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Neighbourhood Sustainability Assessment as Decision Support Tool for Urban Planning

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Definition of CANSAF (Context Adaptive Neighbourhood Sustainability Assessment Framework)

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Abstract

Increasingly, urban sustainability assessment is called to steer urban planning and decision-making. Nonetheless, several issues related to Sustainability, such as its diverse conceptual roots and the complexity of human and physical systems exacerbated by institutional fragmentation, have hindered its applicability and operationalization. As a result, there are difficulties for unequivocally defining what needs to be assessed and finding a shared understanding of the outcomes and the assessment. Furthermore, existing Neighbourhood Sustainability Assessment (NSA) tools ache from the lack of legitimacy and transparency, as a result of fixed evaluation criteria and inflexible implementation. Therefore, this research project aims to develop an NSA Framework, capable of reflecting on the specific context in which it is intended to be applied, as well as the values and priorities from the involved actors in the decision-making process.

Following the engineering cycle composed by three phases i.e. Problem Investigation, Artefact Design and Validation, the research project built over the values and priorities within a Dutch municipal context as a means to acquire insights on the influence of institutional factors in the inclusion of sustainability in urban development. Furthermore, it revealed that the inclusion of sustainability targets in built environment development is not only dependent on the existence of the suitable tools, but also on several elements such as the lack of integration inside and among organizations, the lack of collaborative approaches, the lack of financial resources and behavioural aspects, among which the lack of leadership and unwillingness to break with the status quo are examples . Moreover, municipal institutions are bound to political agendas which are normally guided by short-term objectives and often conflicting with the long-term vision of sustainability. Conversely, the conceptual model for the framework was benchmarked over state-of-the-art National Rating Systems and guided by a 4-dimensional sustainability model covering Institutional concerns on top of the traditional triple bottom line: Economy, Society and Environment. By doing so, a holistic approach is reached, where decision-makers can define the prioritization and importance of each evaluation area. Furthermore, the model allows different indicators to be linked to each evaluation area and to reflect on the particular conditions where it needs to be applied. These considerations lend legitimacy to the decision-making process and increase the transparency of the outcomes.

In summary, the research project allowed the definition of a conceptual sustainability assessment model designed to include contextual information into the evaluation, thereby reflecting the concerns of the involved decision-makers. Moreover, the project explored the institutional factors that can enable or hinder the integration of such framework in urban planning practices. These facts are of high practical relevance for Municipal authorities, as they are characterized by uncoordinated and inflexible organisational structures which might need to undergo substantial changes to enable them to benefit from the potential of the use of such tools.

Key Words – Sustainability Assessment; Sustainable Urban Planning; Neighbourhood Sustainability Assessment; Multi-criteria decision analysis; Institutional Capacity.

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Definitions

Urban Transition	Describes a shift in a population from one that is dispersed across small rural settlements in which agriculture is the dominant economic activity towards one where the population is concentrated in larger, dense urban settlements characterised by industrial and service activities (UN, 2015).
Sustainability Assessment	Evaluation method aimed to provide decision-makers with an evaluation of global to local integrated nature–society systems in short- and long-term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007).
Sustainable Infrastructure	That one which is designed, developed, maintained, reused, and operated in a way that ensures minimal strain on resources, the environment and the economy. It contributes to enhanced public health and welfare, social equity, and diversity (UN-Habitat, 2016).

Abbreviations

BAU	Business as Usual
B&O	*Beheer en Onderhoud* (Dutch for: Management & Maintenance)
DRSA	Dominance-based rough set approach
ELECTRE	ELimination and Choice Expressing REality
GDP	Gross Domestic Product
MCDA	Multi-Criteria Decision Analysis
NSA	Neighbourhood Sustainability Assessment
PROMETHEE	Preference Ranking Organization METHod for Enrichment of Evaluations
PVG	*Projecten, Vastgoed en Grond* (Dutch for: Projects, Real state and Land)
RL	*Ruimtelijke Leefomgeving* (Dutch for: Spatial Living Environment)
SA	Sustainability Assessment

1. Introduction

By the 16th century, 600 million people were inhabiting this planet (Roser, Ritchie, & Ortiz-Ospina, 2019). Since then, human population has been steadily growing, to such extent that currently the amount of people rounds the 7.7 billion and it is expected to grow 2 billion more by 2050 (UN, 2015). Exacerbated by this fact, the ongoing urban transition processes have been increasing the pressures over the earth's resource base, the generation of social negative externalities and the creation of diseconomies from agglomeration. These factors have put an emphasis on the need to steer the transformative force of cities towards sustainable development (UN-Habitat, 2016).

