,05 | 0,09 | 0,14 | 0,18 | 0,12 | 0,30 | 0,20 | 0,17 | 0,17 | 0,20 | 0,21 | 0,26 |
| 3 | Centre 3 | Office | 0,17 | 0,13 | 0,22 | 0,19 | 0,14 | 0,05 | 0,08 | 0,14 | 0,18 | 0,12 | 0,31 | 0,20 | 0,19 | 0,17 | 0,20 | 0,21 | 0,26 |
| 2 | Centre 2 | Office | 0,17 | 0,13 | 0,22 | 0,16 | 0,14 | 0,05 | 0,08 | 0,14 | 0,18 | 0,12 | 0,32 | 0,20 | 0,19 | 0,18 | 0,20 | 0,21 | 0,26 |
| 1 | Centre 1 | Office | 0,18 | 0,13 | 0,23 | 0,18 | 0,14 | 0,05 | 0,08 | 0,14 | 0,20 | 0,13 | 0,36 | 0,21 | 0,18 | 0,19 | 0,21 | 0,22 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,13 | 0,26 | 0,15 | 0,14 | 0,04 | 0,07 | 0,14 | 0,24 | 0,15 | 0,45 | 0,23 | 0,15 | 0,23 | 0,23 | 0,25 | 0,26 |
| -1 | Basement | Parking | 0,19 | 0,14 | 0,24 | 0,15 | 0,14 | 0,04 | 0,07 | 0,13 | 0,25 | 0,18 | 0,45 | 0,23 | 0,16 | 0,19 | 0,17 | 0,24 | 0,24 |
| Final Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,18 | 0,15 | 0,22 | 0,21 | 0,15 | 0,06 | 0,14 | 0,15 | 0,17 | 0,15 | 0,30 | 0,20 | 0,18 | 0,15 | 0,22 | 0,19 | 0,27 |
| 3 | Centre 3 | Office | 0,18 | 0,15 | 0,22 | 0,21 | 0,14 | 0,06 | 0,14 | 0,15 | 0,17 | 0,14 | 0,31 | 0,20 | 0,20 | 0,17 | 0,22 | 0,19 | 0,28 |
| 2 | Centre 2 | Office | 0,18 | 0,14 | 0,23 | 0,17 | 0,14 | 0,06 | 0,14 | 0,15 | 0,18 | 0,15 | 0,33 | 0,21 | 0,20 | 0,17 | 0,22 | 0,19 | 0,27 |
| 1 | Centre 1 | Office | 0,18 | 0,14 | 0,22 | 0,19 | 0,14 | 0,05 | 0,13 | 0,14 | 0,19 | 0,15 | 0,35 | 0,19 | 0,18 | 0,18 | 0,21 | 0,19 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,19 | 0,15 | 0,24 | 0,15 | 0,14 | 0,05 | 0,13 | 0,14 | 0,24 | 0,17 | 0,45 | 0,22 | 0,15 | 0,20 | 0,22 | 0,19 | 0,26 |
| -1 | Basement | Parking | 0,19 | 0,16 | 0,23 | 0,16 | 0,14 | 0,05 | 0,14 | 0,13 | 0,25 | 0,22 | 0,46 | 0,23 | 0,17 | 0,16 | 0,16 | 0,20 | 0,25 |

**Scenario B**

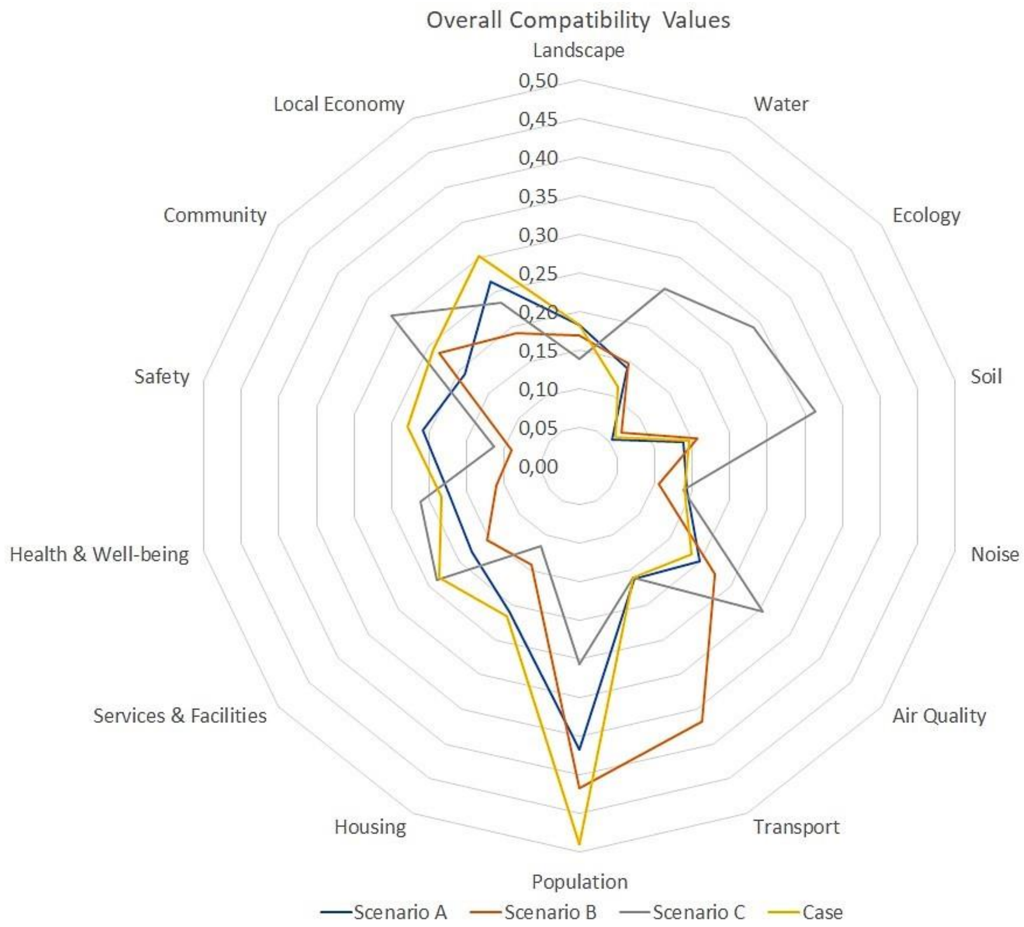
| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,19 | 0,18 | 0,19 | 0,14 | 0,16 | 0,14 | 0,14 | 0,13 | 0,30 | 0,26 | 0,43 | 0,12 | 0,09 | 0,20 | 0,08 | 0,25 | 0,18 |
| 3 | Centre 3 | Office | 0,20 | 0,17 | 0,22 | 0,14 | 0,16 | 0,09 | 0,14 | 0,12 | 0,30 | 0,27 | 0,48 | 0,14 | 0,12 | 0,21 | 0,10 | 0,25 | 0,21 |
| 2 | Centre 2 | Services & Facilities | 0,18 | 0,16 | 0,19 | 0,14 | 0,14 | 0,08 | 0,14 | 0,13 | 0,24 | 0,28 | 0,40 | 0,13 | 0,13 | 0,15 | 0,10 | 0,23 | 0,19 |
| 1 | Centre 1 | Services & Facilities | 0,18 | 0,17 | 0,19 | 0,14 | 0,14 | 0,07 | 0,14 | 0,13 | 0,24 | 0,32 | 0,41 | 0,14 | 0,13 | 0,13 | 0,09 | 0,23 | 0,20 |
| 0 | Plinth | Parking | 0,19 | 0,19 | 0,18 | 0,14 | 0,14 | 0,04 | 0,14 | 0,12 | 0,30 | 0,47 | 0,43 | 0,14 | 0,14 | 0,10 | 0,06 | 0,22 | 0,18 |
| -1 | Basement | Parking | 0,19 | 0,19 | 0,18 | 0,14 | 0,14 | 0,04 | 0,14 | 0,12 | 0,31 | 0,47 | 0,41 | 0,14 | 0,14 | 0,10 | 0,06 | 0,22 | 0,18 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,20 | 0,19 | 0,20 | 0,19 | 0,16 | 0,10 | 0,21 | 0,10 | 0,24 | 0,33 | 0,42 | 0,15 | 0,16 | 0,13 | 0,11 | 0,24 | 0,21 |
| 3 | Centre 3 | Office | 0,20 | 0,18 | 0,21 | 0,19 | 0,16 | 0,09 | 0,18 | 0,10 | 0,24 | 0,34 | 0,44 | 0,16 | 0,18 | 0,13 | 0,12 | 0,24 | 0,22 |
| 2 | Centre 2 | Services & Facilities | 0,19 | 0,18 | 0,20 | 0,19 | 0,15 | 0,08 | 0,17 | 0,10 | 0,21 | 0,34 | 0,41 | 0,15 | 0,19 | 0,11 | 0,12 | 0,24 | 0,21 |
| 1 | Centre 1 | Services & Facilities | 0,17 | 0,16 | 0,18 | 0,17 | 0,14 | 0,07 | 0,15 | 0,09 | 0,19 | 0,33 | 0,38 | 0,14 | 0,17 | 0,10 | 0,10 | 0,21 | 0,19 |
| 0 | Plinth | Parking | 0,18 | 0,18 | 0,18 | 0,16 | 0,14 | 0,05 | 0,14 | 0,07 | 0,24 | 0,43 | 0,43 | 0,14 | 0,16 | 0,08 | 0,07 | 0,23 | 0,17 |
| -1 | Basement | Parking | 0,19 | 0,19 | 0,19 | 0,17 | 0,15 | 0,05 | 0,15 | 0,08 | 0,27 | 0,47 | 0,46 | 0,15 | 0,17 | 0,09 | 0,07 | 0,25 | 0,18 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,17 | 0,17 | 0,17 | 0,17 | 0,15 | 0,07 | 0,17 | 0,14 | 0,14 | 0,31 | 0,36 | 0,13 | 0,12 | 0,09 | 0,07 | 0,22 | 0,18 |
| 3 | Centre 3 | Office | 0,17 | 0,16 | 0,18 | 0,17 | 0,15 | 0,06 | 0,16 | 0,13 | 0,14 | 0,32 | 0,38 | 0,14 | 0,14 | 0,09 | 0,08 | 0,23 | 0,19 |
| 2 | Centre 2 | Services & Facilities | 0,17 | 0,16 | 0,17 | 0,17 | 0,14 | 0,06 | 0,15 | 0,14 | 0,13 | 0,33 | 0,36 | 0,14 | 0,14 | 0,08 | 0,08 | 0,22 | 0,18 |
| 1 | Centre 1 | Services & Facilities | 0,17 | 0,16 | 0,17 | 0,17 | 0,14 | 0,06 | 0,15 | 0,14 | 0,13 | 0,36 | 0,38 | 0,14 | 0,13 | 0,08 | 0,07 | 0,23 | 0,18 |
| 0 | Plinth | Parking | 0,18 | 0,17 | 0,18 | 0,15 | 0,14 | 0,04 | 0,14 | 0,14 | 0,15 | 0,45 | 0,43 | 0,14 | 0,14 | 0,07 | 0,05 | 0,24 | 0,16 |
| -1 | Basement | Parking | 0,18 | 0,17 | 0,18 | 0,15 | 0,14 | 0,04 | 0,14 | 0,13 | 0,16 | 0,45 | 0,43 | 0,14 | 0,14 | 0,07 | 0,05 | 0,24 | 0,16 |
| Final Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,19 | 0,18 | 0,19 | 0,18 | 0,16 | 0,10 | 0,19 | 0,11 | 0,23 | 0,31 | 0,41 | 0,14 | 0,14 | 0,14 | 0,10 | 0,24 | 0,20 |
| 3 | Centre 3 | Office | 0,19 | 0,18 | 0,21 | 0,18 | 0,16 | 0,08 | 0,17 | 0,11 | 0,23 | 0,32 | 0,44 | 0,15 | 0,16 | 0,14 | 0,11 | 0,24 | 0,21 |
| 2 | Centre 2 | Services & Facilities | 0,18 | 0,17 | 0,19 | 0,18 | 0,15 | 0,07 | 0,16 | 0,11 | 0,20 | 0,33 | 0,40 | 0,15 | 0,17 | 0,11 | 0,11 | 0,23 | 0,20 |
| 1 | Centre 1 | Services & Facilities | 0,17 | 0,16 | 0,18 | 0,16 | 0,14 | 0,06 | 0,15 | 0,11 | 0,19 | 0,33 | 0,39 | 0,14 | 0,15 | 0,10 | 0,10 | 0,22 | 0,19 |
| 0 | Plinth | Parking | 0,18 | 0,18 | 0,18 | 0,15 | 0,14 | 0,04 | 0,14 | 0,09 | 0,24 | 0,44 | 0,43 | 0,14 | 0,15 | 0,08 | 0,06 | 0,23 | 0,17 |
| -1 | Basement | Parking | 0,19 | 0,19 | 0,19 | 0,16 | 0,14 | 0,05 | 0,15 | 0,10 | 0,26 | 0,47 | 0,44 | 0,15 | 0,16 | 0,09 | 0,07 | 0,24 | 0,18 |