Sustainability Assessment (SA) as an emergent research field has gained importance in recent decades. Popularization of this field has come as a result of the ubiquitous adoption of *Sustainability* as desirable target in the context of an increasingly urban, complex, dynamic and interconnected reality (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007; Vos, 2007; National Academies of Sciences, Engineering and Medicine, 2016). SA is expected to improve the decision aiding process (Cinelli, Coles, & Kirwan, 2014), which drives it to effectively account for a multidimensional understanding of sustainability (Bond, Morrison-Saunders, & Pope, 2012; Sala, Ciuffo, & Nijkamp, 2015). These influencing factors have pushed the evolution of SA field towards the use of indicator-based tools, as indicators have the capacity to lead to better decisions by simplifying, clarifying and making aggregated information available for stakeholders and policy-makers (Komeily & Srinivasan, 2015).

Nonetheless, the lack of a unique agreed definition of sustainability (Bond & Morrison-Saunders, 2011), the missing consensus on the setting of targeted sustainability objectives among different practices (Komeily & Srinivasan, 2015) and the irresponsiveness to locality (Sharifi & Murayama, 2013), expose a limited ability to effectively assess sustainable development (Sharifi & Murayama, 2013; Komeily & Srinivasan, 2015; Lützkendorf & Balouktsi, 2017; Kaur & Garg, 2019). Consequently, speculation and criticism has been constant factors among practitioners who engage in SA processes (Retzlaff, 2009). In response to these issues, MCDA methodologies has been identified as suited to provide a path towards a sustainable future, by providing structure, transparency and reliability to the SA process (Cinelli, Coles, & Kirwan, 2014)

What is more, the need to increase manageability of urban SA for public institutions and other organisations, has highlighted the importance of focusing on neighbourhoods as a viable scale in which a holistic vision of sustainability can be assessed (Komeily & Srinivasan, 2015). In this context, this research project tackles the identified shortcomings of existing NSA tools, to propose a framework, able to accommodate locality and context-relevance in the assessment process, while accounting for a comprehensive understanding of sustainability. This by developing a conceptual NSA framework, designed as a MCDA tool, intended to support the urban planning process of a Municipal actor such as *Gemeente Apeldoorn*. Finally, as part of a practice-oriented approach, this research deepened into understanding and characterising the organisational features and capabilities to subsequently provide recommendations for changes to be undertaken towards institutional capacity building, as a requirement to achieve higher materialization of the potential benefits of the proposed model (Burch, 2010; Polk, 2011; Castán Broto, 2017).

Subsequent sections further describe the Context guiding the problem formulation, required theoretical background and proposed research strategy. Finally, the results are presented followed by discussion points, conclusion reflecting on the original objective and identified limitations and recommendations for future research on the field.

2. Research Context

Urban transition encompasses a shift in population patterns from one that is dispersed across small rural settlements, dominated by agricultural economic activities, into one where the population is concentrated in urban settlements. Normally, characterized as larger and denser with a dominance of industrial and service activities (UN, 2015). The aforementioned transition processes worldwide, have been in the centre of international concerns for the past decades. The importance surrounding this concern is bound to increase even more, as urban population has already risen above 54% and it is projected to increase to around 67% of the world's total by 2050 (UN, 2015).

On that basis, the transition towards an increasingly urbanized world constitutes a transformative force (UN-Habitat, 2016), capable of steering both, socio-economic trends and climate change phenomena worldwide.

2.1. Urbanization and the Socio-economic Dimensions

Urbanization processes have presented themselves as necessary for driving prosperity in almost all national scenarios. Increasingly, nations and regions depend on economic performance of cities for enhancing productivity and reducing poverty. An evidence of these phenomena is the fact that cities account for more than 80% of the global GDP, thus constituting engines of economic growth (UN-Habitat, 2016).

Higher productivity is achieved in cities as a result of population concentration. Thereby, the emergent urban dynamics perform three main functions for economic gains: matching, sharing and learning (UN-Habitat, 2016). Firstly, cities enable the distinctive match of labour skills supply and demand (OECD, 2010), as well as the requirements from businesses in terms of premises and suppliers. The combined effect of these factors promotes stronger growth and higher flexibility (UN-Habitat, 2016). Secondly, cities offer a supply of shared services and infrastructure allowing the reduction of transportation and communication costs. In addition, access to wider national and global markets (UN-Habitat, 2016), facilitating the formation of linkages and economic relationships between suppliers and buyers (OECD, 2010). Finally, urban settlements create the conditions for knowledge spill-over, whose benefits spread over a regional scope (OECD, 2010). Consequently, firms can benefit from superior flows of information fostering learning and innovation through the co-production of knowledge between businesses, investors and researchers (UN-Habitat, 2016).

Nonetheless, the potential of cities of delivering all aforementioned benefits is not unlimited. On a global scale, economic growth and development will be constrained by the biophysical limits of the Earth which implies a finite pool of resources required for urban industrial development (UN-Habitat, 2016). Furthermore, urban processes can generate negative externalities, which are highly dependent upon planning practices and urbanization trends (UN, 2015). Consequently, poorly planned urbanization can lead to economic disorder, civil unrest, inequality, high carbon intensities, congestion, and vulnerabilities to climate and socioeconomic change (OECD, 2010; UN-Habitat, 2016). In general terms, the aforementioned negative attributes, while not being internalized by firms and households, might show up as direct costs in the long term (OECD, 2010). For instance, higher transportation costs and loss of productivity could come as a result of sprawl and congestion, both factors increasing commuting time. In addition, increased health costs could arise derived from pollution and environmental degradation (OECD, 2010).

2.2. Urbanization and Climate Change

Climate change has been described as one of the greatest challenges of our time, capable of generating adverse impacts severe enough for undermining every country's ability to achieve sustainable development (UN-

Habitat, 2016). In the context of urban transition, cities have a complex relationship with climate change, as cities simultaneously influence and are influenced by it.

On one hand, urban areas concentrate economic activities, households, industries and infrastructures which become hotspots for energy consumption and GHG generation (UN-Habitat, 2016). Resulting from all urban activities, cities contribute to climate change through three main mechanisms, first the direct generation of GHG within city boundaries, second, through the GHG embodied in civil infrastructure and urban energy demand, generated outside the boundaries of the city and third, through the induction of changes in atmospheric chemistry and surface albedo (OECD, 2010). Furthermore, urban activities have deeper consequences like resource depletion, land-use change and loss of biodiversity, all of which push forward the process of global change (National Academies of Sciences, Engineering and Medicine, 2016).

On the other hand, urban dependency on extensive networks for service provision (i.e. transport, sewage, energy, etc.) as well as the high density of built infrastructure (i.e. water treatment and waste disposal facilities, hospitals, etc.) render cities vulnerable to extreme weather events (OECD, 2010). Climate change related effects can be associated to increased frequency and intensity of storm events. These, can disrupt the basic fabric and normal functioning of cities, generating widespread negative impacts over the inhabitants, the infrastructure and the economy (UN-Habitat, 2016). In addition, extreme events might result in hydrological changes with the potential to stress the capacity of drainage and water treatment infrastructure. Consequently, the risk of sanitation problems arises if urban infrastructure is ill-equipped to accommodate sudden water influx demands (OECD, 2010). Moreover, the impact component of flooding risk is high, as it is one of the costliest damaging disasters, due to the compound effect of primary infrastructure damage and loss of life, with the spill-over impacts over social security and public health derived from the potential spread of water-borne pathogens, if the clean water supply were to be compromised (OECD, 2010).

The dual abovementioned relationship between cities and climate change show that despite being a global issue, climate change is a locally manageable problem (UN-Habitat, 2016). Thanks to cities' transformative force, they play a pivotal role for steering the urbanization processes towards sustainability. This means, on first instance, to manage their influence over climate change and other negative environmental impacts. But also, to reduce vulnerabilities of the urban environment to climate change (Romero-Lankao & Dodman, 2011) by effectively managing urbanization patterns, physical exposure, urban planning and disaster preparedness (UN-Habitat, 2016).

2.3. Urbanization Potential for Sustainable Development

As the world continues to undergo urban transition processes, an increasingly urbanized environment puts forward a transformative force which can be used to steer development towards sustainability. Cities taking the lead to address contemporary global challenges like poverty, inequality, environmental degradation and climate change (UN-Habitat, 2016) can generate prosperity and conservation of environmental values. These objectives can be tackled by adequately managing and designing urban spatial configurations, land-use patterns and construction practices.