**Scenario C**

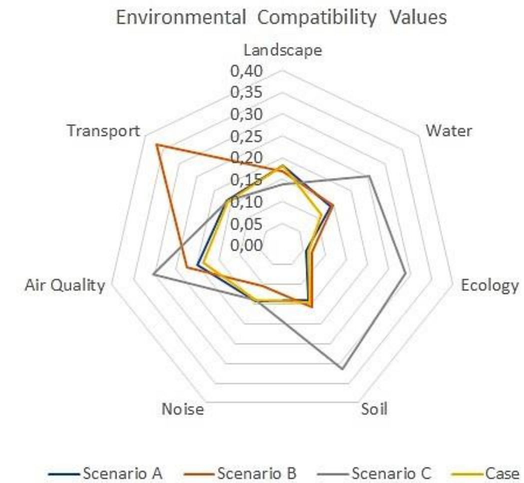
| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,19 | 0,16 | 0,22 | 0,14 | 0,14 | 0,17 | 0,14 | 0,13 | 0,20 | 0,17 | 0,39 | 0,13 | 0,11 | 0,27 | 0,13 | 0,28 | 0,25 |
| 3 | Centre 3 | Residential | 0,20 | 0,16 | 0,23 | 0,15 | 0,15 | 0,19 | 0,14 | 0,13 | 0,22 | 0,17 | 0,39 | 0,13 | 0,12 | 0,29 | 0,18 | 0,28 | 0,25 |
| 2 | Centre 2 | Offices | 0,19 | 0,17 | 0,22 | 0,10 | 0,16 | 0,20 | 0,14 | 0,13 | 0,27 | 0,18 | 0,39 | 0,12 | 0,12 | 0,29 | 0,18 | 0,21 | 0,24 |
| 1 | Centre 1 | Retail & Catering | 0,19 | 0,18 | 0,21 | 0,14 | 0,15 | 0,21 | 0,14 | 0,13 | 0,26 | 0,20 | 0,37 | 0,14 | 0,10 | 0,25 | 0,14 | 0,23 | 0,23 |
| 0 | Plinth | Urban Green | 0,20 | 0,20 | 0,20 | 0,12 | 0,20 | 0,35 | 0,14 | 0,11 | 0,27 | 0,23 | 0,40 | 0,10 | 0,12 | 0,29 | 0,07 | 0,21 | 0,20 |
| -1 | Basement | Parking | 0,17 | 0,17 | 0,18 | 0,12 | 0,17 | 0,11 | 0,14 | 0,09 | 0,21 | 0,34 | 0,40 | 0,13 | 0,11 | 0,15 | 0,06 | 0,19 | 0,20 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,24 | 0,24 | 0,24 | 0,15 | 0,30 | 0,28 | 0,34 | 0,16 | 0,32 | 0,14 | 0,23 | 0,13 | 0,32 | 0,18 | 0,12 | 0,40 | 0,28 |
| 3 | Centre 3 | Residential | 0,25 | 0,25 | 0,24 | 0,16 | 0,31 | 0,30 | 0,34 | 0,15 | 0,34 | 0,14 | 0,23 | 0,13 | 0,34 | 0,18 | 0,15 | 0,40 | 0,28 |
| 2 | Centre 2 | Offices | 0,24 | 0,25 | 0,23 | 0,13 | 0,32 | 0,31 | 0,35 | 0,15 | 0,37 | 0,14 | 0,23 | 0,13 | 0,33 | 0,18 | 0,14 | 0,35 | 0,27 |
| 1 | Centre 1 | Retail & Catering | 0,22 | 0,24 | 0,21 | 0,14 | 0,28 | 0,29 | 0,33 | 0,14 | 0,33 | 0,14 | 0,20 | 0,12 | 0,28 | 0,15 | 0,12 | 0,34 | 0,24 |
| 0 | Plinth | Urban Green | 0,24 | 0,28 | 0,20 | 0,13 | 0,36 | 0,40 | 0,42 | 0,13 | 0,38 | 0,15 | 0,16 | 0,08 | 0,35 | 0,13 | 0,08 | 0,35 | 0,23 |
| -1 | Basement | Parking | 0,23 | 0,26 | 0,20 | 0,14 | 0,36 | 0,26 | 0,36 | 0,13 | 0,37 | 0,19 | 0,16 | 0,10 | 0,36 | 0,10 | 0,08 | 0,36 | 0,25 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,19 | 0,19 | 0,19 | 0,15 | 0,14 | 0,28 | 0,32 | 0,14 | 0,20 | 0,13 | 0,28 | 0,11 | 0,10 | 0,33 | 0,10 | 0,24 | 0,17 |
| 3 | Centre 3 | Residential | 0,20 | 0,20 | 0,19 | 0,15 | 0,14 | 0,29 | 0,33 | 0,14 | 0,21 | 0,12 | 0,28 | 0,11 | 0,10 | 0,34 | 0,11 | 0,24 | 0,17 |
| 2 | Centre 2 | Offices | 0,20 | 0,20 | 0,19 | 0,13 | 0,14 | 0,30 | 0,34 | 0,14 | 0,23 | 0,13 | 0,28 | 0,10 | 0,10 | 0,35 | 0,11 | 0,22 | 0,17 |
| 1 | Centre 1 | Retail & Catering | 0,20 | 0,21 | 0,19 | 0,14 | 0,14 | 0,33 | 0,36 | 0,14 | 0,24 | 0,14 | 0,29 | 0,10 | 0,08 | 0,35 | 0,10 | 0,24 | 0,16 |
| 0 | Plinth | Urban Green | 0,22 | 0,24 | 0,19 | 0,13 | 0,15 | 0,42 | 0,43 | 0,13 | 0,26 | 0,15 | 0,31 | 0,09 | 0,07 | 0,39 | 0,08 | 0,24 | 0,15 |
| -1 | Basement | Parking | 0,19 | 0,21 | 0,18 | 0,13 | 0,14 | 0,28 | 0,36 | 0,13 | 0,24 | 0,18 | 0,31 | 0,09 | 0,07 | 0,31 | 0,07 | 0,23 | 0,15 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,22 | 0,22 | 0,22 | 0,15 | 0,24 | 0,26 | 0,30 | 0,15 | 0,27 | 0,14 | 0,27 | 0,13 | 0,23 | 0,23 | 0,12 | 0,34 | 0,25 |
| 3 | Centre 3 | Residential | 0,23 | 0,22 | 0,23 | 0,16 | 0,25 | 0,28 | 0,30 | 0,15 | 0,29 | 0,14 | 0,27 | 0,13 | 0,25 | 0,23 | 0,15 | 0,34 | 0,25 |
| 2 | Centre 2 | Offices | 0,22 | 0,23 | 0,22 | 0,12 | 0,25 | 0,29 | 0,31 | 0,14 | 0,32 | 0,15 | 0,27 | 0,12 | 0,24 | 0,23 | 0,14 | 0,30 | 0,25 |
| 1 | Centre 1 | Retail & Catering | 0,21 | 0,22 | 0,20 | 0,14 | 0,23 | 0,28 | 0,30 | 0,14 | 0,30 | 0,15 | 0,25 | 0,12 | 0,20 | 0,21 | 0,12 | 0,30 | 0,23 |
| 0 | Plinth | Urban Green | 0,23 | 0,26 | 0,20 | 0,13 | 0,29 | 0,39 | 0,37 | 0,13 | 0,33 | 0,17 | 0,24 | 0,09 | 0,25 | 0,21 | 0,08 | 0,30 | 0,21 |
| -1 | Basement | Parking | 0,21 | 0,23 | 0,19 | 0,13 | 0,28 | 0,23 | 0,31 | 0,12 | 0,31 | 0,22 | 0,24 | 0,10 | 0,25 | 0,15 | 0,07 | 0,30 | 0,22 |