Urban form plays a vital role for reducing energy demand (OECD, 2010), managing environmental impacts and driving economic productivity (UN-Habitat, 2016). Nonetheless, for materializing any potential benefits from urbanization, there is an urgent demand for integrated planning, delivery of services and strategic policy decisions, which are all required to enable cities to be sustainable, inclusive and ensuring high quality of life (UN-Habitat, 2016). Accordingly, for driving sustainable development, urban space transformation needs to be guided by innovative and responsive planning. This aims to include design principles for developing dense, mixed land-use, inclusive, walkable, bikeable and transit-oriented human-scale urban forms (UN-Habitat,

2016). Moreover, factors such as urbanization patterns, physical exposure and disaster readiness (UN-Habitat, 2016) are needed to steer urban development towards resilience and responsiveness to climate change (Romero-Lankao & Dodman, 2011).

In general terms, a sustainable city depends on a balance between economic, environmental and socio-cultural development goals. This balance is rarely isolated from local governance systems characterized by deep citizen involvement and inclusiveness. Conclusively, the adoption of effective governance mechanisms, leadership, land-use planning, regulations and construction practices allows the creation of sustainable, resilient and inclusive cities (UN-Habitat, 2016). As such, these cities synergistically consider a balance of economic and social structures, thus aiming for quality urban systems and reduced impacts over local and global resource base (Alberti, 1996).

3. Problem Statement

Generally speaking, SA can be performed over a varied scope, ranging from single building, neighbourhood, to entire city/region (Kaur & Garg, 2019). Nonetheless, for assessing urban sustainability, it is argued that neighbourhoods embody the nearest environmental, social and economic level to the citizenship, in which a meaningful sustainability assessment can be performed (Komeily & Srinivasan, 2015; Lützkendorf & Balouktsi, 2017). The fact that neighbourhoods constitute the building blocks of urban fabric provides a human scale which deem the sustainability assessment issue more manageable for institutions and organizations.

In this context a neighbourhood acts as the key spatial link between individual buildings and the broader urban context (Deng, 2011, p. 7). Hence, it can be defined as a relatively small geographic area where at least three main elements can be identified: (a) Buildings & Land use, (b) Civil Infrastructure Systems and (c) Socioeconomic relationships (Deng, 2011; Haider, et al., 2018). Consequently, the sustainability of a urban settlement depends on the capacity of each of its neighbourhoods to be sustainable themselves (Sharifi & Murayama, 2013). Ironically, the field of *Neighbourhood Sustainability Assessment (NSA)* has not received the same attention and relevance, in comparison to other SA scales (Sharifi & Murayama, 2013). The aforementioned considerations guided the definition of the scope of the present research project.

In the pursue of effective Urban Sustainable development, it is of paramount importance to formulate clear and objective methods for measuring whether the planning practices and conceived initiatives are indeed capable of shifting the future of cities towards sustainability (Hiremath, Balachandra, Kumar, Bansode, & Murali, 2013). For this reason, effective assessment depends upon the operationalization of the concept of sustainability. In this context, during the past decades this process has meant the development and evolution of urban assessment methodologies implemented as evaluation tools, whose aim is to facilitate prospective evaluation of urban policies and proposals (Gasparatos & Scolobig, 2012). The inclusion of sustainability in early stages of urban planning, through suitable indicators, boosts the integration of sustainable development targets throughout the planning process. As a consequence, this would eventually be translated into sustainable cities by design, where sustainability is fully integrated into the urban fabric (Rosales, 2011).

Several studies have analysed the state of the art of the existing NSA tools and frameworks. These have reflected on particular set-backs from current neighbourhood assessment tools, namely, the degree of coverage of a holistic vision of sustainability, the inclusion of fixed indicators and the authoritarian and subjective weighting of evaluation areas within the tools.

Set-backs regarding the holistic inclusion of sustainability principles from existing NSA tools can be traced to the fact that most of the current frameworks are derived from micro-scale (building scope) assessment

schemes. These spin-offs, on a varying degree, are dominated by a material and physical vision of sustainability. Consequently, concerns for water, energy and resource conservation prime over less tangible socio-economic concerns, such as affordable housing, safe and inclusive communities and local economy (Sharifi & Murayama, 2013; Komeily & Srinivasan, 2015). Moreover, institutional sustainability, represented by governance, decentralization, legal frameworks and instruments, is usually not adequately addressed and sometimes overlooked (Sharifi & Murayama, 2013).