**Case scenario**

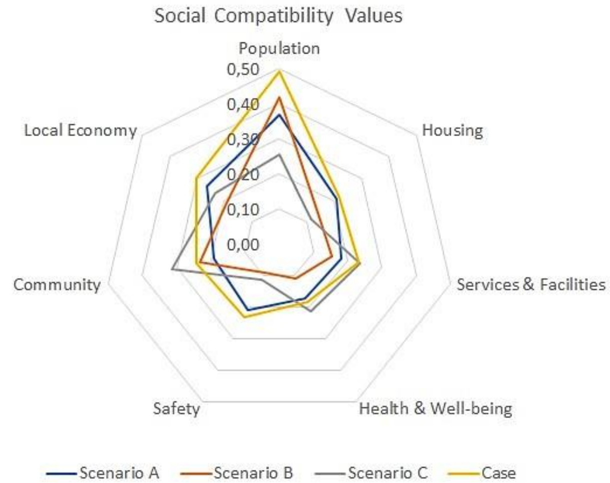
| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,20 | 0,14 | 0,26 | 0,21 | 0,09 | 0,07 | 0,14 | 0,14 | 0,13 | 0,17 | 0,46 | 0,17 | 0,29 | 0,13 | 0,20 | 0,23 | 0,35 |
| 3 | Centre 3 | Residential | 0,20 | 0,14 | 0,26 | 0,21 | 0,09 | 0,07 | 0,14 | 0,14 | 0,13 | 0,18 | 0,46 | 0,18 | 0,28 | 0,13 | 0,20 | 0,23 | 0,35 |
| 2 | Centre 2 | Residential | 0,19 | 0,13 | 0,26 | 0,14 | 0,09 | 0,07 | 0,14 | 0,13 | 0,14 | 0,19 | 0,43 | 0,18 | 0,27 | 0,14 | 0,21 | 0,23 | 0,33 |
| 1 | Centre 1 | Residential | 0,20 | 0,14 | 0,26 | 0,19 | 0,10 | 0,06 | 0,14 | 0,13 | 0,15 | 0,22 | 0,46 | 0,19 | 0,25 | 0,15 | 0,21 | 0,23 | 0,31 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,15 | 0,25 | 0,15 | 0,11 | 0,05 | 0,14 | 0,14 | 0,20 | 0,30 | 0,48 | 0,24 | 0,15 | 0,20 | 0,22 | 0,25 | 0,24 |
| -1 | Basement | Parking | 0,20 | 0,18 | 0,22 | 0,15 | 0,13 | 0,05 | 0,14 | 0,10 | 0,25 | 0,43 | 0,48 | 0,20 | 0,15 | 0,11 | 0,09 | 0,25 | 0,22 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,22 | 0,14 | 0,30 | 0,22 | 0,11 | 0,07 | 0,16 | 0,15 | 0,17 | 0,12 | 0,54 | 0,22 | 0,30 | 0,18 | 0,24 | 0,26 | 0,35 |
| 3 | Centre 3 | Residential | 0,22 | 0,14 | 0,30 | 0,22 | 0,11 | 0,07 | 0,16 | 0,15 | 0,17 | 0,12 | 0,53 | 0,22 | 0,29 | 0,19 | 0,24 | 0,26 | 0,35 |
| 2 | Centre 2 | Residential | 0,22 | 0,14 | 0,29 | 0,18 | 0,11 | 0,06 | 0,15 | 0,15 | 0,17 | 0,13 | 0,52 | 0,22 | 0,29 | 0,19 | 0,24 | 0,26 | 0,34 |
| 1 | Centre 1 | Residential | 0,20 | 0,13 | 0,27 | 0,19 | 0,10 | 0,06 | 0,14 | 0,14 | 0,17 | 0,12 | 0,48 | 0,21 | 0,25 | 0,18 | 0,22 | 0,23 | 0,30 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,14 | 0,27 | 0,16 | 0,12 | 0,05 | 0,14 | 0,14 | 0,20 | 0,15 | 0,49 | 0,24 | 0,17 | 0,22 | 0,24 | 0,25 | 0,26 |
| -1 | Basement | Parking | 0,21 | 0,15 | 0,26 | 0,17 | 0,14 | 0,05 | 0,15 | 0,13 | 0,24 | 0,19 | 0,53 | 0,24 | 0,18 | 0,19 | 0,18 | 0,27 | 0,27 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,20 | 0,13 | 0,26 | 0,19 | 0,11 | 0,07 | 0,14 | 0,14 | 0,17 | 0,12 | 0,43 | 0,20 | 0,21 | 0,18 | 0,29 | 0,20 | 0,29 |
| 3 | Centre 3 | Residential | 0,20 | 0,13 | 0,26 | 0,19 | 0,11 | 0,07 | 0,14 | 0,14 | 0,17 | 0,12 | 0,43 | 0,20 | 0,21 | 0,19 | 0,29 | 0,21 | 0,29 |
| 2 | Centre 2 | Residential | 0,19 | 0,13 | 0,26 | 0,16 | 0,11 | 0,07 | 0,14 | 0,14 | 0,18 | 0,12 | 0,42 | 0,21 | 0,21 | 0,19 | 0,29 | 0,21 | 0,28 |
| 1 | Centre 1 | Residential | 0,20 | 0,14 | 0,26 | 0,18 | 0,11 | 0,06 | 0,14 | 0,14 | 0,19 | 0,13 | 0,45 | 0,21 | 0,19 | 0,20 | 0,28 | 0,22 | 0,28 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,14 | 0,27 | 0,15 | 0,12 | 0,05 | 0,14 | 0,14 | 0,22 | 0,15 | 0,47 | 0,24 | 0,15 | 0,23 | 0,27 | 0,24 | 0,25 |
| -1 | Basement | Parking | 0,20 | 0,15 | 0,25 | 0,15 | 0,13 | 0,05 | 0,14 | 0,13 | 0,25 | 0,18 | 0,47 | 0,23 | 0,15 | 0,19 | 0,20 | 0,24 | 0,24 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,21 | 0,14 | 0,28 | 0,21 | 0,11 | 0,07 | 0,15 | 0,15 | 0,16 | 0,13 | 0,50 | 0,21 | 0,28 | 0,17 | 0,24 | 0,24 | 0,34 |
| 3 | Centre 3 | Residential | 0,21 | 0,14 | 0,28 | 0,21 | 0,11 | 0,07 | 0,15 | 0,15 | 0,16 | 0,13 | 0,50 | 0,21 | 0,28 | 0,18 | 0,24 | 0,24 | 0,33 |
| 2 | Centre 2 | Residential | 0,21 | 0,14 | 0,28 | 0,17 | 0,11 | 0,07 | 0,15 | 0,15 | 0,17 | 0,14 | 0,48 | 0,21 | 0,27 | 0,18 | 0,25 | 0,24 | 0,33 |
| 1 | Centre 1 | Residential | 0,20 | 0,13 | 0,26 | 0,19 | 0,11 | 0,06 | 0,14 | 0,13 | 0,17 | 0,15 | 0,47 | 0,20 | 0,24 | 0,18 | 0,23 | 0,23 | 0,30 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,14 | 0,26 | 0,16 | 0,12 | 0,05 | 0,14 | 0,14 | 0,21 | 0,18 | 0,49 | 0,24 | 0,17 | 0,22 | 0,24 | 0,24 | 0,25 |
| -1 | Basement | Parking | 0,20 | 0,16 | 0,25 | 0,16 | 0,14 | 0,05 | 0,15 | 0,13 | 0,24 | 0,23 | 0,51 | 0,23 | 0,17 | 0,17 | 0,16 | 0,26 | 0,25 |



Overall Compatibility Values
Landscape
Water
Ecology
Soil
Noise
Air Quality
Transport
Population
Housing
Services & Facilities
Health & Well-being
Safety
Community
Local Economy
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
0,45
0,50
Scenario A
Scenario B
Scenario C
Case

Environmental Compatibility Values
Landscape
Water
Ecology
Soil
Noise
Air Quality
Transport
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
Scenario A
Scenario B
Scenario C
Case

Social Compatibility Values
Population
Housing
Services & Facilities
Health & Well-being
Safety
Community
Local Economy
0,00
0,10
0,20
0,30
0,40
0,50
Scenario A
Scenario B
Scenario C
Case

# Appendix E

## Output ESIM Sensitivity Analysis 1

**Sensitivity 1 Scenario A**

| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,18 | 0,17 | 0,20 | 0,24 | 0,18 | 0,06 | 0,18 | 0,18 | 0,15 | 0,16 | 0,20 | 0,20 | 0,19 | 0,13 | 0,19 | 0,22 | 0,28 |
| 3 | Centre 3 | Office | 0,19 | 0,17 | 0,21 | 0,24 | 0,18 | 0,06 | 0,18 | 0,18 | 0,16 | 0,17 | 0,21 | 0,20 | 0,24 | 0,14 | 0,19 | 0,22 | 0,28 |
| 2 | Centre 2 | Office | 0,19 | 0,16 | 0,22 | 0,16 | 0,18 | 0,06 | 0,18 | 0,17 | 0,17 | 0,18 | 0,24 | 0,20 | 0,23 | 0,14 | 0,19 | 0,23 | 0,27 |
| 1 | Centre 1 | Office | 0,20 | 0,17 | 0,22 | 0,22 | 0,18 | 0,06 | 0,18 | 0,17 | 0,19 | 0,21 | 0,27 | 0,20 | 0,22 | 0,16 | 0,19 | 0,24 | 0,27 |
| 0 | Plinth | Retail & Catering | 0,22 | 0,19 | 0,26 | 0,19 | 0,18 | 0,04 | 0,18 | 0,18 | 0,26 | 0,27 | 0,40 | 0,23 | 0,19 | 0,21 | 0,21 | 0,27 | 0,28 |
| -1 | Basement | Parking | 0,21 | 0,19 | 0,23 | 0,19 | 0,18 | 0,04 | 0,18 | 0,15 | 0,27 | 0,36 | 0,40 | 0,23 | 0,21 | 0,13 | 0,09 | 0,27 | 0,25 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,21 | 0,18 | 0,25 | 0,25 | 0,19 | 0,07 | 0,20 | 0,20 | 0,19 | 0,15 | 0,30 | 0,25 | 0,23 | 0,18 | 0,26 | 0,21 | 0,31 |
| 3 | Centre 3 | Office | 0,22 | 0,18 | 0,25 | 0,25 | 0,19 | 0,07 | 0,20 | 0,20 | 0,19 | 0,15 | 0,31 | 0,25 | 0,25 | 0,18 | 0,26 | 0,21 | 0,31 |
| 2 | Centre 2 | Office | 0,22 | 0,18 | 0,26 | 0,21 | 0,19 | 0,07 | 0,20 | 0,20 | 0,20 | 0,16 | 0,32 | 0,25 | 0,25 | 0,18 | 0,26 | 0,21 | 0,31 |
| 1 | Centre 1 | Office | 0,20 | 0,16 | 0,23 | 0,22 | 0,17 | 0,06 | 0,18 | 0,18 | 0,19 | 0,15 | 0,31 | 0,23 | 0,22 | 0,17 | 0,24 | 0,19 | 0,28 |
| 0 | Plinth | Retail & Catering | 0,21 | 0,17 | 0,24 | 0,19 | 0,17 | 0,05 | 0,18 | 0,18 | 0,24 | 0,18 | 0,39 | 0,25 | 0,19 | 0,17 | 0,24 | 0,18 | 0,28 |
| -1 | Basement | Parking | 0,21 | 0,19 | 0,24 | 0,21 | 0,19 | 0,05 | 0,19 | 0,18 | 0,26 | 0,22 | 0,43 | 0,27 | 0,22 | 0,14 | 0,17 | 0,19 | 0,28 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,20 | 0,16 | 0,23 | 0,22 | 0,18 | 0,06 | 0,18 | 0,18 | 0,19 | 0,14 | 0,27 | 0,18 | 0,21 | 0,19 | 0,23 | 0,24 | 0,28 |
| 3 | Centre 3 | Office | 0,20 | 0,16 | 0,23 | 0,22 | 0,18 | 0,06 | 0,18 | 0,18 | 0,19 | 0,14 | 0,28 | 0,18 | 0,22 | 0,19 | 0,23 | 0,24 | 0,28 |
| 2 | Centre 2 | Office | 0,20 | 0,16 | 0,23 | 0,19 | 0,18 | 0,06 | 0,18 | 0,18 | 0,20 | 0,15 | 0,29 | 0,18 | 0,22 | 0,19 | 0,23 | 0,24 | 0,28 |
| 1 | Centre 1 | Office | 0,20 | 0,17 | 0,24 | 0,21 | 0,18 | 0,05 | 0,18 | 0,18 | 0,22 | 0,16 | 0,32 | 0,18 | 0,21 | 0,21 | 0,24 | 0,25 | 0,28 |
| 0 | Plinth | Retail & Catering | 0,22 | 0,17 | 0,26 | 0,19 | 0,18 | 0,04 | 0,18 | 0,18 | 0,26 | 0,18 | 0,39 | 0,19 | 0,19 | 0,25 | 0,25 | 0,27 | 0,28 |
| -1 | Basement | Parking | 0,21 | 0,18 | 0,24 | 0,19 | 0,18 | 0,04 | 0,18 | 0,17 | 0,26 | 0,21 | 0,39 | 0,19 | 0,20 | 0,20 | 0,19 | 0,27 | 0,27 |
| Final Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,20 | 0,17 | 0,24 | 0,24 | 0,19 | 0,07 | 0,19 | 0,19 | 0,18 | 0,15 | 0,28 | 0,23 | 0,22 | 0,17 | 0,24 | 0,22 | 0,30 |
| 3 | Centre 3 | Office | 0,21 | 0,17 | 0,24 | 0,24 | 0,18 | 0,07 | 0,19 | 0,19 | 0,19 | 0,15 | 0,28 | 0,23 | 0,23 | 0,18 | 0,25 | 0,22 | 0,30 |
| 2 | Centre 2 | Office | 0,21 | 0,17 | 0,24 | 0,20 | 0,18 | 0,07 | 0,19 | 0,19 | 0,20 | 0,16 | 0,29 | 0,23 | 0,23 | 0,19 | 0,25 | 0,22 | 0,30 |
| 1 | Centre 1 | Office | 0,20 | 0,17 | 0,24 | 0,22 | 0,18 | 0,06 | 0,18 | 0,18 | 0,21 | 0,16 | 0,31 | 0,22 | 0,21 | 0,19 | 0,23 | 0,21 | 0,28 |
| 0 | Plinth | Retail & Catering | 0,21 | 0,18 | 0,25 | 0,19 | 0,18 | 0,05 | 0,18 | 0,18 | 0,26 | 0,19 | 0,39 | 0,24 | 0,19 | 0,22 | 0,24 | 0,21 | 0,28 |
| -1 | Basement | Parking | 0,21 | 0,18 | 0,24 | 0,20 | 0,18 | 0,05 | 0,19 | 0,17 | 0,26 | 0,23 | 0,40 | 0,25 | 0,20 | 0,18 | 0,17 | 0,22 | 0,28 |