An additional covered aspect concerns the fact that current assessment tools make use of fixed set of indicators, deeming the systems inflexible (Lützkendorf & Balouktsi, 2017). Even more, the general strategy for the assessment is based on fixed target performances, which determine the award of points for the projects (Sharifi & Murayama, 2013). Inflexibility, for the issues mentioned above, reflects on the lack of mechanisms from the existing tools to achieve local adaptability (Komeily & Srinivasan, 2015) and inclusion of regional issues, goals and contexts. This fact has raised criticism against current NSA tools (Retzlaff, 2009). Unfortunately, current frameworks have very limited methods to include local contexts (Komeily & Srinivasan, 2015). Aspects such as region-specific information, as well as spatial and natural features ought to be included in the assessment methodologies (Kaur & Garg, 2019) as a way of assuring site-specific relevance of the tools (Sharifi & Murayama, 2013).

Finally, a main source of concern rises from the arbitrary, and in many cases questionable, process for the allocation of weights and relative importance for each assessment criterion in current NSA tools. In practice, qualitative approaches for determining the relative importance of the criteria within each framework is a highly subjective and ambiguous process (Sharifi & Murayama, 2013; Komeily & Srinivasan, 2015; Kaur & Garg, 2019). Consequently, the lack of clear and rigorous methods to undergo this process will remain cause of speculation and criticism (Retzlaff, 2009).

Conclusively, after revising the state of the art of NSA frameworks, the problem guiding this research project can be stated as the lack of fitness-for-purpose of current NSA tools. Rooted on fragmented visions of sustainability and due to a minimal adaptability and arguable objectivity, current tools are failing to comply with the primal goal of any sustainability assessment framework: to bridge the gap between science and policy (UN, 1992). The latter being experimentally-driven without proper models to guide sustainability assessment and implementation (Anguelovski & Carmin, 2011). As a result, not representing an added value for improving the decision-making process and not tapping on the potential from urban development projects to steer the transformation of cities towards sustainability, resilience and climate adaptation.

4. Research Goal

4.1. Research Objective

Neighbourhood-level sustainable development initiatives are normally guided by unbalanced or fragmented perceptions of sustainability. Hereof, accounting for narrow visions of sustainable development can hinder the ability of neighbourhoods to actually promote healthy social life and boost local economy. On top of the environmental concerns, these aspects constitute the desirable outcomes of a sustainable neighbourhood (Komeily & Srinivasan, 2015).

In this regard, attaining an inclusive vision of sustainability for providing a path to a sustainable future can represent a complex task. For this reason, decisions towards this objective must be taken over structured, transparent and reliable decision-environments. In this context, MCDA methodologies, due to their

integrated nature, can be useful as key tools for performing sustainability assessment (Cinelli, Coles, & Kirwan, 2014).

The set of MCDA methodologies, are those which allow to explicitly account for multiple individual criteria in a comprehensive and flexible manner, with a varying degree of aggregation. Furthermore, in a structured way they consider interrelations and dependencies among the aforementioned criteria (Cinelli, Coles, & Kirwan, 2014), for instance, those ones associated with social, economic and environmental indicators (Zanghelini, Cherubini, & Soares, 2018). Moreover, MCDA approaches allow to account for a varying degree of importance of each criterion, reflecting on the values of decision-makers and other stakeholders (Zanghelini, Cherubini, & Soares, 2018). As a result, MCDA-based frameworks provide a transparent and fit-for-purpose aid in the decision-making process, allowing the comparison and ranking of alternatives in contexts where complexity, and conflicting interests might arise (Cinelli, Coles, & Kirwan, 2014; Zanghelini, Cherubini, & Soares, 2018).

To reflect on the aforementioned considerations, the objective for this research project can be stated as follows:

> *To develop a conceptual Neighbourhood Sustainability Assessment framework to be used as a decision support system for the urban planning process.*

This objective is constrained by the premise that incorporating local values, context and region-specific features is vital for giving flexibility and relevance to the sustainability assessment process. Moreover, involvement of internal stakeholders and decision-makers through an intersubjective approach, fosters a sense of legitimacy and ownership to the assessment framework (Block, van Assche, & Goeminne, 2013). A further target for the research is to enable the use of Sustainability Assessment as means to facilitate external communication. Aligned with the objectives of the municipality, this would strengthen the decision-making process and elevate the quality of policy formulation (Block, van Assche, & Goeminne, 2013). The inclusion of external stakeholders (i.e. companies, citizenship) in the sustainability debate allow authorities to provide policies that come as a result of transparent and accountable decision processes.

4.2. Research Questions

Derived from the aforementioned research objective, the main question for this project can be stated as follows:

> *How can a conceptual Neighbourhood Sustainability Assessment framework be designed, for attaining an integrated evaluation based on context-dependent features and priorities?*

From this main question a set of sub-questions can be derived, to reflect on the set of steps considered to be needed to achieve the proposed objective:

1. What are the particular contextual values and priorities from the Municipality of Apeldoorn, that are relevant for reaching a relevant understanding of sustainability for the built environment?
2. What is the most suitable MCDA methodology to comply with a non-reductionist assessment of neighbourhood sustainable development alternatives?
3. For the context of the city, what are the most relevant indicators to account for a holistic sustainability assessment of neighbourhood development proposals?
4. How can a MCDA framework include integration and flexibility into the assessment process?

5. What specific considerations should the Municipality of Apeldoorn have in order to facilitate the use of a Neighbourhood Sustainability Assessment framework in the urban planning process?

5. Theoretical Background

This section covers the theoretical knowledge base upon which the research project is constructed. The following subsections are the result of an extensive literature review, and they briefly describe the most important outcomes of it. Firstly, a general description of the chosen sustainability model will be done, to provide clarity on the understanding of the concept and its constituent elements in the context of the research project. Secondly, deepening into the importance of SA and the particular relevance of MCDA as assessment methodology within the field. In addition, it covers the considerations guiding the selection of a specific type of MCDA, which reflects on how well suited it is to solve the problem at hand. Finally, the Business Motivation Model (BMM) is briefly described, including the pertinence of its use as part of this research. More specifically, the *Internal Influencers* for organizations are covered in more detail, as they guide the sense-making and classification process for specific findings along the research.

5.1. Sustainability Model

5.1.1. Conceptual Evolution

The evolution of the concept of Sustainability, contrary to the idea of it being contemporary, has been an ongoing process getting influence from different knowledge areas. These can be traced back as early as the end of the 19th century, when the initial notion of intergenerational equity was formulated in response to increasingly irresponsible consumption patterns (Kidd, 1992). Nonetheless, the explicit use of the word "sustainability" in connection with concerns for the human future can be positioned in 1972, in a British book: *Blueprint for Survival* by Edward Goldsmith (Kidd, 1992). Later, during the *Stockholm Conference on the Human Environment*, the existing conflicts between development and environment were officially recognized. These happenings proved to be instrumental in the adoption of the term as a method to institutionalize the concerns of said conflicts through the United Nations Environmental Program (UNEP) (Kidd, 1992).

Years later, *Our Common Future (1987)*, also known as the *Brundtland Report* accomplished a breakpoint for the unfolding of the concept of *sustainable development* by two main reasons. Firstly, it allowed to transfer the concept of sustainability from a theoretical context into a global political arena. And secondly, it addressed the concept in a broad perspective. This means, it went beyond the physical component of environmental concerns by addressing the need for social and political action (Kidd, 1992). The Report developed at a conceptual level, a definition of sustainable development by addressing four main areas of concern: (1) safeguarding long-term ecological sustainability; (2) satisfaction of basic human needs; (3) Intra-generational equity; and (4) Inter-generational equity (Holden, Linnerud, & Banister, 2014).

5.1.2. Operationalization

5.1.2.1. The Triple Bottom Line

The concept outlined by the Brundtland Report (1987) showed a high level of abstraction, making it difficult to operationalize as a multi-dimensional concept. Pursuant to deal with the operationalization issues aching the concept of Sustainability, the United Nations Conference on Environment & Development (UNCED), through Agenda 21, developed a more practice-oriented definition of *sustainable development*. This definition, encompassed social, economic and environmental dimensions (UN, 1992). As a result, the concept of the

"Triple Bottom Line" emerged, to describe the interactions between these three dimensions (Silvius, Kampinga, Paniagua, & Mooi, 2017).

5.1.2.2. The 4-pillar Model

Following the spread and increasingly growing acceptance of the triple-bottom line model, several authors have proposed different models for sustainability. Thus, expanding its definition to further reflect aspects like culture and governance as influencers of sustainability (Ali-Toudert & Ji, 2017). Arguably, cultural aspects represent an extension of the human component (Ali-Toudert & Ji, 2017), allowing them to be included as part of the Social dimension. Nonetheless, governance adds a managerial and decision-making component as a factor which enables successful implementation of sustainability (Ali-Toudert & Ji, 2017).