**Sensitivity 1 Scenario B**

| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,21 | 0,21 | 0,20 | 0,18 | 0,20 | 0,13 | 0,18 | 0,21 | 0,30 | 0,27 | 0,38 | 0,16 | 0,10 | 0,21 | 0,09 | 0,27 | 0,22 |
| 3 | Centre 3 | Office | 0,22 | 0,22 | 0,23 | 0,18 | 0,20 | 0,09 | 0,28 | 0,19 | 0,32 | 0,28 | 0,42 | 0,18 | 0,16 | 0,22 | 0,12 | 0,27 | 0,24 |
| 2 | Centre 2 | Services & Facilities | 0,20 | 0,20 | 0,21 | 0,18 | 0,18 | 0,07 | 0,22 | 0,21 | 0,26 | 0,28 | 0,37 | 0,17 | 0,17 | 0,17 | 0,12 | 0,26 | 0,22 |
| 1 | Centre 1 | Services & Facilities | 0,20 | 0,20 | 0,21 | 0,18 | 0,18 | 0,07 | 0,20 | 0,21 | 0,26 | 0,30 | 0,37 | 0,17 | 0,17 | 0,16 | 0,11 | 0,26 | 0,23 |
| 0 | Plinth | Parking | 0,21 | 0,22 | 0,20 | 0,18 | 0,18 | 0,04 | 0,19 | 0,20 | 0,31 | 0,41 | 0,38 | 0,18 | 0,18 | 0,12 | 0,07 | 0,25 | 0,21 |
| -1 | Basement | Parking | 0,21 | 0,22 | 0,20 | 0,18 | 0,18 | 0,04 | 0,18 | 0,21 | 0,32 | 0,41 | 0,38 | 0,18 | 0,18 | 0,12 | 0,07 | 0,25 | 0,21 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,21 | 0,20 | 0,22 | 0,23 | 0,20 | 0,11 | 0,20 | 0,12 | 0,25 | 0,31 | 0,38 | 0,19 | 0,18 | 0,15 | 0,12 | 0,27 | 0,24 |
| 3 | Centre 3 | Office | 0,22 | 0,21 | 0,23 | 0,23 | 0,20 | 0,09 | 0,24 | 0,12 | 0,25 | 0,31 | 0,39 | 0,20 | 0,22 | 0,15 | 0,13 | 0,27 | 0,25 |
| 2 | Centre 2 | Services & Facilities | 0,21 | 0,20 | 0,22 | 0,23 | 0,19 | 0,08 | 0,22 | 0,12 | 0,23 | 0,31 | 0,37 | 0,19 | 0,22 | 0,13 | 0,13 | 0,26 | 0,24 |
| 1 | Centre 1 | Services & Facilities | 0,19 | 0,18 | 0,20 | 0,21 | 0,17 | 0,07 | 0,19 | 0,11 | 0,21 | 0,29 | 0,34 | 0,18 | 0,20 | 0,12 | 0,11 | 0,24 | 0,22 |
| 0 | Plinth | Parking | 0,19 | 0,19 | 0,20 | 0,19 | 0,18 | 0,05 | 0,19 | 0,08 | 0,25 | 0,38 | 0,38 | 0,18 | 0,19 | 0,10 | 0,07 | 0,25 | 0,21 |
| -1 | Basement | Parking | 0,21 | 0,20 | 0,21 | 0,21 | 0,19 | 0,05 | 0,19 | 0,09 | 0,28 | 0,41 | 0,41 | 0,19 | 0,21 | 0,10 | 0,08 | 0,27 | 0,22 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,19 | 0,19 | 0,18 | 0,21 | 0,19 | 0,08 | 0,18 | 0,18 | 0,22 | 0,29 | 0,32 | 0,17 | 0,15 | 0,10 | 0,09 | 0,25 | 0,20 |
| 3 | Centre 3 | Office | 0,19 | 0,19 | 0,19 | 0,21 | 0,19 | 0,07 | 0,21 | 0,17 | 0,23 | 0,29 | 0,33 | 0,18 | 0,17 | 0,10 | 0,09 | 0,25 | 0,20 |
| 2 | Centre 2 | Services & Facilities | 0,19 | 0,19 | 0,19 | 0,21 | 0,18 | 0,06 | 0,19 | 0,18 | 0,21 | 0,29 | 0,32 | 0,18 | 0,17 | 0,09 | 0,09 | 0,25 | 0,20 |
| 1 | Centre 1 | Services & Facilities | 0,19 | 0,19 | 0,19 | 0,20 | 0,18 | 0,06 | 0,19 | 0,18 | 0,22 | 0,32 | 0,34 | 0,18 | 0,17 | 0,09 | 0,08 | 0,25 | 0,20 |
| 0 | Plinth | Parking | 0,20 | 0,20 | 0,19 | 0,19 | 0,18 | 0,04 | 0,18 | 0,17 | 0,26 | 0,39 | 0,38 | 0,18 | 0,17 | 0,09 | 0,06 | 0,26 | 0,19 |
| -1 | Basement | Parking | 0,20 | 0,20 | 0,19 | 0,19 | 0,18 | 0,04 | 0,18 | 0,17 | 0,26 | 0,39 | 0,38 | 0,18 | 0,17 | 0,08 | 0,06 | 0,26 | 0,19 |
| Final Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,20 | 0,20 | 0,21 | 0,22 | 0,20 | 0,11 | 0,19 | 0,15 | 0,25 | 0,30 | 0,37 | 0,18 | 0,16 | 0,15 | 0,11 | 0,27 | 0,23 |
| 3 | Centre 3 | Office | 0,21 | 0,21 | 0,22 | 0,22 | 0,20 | 0,09 | 0,24 | 0,14 | 0,26 | 0,30 | 0,39 | 0,19 | 0,19 | 0,15 | 0,12 | 0,27 | 0,24 |
| 2 | Centre 2 | Services & Facilities | 0,20 | 0,20 | 0,21 | 0,22 | 0,19 | 0,08 | 0,21 | 0,15 | 0,23 | 0,30 | 0,36 | 0,19 | 0,20 | 0,13 | 0,12 | 0,26 | 0,23 |
| 1 | Centre 1 | Services & Facilities | 0,19 | 0,19 | 0,20 | 0,20 | 0,18 | 0,07 | 0,19 | 0,14 | 0,22 | 0,30 | 0,35 | 0,18 | 0,19 | 0,12 | 0,11 | 0,25 | 0,22 |
| 0 | Plinth | Parking | 0,20 | 0,20 | 0,20 | 0,19 | 0,18 | 0,05 | 0,19 | 0,13 | 0,27 | 0,39 | 0,38 | 0,18 | 0,19 | 0,10 | 0,07 | 0,25 | 0,20 |
| -1 | Basement | Parking | 0,20 | 0,21 | 0,20 | 0,20 | 0,19 | 0,05 | 0,19 | 0,13 | 0,29 | 0,41 | 0,40 | 0,19 | 0,20 | 0,10 | 0,07 | 0,27 | 0,21 |

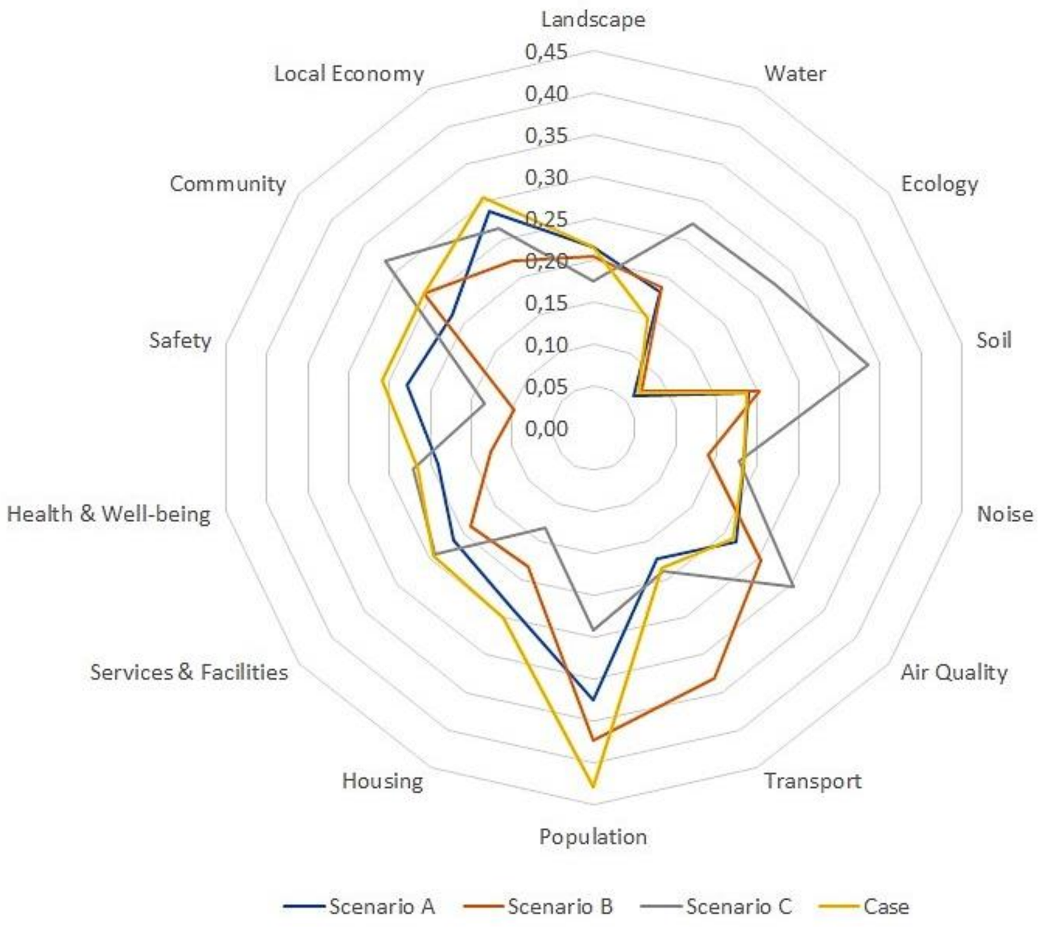
**Sensitivity 1 Scenario C**

| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,22 | 0,21 | 0,23 | 0,17 | 0,20 | 0,21 | 0,29 | 0,16 | 0,24 | 0,21 | 0,34 | 0,17 | 0,12 | 0,31 | 0,18 | 0,22 | 0,27 |
| 3 | Centre 3 | Residential | 0,22 | 0,21 | 0,23 | 0,17 | 0,20 | 0,22 | 0,29 | 0,16 | 0,25 | 0,21 | 0,34 | 0,17 | 0,12 | 0,31 | 0,19 | 0,22 | 0,26 |
| 2 | Centre 2 | Offices | 0,22 | 0,22 | 0,23 | 0,15 | 0,21 | 0,22 | 0,29 | 0,16 | 0,26 | 0,21 | 0,34 | 0,17 | 0,12 | 0,31 | 0,19 | 0,20 | 0,26 |
| 1 | Centre 1 | Retail & Catering | 0,22 | 0,22 | 0,22 | 0,17 | 0,21 | 0,22 | 0,30 | 0,16 | 0,26 | 0,22 | 0,33 | 0,17 | 0,11 | 0,30 | 0,17 | 0,21 | 0,26 |
| 0 | Plinth | Urban Green | 0,23 | 0,24 | 0,21 | 0,16 | 0,23 | 0,29 | 0,34 | 0,15 | 0,25 | 0,24 | 0,36 | 0,15 | 0,11 | 0,31 | 0,13 | 0,19 | 0,25 |
| -1 | Basement | Parking | 0,21 | 0,22 | 0,21 | 0,16 | 0,22 | 0,20 | 0,30 | 0,14 | 0,24 | 0,26 | 0,36 | 0,17 | 0,10 | 0,26 | 0,12 | 0,18 | 0,25 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,25 | 0,26 | 0,25 | 0,20 | 0,31 | 0,27 | 0,34 | 0,20 | 0,33 | 0,17 | 0,22 | 0,15 | 0,33 | 0,19 | 0,15 | 0,40 | 0,30 |
| 3 | Centre 3 | Residential | 0,26 | 0,26 | 0,25 | 0,20 | 0,31 | 0,29 | 0,34 | 0,20 | 0,34 | 0,17 | 0,21 | 0,15 | 0,34 | 0,19 | 0,16 | 0,40 | 0,30 |
| 2 | Centre 2 | Offices | 0,26 | 0,27 | 0,24 | 0,17 | 0,32 | 0,29 | 0,35 | 0,20 | 0,35 | 0,17 | 0,21 | 0,14 | 0,34 | 0,19 | 0,16 | 0,37 | 0,30 |
| 1 | Centre 1 | Retail & Catering | 0,23 | 0,24 | 0,22 | 0,17 | 0,29 | 0,26 | 0,32 | 0,18 | 0,32 | 0,16 | 0,19 | 0,13 | 0,29 | 0,16 | 0,13 | 0,35 | 0,27 |
| 0 | Plinth | Urban Green | 0,24 | 0,28 | 0,21 | 0,17 | 0,34 | 0,35 | 0,38 | 0,17 | 0,35 | 0,18 | 0,15 | 0,09 | 0,34 | 0,13 | 0,10 | 0,36 | 0,26 |
| -1 | Basement | Parking | 0,24 | 0,27 | 0,21 | 0,18 | 0,36 | 0,26 | 0,36 | 0,17 | 0,36 | 0,21 | 0,16 | 0,10 | 0,36 | 0,12 | 0,09 | 0,38 | 0,28 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,21 | 0,21 | 0,21 | 0,18 | 0,16 | 0,25 | 0,31 | 0,18 | 0,22 | 0,17 | 0,28 | 0,13 | 0,11 | 0,32 | 0,12 | 0,27 | 0,21 |
| 3 | Centre 3 | Residential | 0,21 | 0,21 | 0,21 | 0,18 | 0,16 | 0,27 | 0,31 | 0,18 | 0,23 | 0,17 | 0,28 | 0,13 | 0,12 | 0,32 | 0,13 | 0,27 | 0,21 |
| 2 | Centre 2 | Offices | 0,21 | 0,22 | 0,20 | 0,16 | 0,17 | 0,27 | 0,32 | 0,18 | 0,24 | 0,17 | 0,28 | 0,13 | 0,11 | 0,32 | 0,13 | 0,25 | 0,21 |
| 1 | Centre 1 | Retail & Catering | 0,21 | 0,23 | 0,20 | 0,17 | 0,17 | 0,29 | 0,33 | 0,18 | 0,26 | 0,18 | 0,29 | 0,12 | 0,09 | 0,33 | 0,12 | 0,27 | 0,20 |
| 0 | Plinth | Urban Green | 0,22 | 0,25 | 0,20 | 0,17 | 0,19 | 0,36 | 0,38 | 0,17 | 0,27 | 0,19 | 0,31 | 0,10 | 0,08 | 0,35 | 0,09 | 0,26 | 0,19 |
| -1 | Basement | Parking | 0,21 | 0,22 | 0,19 | 0,17 | 0,18 | 0,25 | 0,34 | 0,16 | 0,26 | 0,22 | 0,31 | 0,11 | 0,08 | 0,29 | 0,08 | 0,25 | 0,19 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,24 | 0,24 | 0,24 | 0,19 | 0,26 | 0,26 | 0,32 | 0,19 | 0,29 | 0,18 | 0,25 | 0,15 | 0,24 | 0,24 | 0,15 | 0,34 | 0,28 |
| 3 | Centre 3 | Residential | 0,24 | 0,24 | 0,24 | 0,19 | 0,26 | 0,27 | 0,33 | 0,19 | 0,30 | 0,18 | 0,25 | 0,15 | 0,25 | 0,24 | 0,16 | 0,34 | 0,28 |
| 2 | Centre 2 | Offices | 0,24 | 0,25 | 0,23 | 0,17 | 0,27 | 0,27 | 0,33 | 0,19 | 0,31 | 0,18 | 0,25 | 0,14 | 0,25 | 0,24 | 0,16 | 0,31 | 0,27 |
| 1 | Centre 1 | Retail & Catering | 0,23 | 0,24 | 0,22 | 0,17 | 0,25 | 0,26 | 0,32 | 0,18 | 0,30 | 0,18 | 0,24 | 0,14 | 0,22 | 0,22 | 0,14 | 0,30 | 0,25 |
| 0 | Plinth | Urban Green | 0,23 | 0,26 | 0,21 | 0,17 | 0,29 | 0,34 | 0,37 | 0,17 | 0,31 | 0,19 | 0,23 | 0,10 | 0,24 | 0,21 | 0,10 | 0,31 | 0,25 |
| -1 | Basement | Parking | 0,23 | 0,25 | 0,21 | 0,17 | 0,30 | 0,25 | 0,35 | 0,16 | 0,31 | 0,22 | 0,23 | 0,12 | 0,25 | 0,18 | 0,10 | 0,31 | 0,26 |

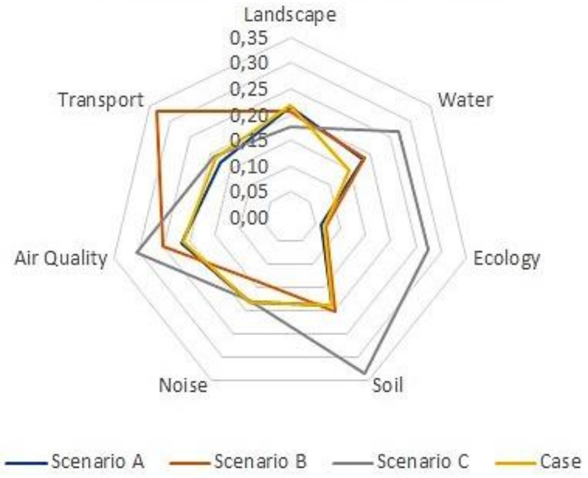
**Sensitivity 1 Case scenario**

| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,22 | 0,17 | 0,26 | 0,22 | 0,13 | 0,08 | 0,18 | 0,18 | 0,19 | 0,23 | 0,39 | 0,22 | 0,24 | 0,19 | 0,26 | 0,23 | 0,30 |
| 3 | Centre 3 | Residential | 0,22 | 0,17 | 0,26 | 0,22 | 0,13 | 0,08 | 0,18 | 0,18 | 0,19 | 0,24 | 0,39 | 0,22 | 0,24 | 0,19 | 0,26 | 0,23 | 0,30 |
| 2 | Centre 2 | Residential | 0,22 | 0,17 | 0,26 | 0,19 | 0,14 | 0,08 | 0,18 | 0,18 | 0,19 | 0,24 | 0,38 | 0,23 | 0,23 | 0,19 | 0,26 | 0,23 | 0,30 |
| 1 | Centre 1 | Residential | 0,22 | 0,18 | 0,26 | 0,21 | 0,14 | 0,08 | 0,18 | 0,18 | 0,20 | 0,26 | 0,39 | 0,23 | 0,23 | 0,20 | 0,26 | 0,23 | 0,29 |
| 0 | Plinth | Retail & Catering | 0,23 | 0,19 | 0,26 | 0,19 | 0,15 | 0,06 | 0,18 | 0,18 | 0,24 | 0,31 | 0,41 | 0,25 | 0,19 | 0,22 | 0,24 | 0,25 | 0,27 |
| -1 | Basement | Parking | 0,22 | 0,19 | 0,25 | 0,19 | 0,17 | 0,06 | 0,18 | 0,16 | 0,25 | 0,34 | 0,41 | 0,24 | 0,19 | 0,18 | 0,18 | 0,25 | 0,27 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,24 | 0,17 | 0,31 | 0,25 | 0,14 | 0,07 | 0,20 | 0,20 | 0,19 | 0,15 | 0,47 | 0,26 | 0,30 | 0,22 | 0,28 | 0,28 | 0,35 |
| 3 | Centre 3 | Residential | 0,24 | 0,17 | 0,31 | 0,25 | 0,14 | 0,07 | 0,20 | 0,20 | 0,20 | 0,15 | 0,47 | 0,26 | 0,30 | 0,22 | 0,28 | 0,28 | 0,35 |
| 2 | Centre 2 | Residential | 0,24 | 0,17 | 0,30 | 0,22 | 0,15 | 0,07 | 0,20 | 0,20 | 0,20 | 0,16 | 0,46 | 0,26 | 0,29 | 0,22 | 0,28 | 0,28 | 0,34 |
| 1 | Centre 1 | Residential | 0,22 | 0,16 | 0,27 | 0,22 | 0,13 | 0,06 | 0,18 | 0,18 | 0,19 | 0,15 | 0,42 | 0,24 | 0,25 | 0,21 | 0,25 | 0,25 | 0,30 |
| 0 | Plinth | Retail & Catering | 0,22 | 0,17 | 0,28 | 0,20 | 0,15 | 0,05 | 0,18 | 0,18 | 0,23 | 0,17 | 0,42 | 0,26 | 0,21 | 0,24 | 0,26 | 0,26 | 0,28 |
| -1 | Basement | Parking | 0,23 | 0,18 | 0,28 | 0,21 | 0,18 | 0,05 | 0,19 | 0,17 | 0,26 | 0,21 | 0,46 | 0,27 | 0,22 | 0,22 | 0,21 | 0,29 | 0,29 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,21 | 0,16 | 0,27 | 0,22 | 0,13 | 0,09 | 0,18 | 0,18 | 0,19 | 0,14 | 0,39 | 0,23 | 0,24 | 0,21 | 0,29 | 0,22 | 0,30 |
| 3 | Centre 3 | Residential | 0,21 | 0,16 | 0,27 | 0,22 | 0,13 | 0,08 | 0,18 | 0,18 | 0,19 | 0,14 | 0,39 | 0,23 | 0,23 | 0,21 | 0,29 | 0,22 | 0,30 |
| 2 | Centre 2 | Residential | 0,21 | 0,16 | 0,27 | 0,19 | 0,13 | 0,08 | 0,18 | 0,18 | 0,19 | 0,15 | 0,38 | 0,24 | 0,23 | 0,21 | 0,29 | 0,23 | 0,29 |
| 1 | Centre 1 | Residential | 0,22 | 0,16 | 0,27 | 0,21 | 0,14 | 0,07 | 0,18 | 0,18 | 0,21 | 0,16 | 0,40 | 0,24 | 0,22 | 0,22 | 0,29 | 0,24 | 0,29 |
| 0 | Plinth | Retail & Catering | 0,22 | 0,17 | 0,28 | 0,19 | 0,15 | 0,05 | 0,18 | 0,18 | 0,25 | 0,18 | 0,41 | 0,27 | 0,19 | 0,26 | 0,28 | 0,26 | 0,27 |
| -1 | Basement | Parking | 0,22 | 0,17 | 0,26 | 0,19 | 0,17 | 0,05 | 0,18 | 0,16 | 0,26 | 0,21 | 0,41 | 0,25 | 0,19 | 0,21 | 0,20 | 0,26 | 0,27 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,23 | 0,17 | 0,29 | 0,24 | 0,14 | 0,08 | 0,19 | 0,19 | 0,19 | 0,17 | 0,44 | 0,25 | 0,27 | 0,21 | 0,28 | 0,26 | 0,33 |
| 3 | Centre 3 | Residential | 0,23 | 0,17 | 0,29 | 0,24 | 0,14 | 0,08 | 0,19 | 0,19 | 0,19 | 0,17 | 0,44 | 0,25 | 0,27 | 0,21 | 0,28 | 0,26 | 0,33 |
| 2 | Centre 2 | Residential | 0,23 | 0,17 | 0,29 | 0,21 | 0,14 | 0,08 | 0,19 | 0,19 | 0,20 | 0,17 | 0,43 | 0,25 | 0,27 | 0,21 | 0,28 | 0,26 | 0,32 |
| 1 | Centre 1 | Residential | 0,22 | 0,16 | 0,27 | 0,22 | 0,14 | 0,07 | 0,18 | 0,18 | 0,19 | 0,17 | 0,41 | 0,24 | 0,24 | 0,21 | 0,26 | 0,24 | 0,30 |
| 0 | Plinth | Retail & Catering | 0,22 | 0,17 | 0,27 | 0,19 | 0,15 | 0,05 | 0,18 | 0,18 | 0,23 | 0,20 | 0,42 | 0,26 | 0,20 | 0,24 | 0,26 | 0,26 | 0,28 |
| -1 | Basement | Parking | 0,23 | 0,18 | 0,27 | 0,20 | 0,17 | 0,05 | 0,19 | 0,17 | 0,26 | 0,23 | 0,44 | 0,26 | 0,21 | 0,21 | 0,20 | 0,27 | 0,28 |