Furthermore, in 1995 The United Nations Commission on Sustainable Development (CSD) identified a political-institutional dimension, to be added to the triple-bottom line as relevant for the sustainable development concept (Kaur & Garg, 2019). Consequently, by considering an institutional component, a sense of policy and institutional responsibility is added to the sustainability model (Ali-Toudert & Ji, 2017). Hence, increasing the ability to assess the performance of government towards sustainable development goals (Kumar, Murtyb, Guptac, & Dikshit, 2012).

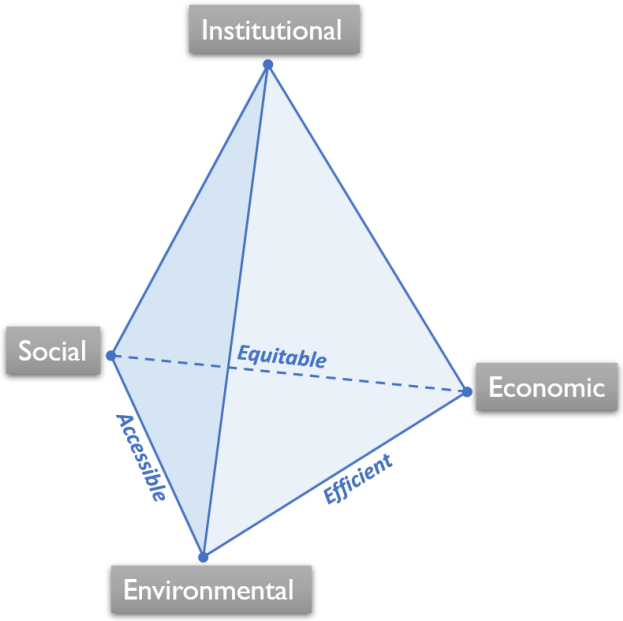

Figure 1: The prism of sustainability
Represents the capacity of the institutional dimension to act as a linkage between economy, society and environment. Institutional dimension performs a different role towards each one of the other three dimensions, to attain efficiency, accessibility and equity. Own elaboration, following the description of the 4-pillar model (Kumar, Murtyb, Guptac, & Dikshit, 2012; Ali-Toudert & Ji, 2017).

For the scope of this research a 4-pillar model was chosen. This is grounded on the fact that an already institutionalized and widely accepted "triple bottom line", covering Social, Economic and Environmental concerns, would help comparability across existing literature and tools. Secondly, the inclusion of the Institutional dimension, is based on its capacity to encourage the linkage between the other dimensions (Kaur & Garg, 2019), and to represent the governance decision-making component deemed necessary for guiding urban planning initiatives towards sustainability.

5.1.3. Institutional Capacity Base for Sustainable Development

As mentioned earlier, the institutional component from the 4-pillar sustainability model, reflects on the governance process and linkage promotion of the other three dimensions (Kaur & Garg, 2019). Nonetheless, this perspective is a partial representation of what the Institutional dimension entitles as it represents as well,

the procedural and organisational structures such as relations of work, hierarchies, lines of command, division of labour, channels of communication and values and attitudes present within their organisational boundaries (Nykvist & Nilsson, 2009). It is hereby possible to conclude that thanks to all these features, on top of the ones included as part of the assessment process, the Institutional dimension goes far beyond the reach of the 4-pillar assessment model.

In this context, *Institutional capacity* can be defined as the ability of different organisations (i.e. administrative, governmental, agencies, etc.) to respond and manage current economic, social and environmental challenges (Polk, 2011). As a result, such organisations, as institutional actors, play a role of enablers of change towards sustainability.

The capacity of these organisations on performing their role, in the context of this research, is dependent on factors on different levels within the organisational environment. Nykvist & Nilsson (2009) present a three-tier analysis framework which helps to rationalise these factors. The framework recognizes Micro-, Meso- and Macro- level institutional aspects influencing sustainable development. The Micro-level covers the practical resources, their expertise and time allocation. The Meso-level deals with organisational processes and management structures systems for knowledge transfer, norms and incentive mechanisms. Finally, the Macro-level is concerned with linkages of systems with external societal values and connections with wider policy network stakeholders (Nykvist & Nilsson, 2009) . While being an important and influential aspect, the focus of the research lays on the internal factors, mainly represented by the Micro- and Meso-level. Hence, the Macro-level falls out of the scope of this research.