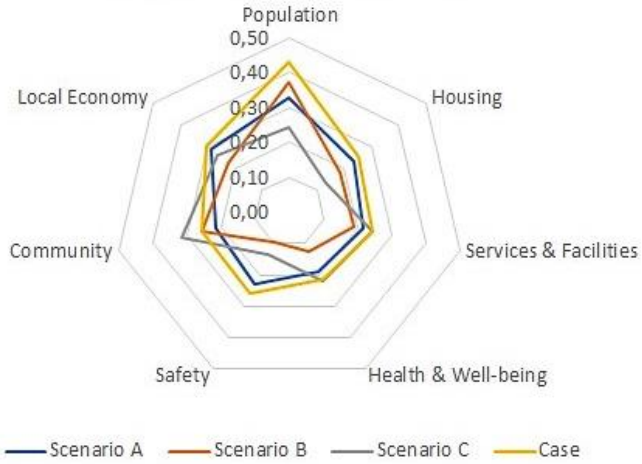
### Overall Compatibility Value Sensitivity 1




### Environmental Compatibility Sensitivity 1




### Social Compatibility Sensitivity 1



# Appendix F

## Output ESIM Sensitivity Analysis 2

**Sensitivity 2 Scenario A**

| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,17 | 0,14 | 0,20 | 0,17 | 0,12 | 0,06 | 0,12 | 0,12 | 0,17 | 0,25 | 0,31 | 0,17 | 0,15 | 0,14 | 0,16 | 0,20 | 0,25 |
| 3 | Centre 3 | Office | 0,17 | 0,14 | 0,20 | 0,17 | 0,12 | 0,06 | 0,12 | 0,12 | 0,17 | 0,25 | 0,32 | 0,17 | 0,17 | 0,15 | 0,17 | 0,20 | 0,25 |
| 2 | Centre 2 | Office | 0,17 | 0,14 | 0,21 | 0,15 | 0,12 | 0,06 | 0,12 | 0,12 | 0,18 | 0,26 | 0,33 | 0,17 | 0,17 | 0,15 | 0,17 | 0,21 | 0,25 |
| 1 | Centre 1 | Office | 0,18 | 0,15 | 0,21 | 0,16 | 0,12 | 0,06 | 0,12 | 0,12 | 0,19 | 0,27 | 0,35 | 0,17 | 0,16 | 0,15 | 0,17 | 0,21 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,16 | 0,24 | 0,14 | 0,12 | 0,05 | 0,12 | 0,12 | 0,23 | 0,33 | 0,45 | 0,19 | 0,14 | 0,19 | 0,19 | 0,24 | 0,25 |
| -1 | Basement | Parking | 0,19 | 0,16 | 0,23 | 0,14 | 0,12 | 0,05 | 0,12 | 0,11 | 0,23 | 0,38 | 0,45 | 0,20 | 0,15 | 0,15 | 0,15 | 0,24 | 0,23 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,18 | 0,14 | 0,23 | 0,20 | 0,13 | 0,07 | 0,13 | 0,13 | 0,17 | 0,11 | 0,36 | 0,20 | 0,18 | 0,16 | 0,23 | 0,17 | 0,28 |
| 3 | Centre 3 | Office | 0,18 | 0,14 | 0,23 | 0,20 | 0,13 | 0,07 | 0,13 | 0,13 | 0,18 | 0,11 | 0,36 | 0,20 | 0,20 | 0,16 | 0,23 | 0,17 | 0,28 |
| 2 | Centre 2 | Office | 0,18 | 0,13 | 0,23 | 0,17 | 0,13 | 0,07 | 0,13 | 0,13 | 0,18 | 0,12 | 0,38 | 0,20 | 0,20 | 0,16 | 0,23 | 0,17 | 0,28 |
| 1 | Centre 1 | Office | 0,17 | 0,12 | 0,21 | 0,17 | 0,12 | 0,06 | 0,12 | 0,12 | 0,17 | 0,11 | 0,36 | 0,18 | 0,17 | 0,15 | 0,21 | 0,16 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,17 | 0,13 | 0,22 | 0,14 | 0,12 | 0,06 | 0,12 | 0,12 | 0,21 | 0,13 | 0,45 | 0,21 | 0,14 | 0,14 | 0,22 | 0,14 | 0,25 |
| -1 | Basement | Parking | 0,18 | 0,14 | 0,23 | 0,15 | 0,13 | 0,06 | 0,13 | 0,12 | 0,23 | 0,16 | 0,50 | 0,23 | 0,16 | 0,12 | 0,18 | 0,15 | 0,25 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,17 | 0,12 | 0,21 | 0,17 | 0,12 | 0,06 | 0,12 | 0,12 | 0,17 | 0,11 | 0,31 | 0,18 | 0,16 | 0,16 | 0,19 | 0,19 | 0,25 |
| 3 | Centre 3 | Office | 0,17 | 0,12 | 0,21 | 0,17 | 0,12 | 0,06 | 0,12 | 0,12 | 0,17 | 0,11 | 0,31 | 0,19 | 0,17 | 0,17 | 0,19 | 0,19 | 0,25 |
| 2 | Centre 2 | Office | 0,17 | 0,12 | 0,21 | 0,15 | 0,12 | 0,06 | 0,12 | 0,12 | 0,18 | 0,11 | 0,33 | 0,19 | 0,17 | 0,17 | 0,19 | 0,20 | 0,25 |
| 1 | Centre 1 | Office | 0,17 | 0,13 | 0,22 | 0,16 | 0,12 | 0,06 | 0,12 | 0,12 | 0,19 | 0,12 | 0,37 | 0,19 | 0,16 | 0,18 | 0,20 | 0,21 | 0,24 |
| 0 | Plinth | Retail & Catering | 0,19 | 0,13 | 0,25 | 0,13 | 0,12 | 0,05 | 0,12 | 0,12 | 0,23 | 0,14 | 0,46 | 0,21 | 0,13 | 0,22 | 0,22 | 0,23 | 0,25 |
| -1 | Basement | Parking | 0,18 | 0,13 | 0,23 | 0,13 | 0,12 | 0,05 | 0,12 | 0,11 | 0,24 | 0,16 | 0,46 | 0,22 | 0,14 | 0,18 | 0,17 | 0,23 | 0,23 |
| Final Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Office | 0,18 | 0,14 | 0,22 | 0,19 | 0,13 | 0,07 | 0,13 | 0,13 | 0,17 | 0,14 | 0,34 | 0,19 | 0,17 | 0,16 | 0,21 | 0,18 | 0,27 |
| 3 | Centre 3 | Office | 0,18 | 0,13 | 0,22 | 0,19 | 0,12 | 0,07 | 0,13 | 0,13 | 0,17 | 0,13 | 0,33 | 0,20 | 0,18 | 0,16 | 0,21 | 0,18 | 0,27 |
| 2 | Centre 2 | Office | 0,18 | 0,13 | 0,22 | 0,16 | 0,12 | 0,07 | 0,13 | 0,13 | 0,18 | 0,13 | 0,34 | 0,20 | 0,18 | 0,17 | 0,21 | 0,18 | 0,27 |
| 1 | Centre 1 | Office | 0,17 | 0,13 | 0,22 | 0,17 | 0,12 | 0,06 | 0,12 | 0,12 | 0,19 | 0,13 | 0,37 | 0,18 | 0,16 | 0,17 | 0,20 | 0,18 | 0,25 |
| 0 | Plinth | Retail & Catering | 0,18 | 0,13 | 0,23 | 0,14 | 0,12 | 0,05 | 0,12 | 0,12 | 0,23 | 0,16 | 0,46 | 0,21 | 0,14 | 0,19 | 0,22 | 0,18 | 0,25 |
| -1 | Basement | Parking | 0,19 | 0,14 | 0,23 | 0,14 | 0,12 | 0,06 | 0,13 | 0,12 | 0,24 | 0,19 | 0,47 | 0,22 | 0,15 | 0,16 | 0,18 | 0,18 | 0,24 |

**Sensitivity 2 Scenario B**

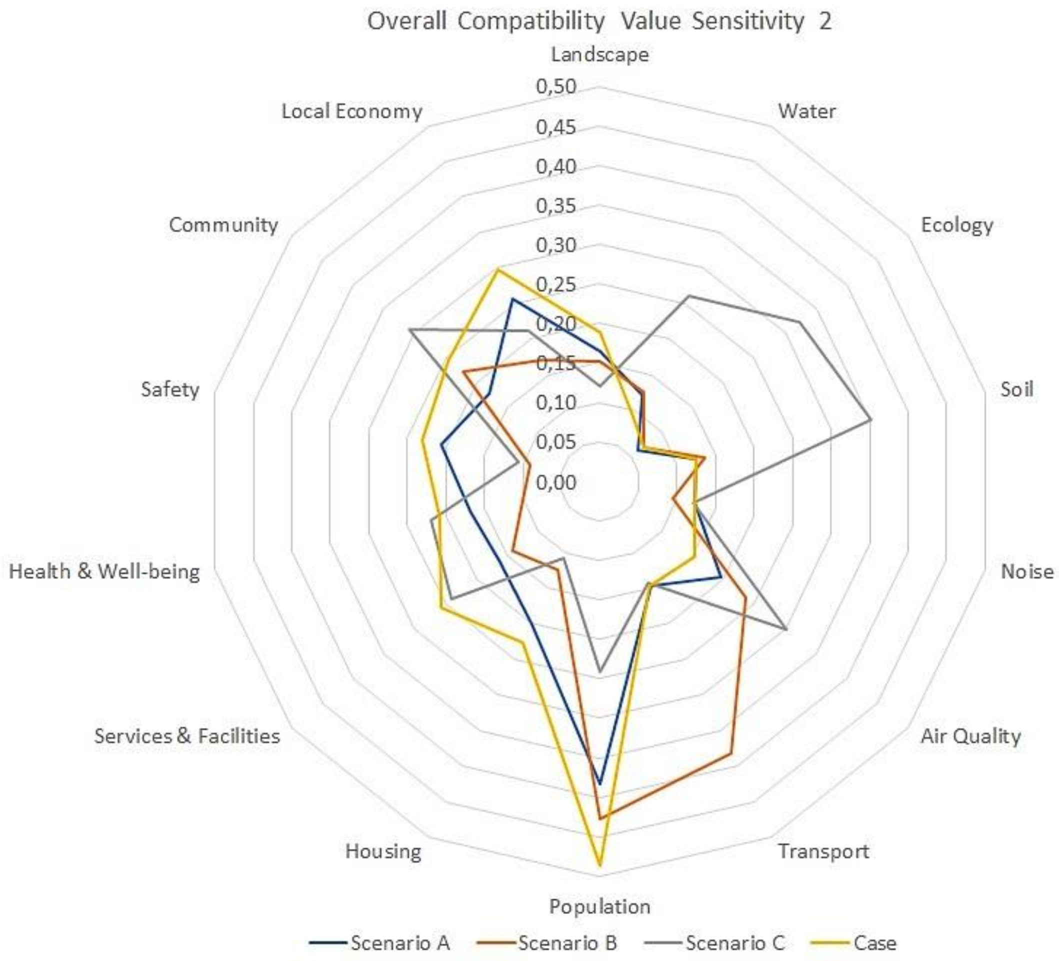
| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,18 | 0,17 | 0,19 | 0,12 | 0,13 | 0,08 | 0,15 | 0,10 | 0,30 | 0,34 | 0,45 | 0,12 | 0,11 | 0,15 | 0,09 | 0,23 | 0,16 |
| 3 | Centre 3 | Office | 0,18 | 0,17 | 0,19 | 0,12 | 0,13 | 0,07 | 0,14 | 0,10 | 0,30 | 0,34 | 0,47 | 0,12 | 0,12 | 0,16 | 0,10 | 0,23 | 0,17 |
| 2 | Centre 2 | Services & Facilities | 0,18 | 0,17 | 0,19 | 0,12 | 0,12 | 0,07 | 0,13 | 0,10 | 0,28 | 0,35 | 0,44 | 0,12 | 0,12 | 0,14 | 0,10 | 0,23 | 0,17 |
| 1 | Centre 1 | Services & Facilities | 0,18 | 0,17 | 0,19 | 0,12 | 0,12 | 0,06 | 0,13 | 0,10 | 0,28 | 0,37 | 0,45 | 0,12 | 0,12 | 0,13 | 0,09 | 0,22 | 0,17 |
| 0 | Plinth | Parking | 0,18 | 0,18 | 0,18 | 0,12 | 0,12 | 0,05 | 0,12 | 0,09 | 0,31 | 0,46 | 0,45 | 0,12 | 0,12 | 0,10 | 0,07 | 0,22 | 0,15 |
| -1 | Basement | Parking | 0,18 | 0,18 | 0,17 | 0,12 | 0,12 | 0,05 | 0,12 | 0,09 | 0,31 | 0,46 | 0,44 | 0,12 | 0,12 | 0,10 | 0,07 | 0,22 | 0,15 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,19 | 0,18 | 0,19 | 0,18 | 0,14 | 0,10 | 0,17 | 0,11 | 0,22 | 0,34 | 0,42 | 0,13 | 0,16 | 0,12 | 0,12 | 0,23 | 0,19 |
| 3 | Centre 3 | Office | 0,19 | 0,18 | 0,20 | 0,18 | 0,14 | 0,09 | 0,15 | 0,10 | 0,23 | 0,35 | 0,45 | 0,13 | 0,17 | 0,12 | 0,12 | 0,23 | 0,20 |
| 2 | Centre 2 | Services & Facilities | 0,18 | 0,17 | 0,19 | 0,18 | 0,13 | 0,08 | 0,14 | 0,10 | 0,21 | 0,36 | 0,42 | 0,13 | 0,17 | 0,10 | 0,12 | 0,22 | 0,19 |
| 1 | Centre 1 | Services & Facilities | 0,17 | 0,16 | 0,17 | 0,16 | 0,12 | 0,07 | 0,13 | 0,09 | 0,19 | 0,34 | 0,38 | 0,12 | 0,16 | 0,09 | 0,11 | 0,20 | 0,17 |
| 0 | Plinth | Parking | 0,17 | 0,17 | 0,17 | 0,14 | 0,12 | 0,06 | 0,12 | 0,09 | 0,23 | 0,44 | 0,44 | 0,12 | 0,14 | 0,08 | 0,08 | 0,22 | 0,15 |
| -1 | Basement | Parking | 0,19 | 0,18 | 0,19 | 0,15 | 0,13 | 0,06 | 0,13 | 0,09 | 0,25 | 0,48 | 0,47 | 0,13 | 0,15 | 0,08 | 0,08 | 0,24 | 0,16 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,16 | 0,16 | 0,16 | 0,16 | 0,13 | 0,08 | 0,15 | 0,09 | 0,21 | 0,32 | 0,36 | 0,12 | 0,11 | 0,09 | 0,06 | 0,21 | 0,17 |
| 3 | Centre 3 | Office | 0,16 | 0,16 | 0,17 | 0,16 | 0,13 | 0,07 | 0,14 | 0,09 | 0,21 | 0,32 | 0,38 | 0,12 | 0,12 | 0,09 | 0,06 | 0,21 | 0,17 |
| 2 | Centre 2 | Services & Facilities | 0,16 | 0,15 | 0,16 | 0,15 | 0,12 | 0,06 | 0,13 | 0,09 | 0,19 | 0,33 | 0,36 | 0,12 | 0,12 | 0,08 | 0,06 | 0,21 | 0,17 |
| 1 | Centre 1 | Services & Facilities | 0,16 | 0,16 | 0,16 | 0,15 | 0,12 | 0,06 | 0,13 | 0,09 | 0,20 | 0,37 | 0,39 | 0,12 | 0,12 | 0,08 | 0,06 | 0,21 | 0,16 |
| 0 | Plinth | Parking | 0,17 | 0,17 | 0,17 | 0,13 | 0,12 | 0,05 | 0,12 | 0,09 | 0,24 | 0,46 | 0,44 | 0,12 | 0,12 | 0,07 | 0,05 | 0,22 | 0,15 |
| -1 | Basement | Parking | 0,17 | 0,17 | 0,17 | 0,13 | 0,12 | 0,05 | 0,12 | 0,08 | 0,24 | 0,46 | 0,44 | 0,12 | 0,12 | 0,07 | 0,05 | 0,23 | 0,14 |
| Final Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Urban Green | 0,18 | 0,18 | 0,19 | 0,16 | 0,13 | 0,09 | 0,16 | 0,10 | 0,24 | 0,34 | 0,42 | 0,12 | 0,14 | 0,12 | 0,10 | 0,23 | 0,18 |
| 3 | Centre 3 | Office | 0,18 | 0,17 | 0,19 | 0,16 | 0,13 | 0,08 | 0,15 | 0,10 | 0,24 | 0,34 | 0,44 | 0,13 | 0,15 | 0,12 | 0,11 | 0,23 | 0,19 |
| 2 | Centre 2 | Services & Facilities | 0,18 | 0,17 | 0,19 | 0,16 | 0,13 | 0,07 | 0,14 | 0,10 | 0,22 | 0,35 | 0,41 | 0,13 | 0,15 | 0,10 | 0,10 | 0,22 | 0,18 |
| 1 | Centre 1 | Services & Facilities | 0,17 | 0,16 | 0,17 | 0,15 | 0,12 | 0,07 | 0,13 | 0,09 | 0,21 | 0,35 | 0,40 | 0,12 | 0,14 | 0,10 | 0,09 | 0,21 | 0,17 |
| 0 | Plinth | Parking | 0,17 | 0,17 | 0,17 | 0,13 | 0,12 | 0,05 | 0,12 | 0,09 | 0,25 | 0,45 | 0,44 | 0,12 | 0,13 | 0,08 | 0,07 | 0,22 | 0,15 |
| -1 | Basement | Parking | 0,18 | 0,18 | 0,18 | 0,14 | 0,12 | 0,06 | 0,13 | 0,09 | 0,26 | 0,47 | 0,46 | 0,13 | 0,14 | 0,09 | 0,07 | 0,23 | 0,15 |

**Sensitivity 2 Scenario C**

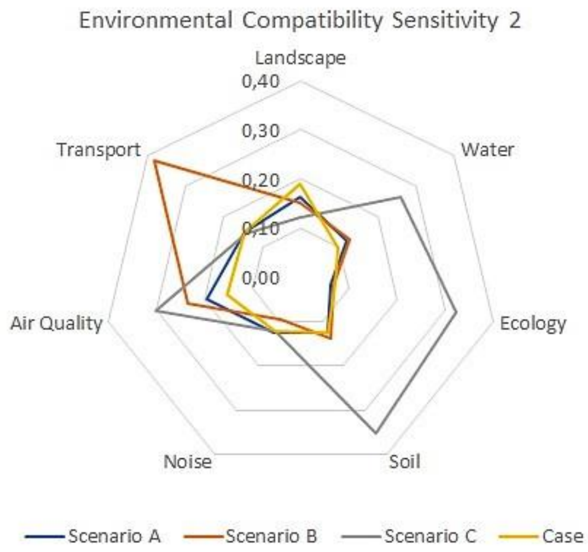
| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,19 | 0,19 | 0,20 | 0,12 | 0,16 | 0,24 | 0,28 | 0,11 | 0,25 | 0,18 | 0,36 | 0,10 | 0,09 | 0,32 | 0,12 | 0,22 | 0,17 |
| 3 | Centre 3 | Residential | 0,20 | 0,19 | 0,20 | 0,12 | 0,16 | 0,25 | 0,29 | 0,11 | 0,26 | 0,18 | 0,36 | 0,10 | 0,09 | 0,33 | 0,14 | 0,22 | 0,17 |
| 2 | Centre 2 | Offices | 0,20 | 0,20 | 0,20 | 0,10 | 0,16 | 0,26 | 0,29 | 0,11 | 0,28 | 0,18 | 0,36 | 0,10 | 0,09 | 0,33 | 0,14 | 0,20 | 0,16 |
| 1 | Centre 1 | Retail & Catering | 0,20 | 0,20 | 0,19 | 0,12 | 0,16 | 0,27 | 0,30 | 0,11 | 0,28 | 0,19 | 0,36 | 0,10 | 0,09 | 0,31 | 0,13 | 0,21 | 0,16 |
| 0 | Plinth | Urban Green | 0,21 | 0,23 | 0,19 | 0,11 | 0,19 | 0,35 | 0,37 | 0,10 | 0,28 | 0,21 | 0,40 | 0,09 | 0,09 | 0,34 | 0,09 | 0,19 | 0,14 |
| -1 | Basement | Parking | 0,19 | 0,20 | 0,18 | 0,11 | 0,17 | 0,24 | 0,30 | 0,10 | 0,26 | 0,24 | 0,40 | 0,10 | 0,08 | 0,28 | 0,08 | 0,18 | 0,14 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,24 | 0,24 | 0,23 | 0,13 | 0,32 | 0,32 | 0,35 | 0,13 | 0,33 | 0,12 | 0,21 | 0,13 | 0,33 | 0,17 | 0,12 | 0,40 | 0,27 |
| 3 | Centre 3 | Residential | 0,24 | 0,25 | 0,24 | 0,14 | 0,33 | 0,33 | 0,35 | 0,13 | 0,35 | 0,12 | 0,21 | 0,13 | 0,35 | 0,17 | 0,13 | 0,40 | 0,27 |
| 2 | Centre 2 | Offices | 0,24 | 0,26 | 0,23 | 0,12 | 0,33 | 0,34 | 0,36 | 0,13 | 0,38 | 0,13 | 0,21 | 0,13 | 0,34 | 0,17 | 0,13 | 0,36 | 0,26 |
| 1 | Centre 1 | Retail & Catering | 0,22 | 0,23 | 0,20 | 0,12 | 0,29 | 0,32 | 0,34 | 0,12 | 0,33 | 0,12 | 0,18 | 0,12 | 0,29 | 0,14 | 0,11 | 0,34 | 0,23 |
| 0 | Plinth | Urban Green | 0,24 | 0,28 | 0,20 | 0,12 | 0,37 | 0,42 | 0,42 | 0,12 | 0,39 | 0,13 | 0,14 | 0,09 | 0,36 | 0,12 | 0,08 | 0,36 | 0,23 |
| -1 | Basement | Parking | 0,24 | 0,27 | 0,20 | 0,12 | 0,37 | 0,32 | 0,38 | 0,12 | 0,40 | 0,16 | 0,15 | 0,10 | 0,38 | 0,10 | 0,08 | 0,38 | 0,25 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,18 | 0,17 | 0,18 | 0,13 | 0,12 | 0,28 | 0,31 | 0,12 | 0,13 | 0,11 | 0,27 | 0,10 | 0,10 | 0,33 | 0,09 | 0,23 | 0,16 |
| 3 | Centre 3 | Residential | 0,18 | 0,18 | 0,19 | 0,13 | 0,12 | 0,30 | 0,32 | 0,12 | 0,14 | 0,11 | 0,27 | 0,10 | 0,10 | 0,34 | 0,11 | 0,23 | 0,16 |
| 2 | Centre 2 | Offices | 0,18 | 0,18 | 0,18 | 0,11 | 0,12 | 0,31 | 0,33 | 0,12 | 0,15 | 0,11 | 0,27 | 0,09 | 0,10 | 0,35 | 0,11 | 0,21 | 0,15 |
| 1 | Centre 1 | Retail & Catering | 0,19 | 0,19 | 0,18 | 0,12 | 0,12 | 0,33 | 0,36 | 0,12 | 0,15 | 0,12 | 0,28 | 0,10 | 0,08 | 0,35 | 0,09 | 0,23 | 0,14 |
| 0 | Plinth | Urban Green | 0,20 | 0,22 | 0,19 | 0,12 | 0,14 | 0,43 | 0,44 | 0,12 | 0,16 | 0,14 | 0,31 | 0,08 | 0,08 | 0,39 | 0,07 | 0,23 | 0,13 |
| -1 | Basement | Parking | 0,18 | 0,19 | 0,17 | 0,12 | 0,12 | 0,29 | 0,35 | 0,11 | 0,16 | 0,16 | 0,31 | 0,09 | 0,07 | 0,31 | 0,07 | 0,22 | 0,13 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Services & Facilities | 0,22 | 0,22 | 0,21 | 0,13 | 0,24 | 0,30 | 0,33 | 0,13 | 0,28 | 0,13 | 0,25 | 0,12 | 0,23 | 0,23 | 0,11 | 0,33 | 0,23 |
| 3 | Centre 3 | Residential | 0,22 | 0,23 | 0,22 | 0,13 | 0,26 | 0,31 | 0,33 | 0,13 | 0,29 | 0,13 | 0,25 | 0,12 | 0,25 | 0,23 | 0,13 | 0,33 | 0,22 |
| 2 | Centre 2 | Offices | 0,22 | 0,23 | 0,21 | 0,11 | 0,26 | 0,32 | 0,34 | 0,13 | 0,31 | 0,13 | 0,25 | 0,11 | 0,24 | 0,24 | 0,13 | 0,30 | 0,22 |
| 1 | Centre 1 | Retail & Catering | 0,21 | 0,22 | 0,20 | 0,12 | 0,23 | 0,31 | 0,33 | 0,12 | 0,29 | 0,13 | 0,24 | 0,11 | 0,21 | 0,22 | 0,11 | 0,29 | 0,20 |
| 0 | Plinth | Urban Green | 0,23 | 0,26 | 0,19 | 0,11 | 0,29 | 0,41 | 0,42 | 0,11 | 0,32 | 0,15 | 0,23 | 0,09 | 0,25 | 0,22 | 0,08 | 0,30 | 0,19 |
| -1 | Basement | Parking | 0,22 | 0,24 | 0,19 | 0,12 | 0,28 | 0,30 | 0,36 | 0,11 | 0,32 | 0,18 | 0,23 | 0,10 | 0,26 | 0,18 | 0,08 | 0,31 | 0,20 |

**Sensitivity 2 Case scenario**

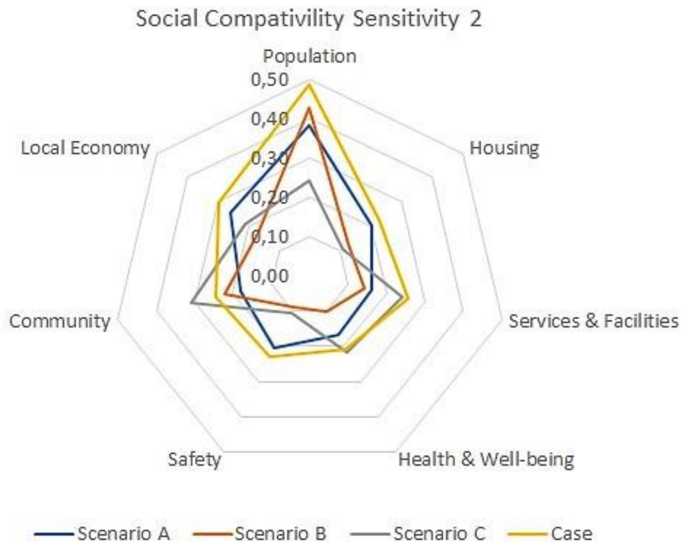
| Floor Level | Floor Section | Floor Name | Average Value | Average Environmental | Average Social | Landscape | Water | Ecology | Soil | Noise | Air Quality | Transport | Population | Housing | Services & Facilities | Health & Well-being | Safety | Community | Local Economy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Level Value (Radius 100m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,19 | 0,14 | 0,24 | 0,17 | 0,10 | 0,07 | 0,12 | 0,12 | 0,17 | 0,25 | 0,44 | 0,17 | 0,19 | 0,16 | 0,26 | 0,20 | 0,28 |
| 3 | Centre 3 | Residential | 0,19 | 0,14 | 0,24 | 0,17 | 0,10 | 0,07 | 0,12 | 0,12 | 0,17 | 0,25 | 0,44 | 0,18 | 0,19 | 0,16 | 0,26 | 0,20 | 0,28 |
| 2 | Centre 2 | Residential | 0,19 | 0,14 | 0,24 | 0,15 | 0,10 | 0,07 | 0,12 | 0,12 | 0,17 | 0,26 | 0,44 | 0,18 | 0,19 | 0,16 | 0,26 | 0,20 | 0,27 |
| 1 | Centre 1 | Residential | 0,19 | 0,15 | 0,24 | 0,16 | 0,10 | 0,07 | 0,12 | 0,12 | 0,18 | 0,27 | 0,44 | 0,18 | 0,18 | 0,17 | 0,26 | 0,20 | 0,27 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,15 | 0,25 | 0,14 | 0,11 | 0,06 | 0,12 | 0,12 | 0,21 | 0,33 | 0,48 | 0,21 | 0,14 | 0,19 | 0,24 | 0,23 | 0,24 |
| -1 | Basement | Parking | 0,20 | 0,16 | 0,23 | 0,14 | 0,11 | 0,06 | 0,12 | 0,11 | 0,23 | 0,38 | 0,48 | 0,20 | 0,14 | 0,16 | 0,19 | 0,23 | 0,23 |
| Location Level Value (Radius 200m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,22 | 0,13 | 0,32 | 0,23 | 0,10 | 0,08 | 0,13 | 0,13 | 0,14 | 0,10 | 0,53 | 0,25 | 0,34 | 0,23 | 0,23 | 0,28 | 0,35 |
| 3 | Centre 3 | Residential | 0,22 | 0,13 | 0,32 | 0,23 | 0,10 | 0,08 | 0,13 | 0,13 | 0,14 | 0,10 | 0,53 | 0,25 | 0,34 | 0,23 | 0,23 | 0,28 | 0,35 |
| 2 | Centre 2 | Residential | 0,22 | 0,13 | 0,32 | 0,20 | 0,10 | 0,08 | 0,13 | 0,13 | 0,14 | 0,11 | 0,53 | 0,25 | 0,33 | 0,24 | 0,23 | 0,28 | 0,35 |
| 1 | Centre 1 | Residential | 0,20 | 0,12 | 0,28 | 0,20 | 0,09 | 0,07 | 0,12 | 0,12 | 0,13 | 0,10 | 0,48 | 0,23 | 0,29 | 0,22 | 0,21 | 0,25 | 0,30 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,11 | 0,28 | 0,20 | 0,08 | 0,07 | 0,12 | 0,12 | 0,11 | 0,10 | 0,47 | 0,25 | 0,27 | 0,24 | 0,22 | 0,25 | 0,28 |
| -1 | Basement | Parking | 0,21 | 0,13 | 0,29 | 0,22 | 0,09 | 0,08 | 0,13 | 0,12 | 0,13 | 0,12 | 0,50 | 0,25 | 0,30 | 0,21 | 0,18 | 0,27 | 0,30 |
| Area Level Value (Radius 300m) | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,19 | 0,12 | 0,25 | 0,17 | 0,10 | 0,07 | 0,12 | 0,12 | 0,17 | 0,11 | 0,44 | 0,19 | 0,20 | 0,17 | 0,28 | 0,20 | 0,28 |
| 3 | Centre 3 | Residential | 0,19 | 0,12 | 0,25 | 0,17 | 0,10 | 0,07 | 0,12 | 0,12 | 0,17 | 0,11 | 0,44 | 0,19 | 0,20 | 0,18 | 0,28 | 0,20 | 0,28 |
| 2 | Centre 2 | Residential | 0,19 | 0,12 | 0,25 | 0,15 | 0,10 | 0,07 | 0,12 | 0,12 | 0,18 | 0,11 | 0,44 | 0,19 | 0,19 | 0,18 | 0,28 | 0,20 | 0,27 |
| 1 | Centre 1 | Residential | 0,19 | 0,12 | 0,25 | 0,16 | 0,10 | 0,06 | 0,12 | 0,12 | 0,19 | 0,12 | 0,45 | 0,20 | 0,18 | 0,19 | 0,27 | 0,21 | 0,27 |
| 0 | Plinth | Retail & Catering | 0,19 | 0,13 | 0,26 | 0,13 | 0,11 | 0,05 | 0,12 | 0,12 | 0,22 | 0,14 | 0,48 | 0,23 | 0,13 | 0,22 | 0,26 | 0,23 | 0,24 |
| -1 | Basement | Parking | 0,19 | 0,13 | 0,24 | 0,13 | 0,11 | 0,05 | 0,12 | 0,11 | 0,24 | 0,16 | 0,48 | 0,22 | 0,13 | 0,18 | 0,20 | 0,23 | 0,23 |
| Final Weighted Aggregation Value | | | | | | | | | | | | | | | | | | | |
| 4 | Top | Residential | 0,21 | 0,13 | 0,29 | 0,21 | 0,10 | 0,07 | 0,13 | 0,13 | 0,15 | 0,13 | 0,50 | 0,22 | 0,28 | 0,20 | 0,25 | 0,25 | 0,32 |
| 3 | Centre 3 | Residential | 0,21 | 0,13 | 0,29 | 0,21 | 0,10 | 0,07 | 0,13 | 0,13 | 0,15 | 0,13 | 0,50 | 0,22 | 0,28 | 0,21 | 0,25 | 0,25 | 0,32 |
| 2 | Centre 2 | Residential | 0,21 | 0,13 | 0,29 | 0,18 | 0,10 | 0,07 | 0,13 | 0,13 | 0,15 | 0,14 | 0,49 | 0,22 | 0,28 | 0,21 | 0,25 | 0,25 | 0,32 |
| 1 | Centre 1 | Residential | 0,20 | 0,12 | 0,27 | 0,19 | 0,09 | 0,07 | 0,12 | 0,12 | 0,15 | 0,14 | 0,47 | 0,21 | 0,25 | 0,20 | 0,23 | 0,23 | 0,29 |
| 0 | Plinth | Retail & Catering | 0,20 | 0,12 | 0,27 | 0,17 | 0,09 | 0,06 | 0,12 | 0,12 | 0,15 | 0,15 | 0,47 | 0,24 | 0,22 | 0,23 | 0,23 | 0,24 | 0,27 |
| -1 | Basement | Parking | 0,20 | 0,14 | 0,27 | 0,18 | 0,10 | 0,07 | 0,13 | 0,12 | 0,17 | 0,18 | 0,49 | 0,23 | 0,23 | 0,20 | 0,19 | 0,25 | 0,27 |



Overall Compatibility Value Sensitivity 2
Landscape
Water
Ecology
Soil
Noise
Air Quality
Transport
Population
Housing
Services & Facilities
Health & Well-being
Safety
Community
Local Economy
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
0,45
0,50
Scenario A
Scenario B
Scenario C
Case

Environmental Compatibility Sensitivity 2
Landscape
Water
Ecology
Soil
Noise
Air Quality
Transport
0,00
0,10
0,20
0,30
0,40
Scenario A
Scenario B
Scenario C
Case

Social Compativility Sensitivity 2
Population
Housing
Services & Facilities
Health & Well-being
Safety
Community
Local Economy
0,00
0,10
0,20
0,30
0,40
0,50
Scenario A
Scenario B
Scenario C
Case