Herein, the most relevant factors as classified by Nykvist & Nilsson (2009), are as follows: **(i) Micro-level** – availability of resources (i.e. Time, money, staff), with an emphasis on capacities (skills, expertise and responsibilities) and **(ii) Meso-level** – Organisational norms and culture, formal and informal decision rules, coordination processes and leadership.

It can be concluded that reaching a broader intuitional capacity base is necessary to overcome constraints for sustainable urban planning. As the barriers for sustainable development are not just technical, but dependant on external constraints such as administrative structures, political short-term timetables and expenditure controls, among the most relevant (Romero-Lankao & Dodman, 2011).

5.2. MCDA Methods for Sustainability Assessment

Sustainability science is an emergent field of study directly related to the evolution of the concept of sustainability. This field intends to describe the complex and dynamic interactions between environmental, economic and social aspects (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007). The intrinsically related area of *SA* has been developed hand by hand with the latter, in response to the challenges that such endeavour generates. Namely, to fulfil the need of providing efficient and reliable tools (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007) able to explicitly address the aforementioned interdependencies of sustainability dimensions. Consequently, the development of policies, programs and projects require coordination through adequate management instruments (Devuyst, 2000).

In this context SA can be defined as a formal process of identifying, predicting and evaluating the potential impacts of different types of initiatives on the sustainable development of society (Devuyst, 2000). Nonetheless, the increasing amount of proposed approaches to SA reflects the conceptual difficulties that sustainability involves, propagating on varied visions for its assessment, varied methodologies and timewise orientation (retrospective vs. prospective) (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007). Among the different assessment methods, MCDA are considered particularly useful for SA. Categorised as integrated

prospective methodologies (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007), they provide capabilities to guide policy-making (Hiremath, Balachandra, Kumar, Bansode, & Murali, 2013) by adopting a more comprehensive view of sustainability (Gasparatos & Scolobig, 2012).

Integrated assessment is a methodology which handles information from individual indicators in a comprehensive manner, by addressing the interrelationships and interdependencies among them (Cinelli, Coles, & Kirwan, 2014). MCDA methodologies have been considered as appropriate for performing SA, as they consider different sustainability spheres, stakeholders' perspectives and values (Zanghelini, Cherubini, & Soares, 2018). MCDA approaches allow to account explicitly for multiple criteria with different importance and with a varied degree of aggregation. In this context these assessment methods support decision-making by allowing the comparison and ranking of existing alternatives (Cinelli, Coles, & Kirwan, 2014). By deepening into the decision problem, MCDA outcomes allow decision-makers to explore various possibilities, debate, argue and interpret them (Polk, 2011).

Three main categories have been proposed to categorise MCDA methodologies according to their generated outcome: (1) Aggregation-based utility function, (2) Pairwise comparison outranking relations and (3) Sets of decision-rules (Cinelli, Coles, & Kirwan, 2014). In the context of this research, the expected outcome of the assessment is a ranked set of alternatives for urban development projects. Hence, the specific MCDA method is steered towards the Pairwise comparison outranking relations (Roy & Słowiński, 2013).

In this category, ELECTRE and PROMETHEE methods are the most widely known and implemented for the outranking assessment. Aligned with the objective of this research, which aims to reflect on a strong vision of sustainability, MCDA methods able to abolish the compensation effect, thus eliminating intrinsic trade-offs between sustainability spheres are preferred. Under these constraints, both ELECTRE and PROMETHEE methods were suitable candidates over other methods from the MCDA outranking family (Cinelli, Coles, & Kirwan, 2014). On top of this non-reductionist feature, the shortlisted methods allow the inclusion of preference information from decision-makers and provide the ability to increase their comprehension of the assessment process (Behzadian, Kazemzadeh, Albadvi, & Aghdasi, 2010; Roy & Słowiński, 2013). Nonetheless, PROMETHEE is chosen over ELECTRE, mainly for reflecting on the performance difference between each pair of alternatives (Brans & Mareschal, 2005).

The PROMETHEE method, developed by J.P Brans in the 1980's, accounts for a series of conditions which determine its behaviour and outcomes (Brans & Mareschal, 2005):

i. The extent of the performance difference between two alternatives must be accounted for.
ii. The criteria scales are irrelevant for the pairwise comparison.
iii. The methods are easily understandable by the decision-makers.
iv. Information on the conflicting nature of the criteria is transparent for the decision-makers.
v. Weights are assigned to reflect the thinking processes and preferences from decision-makers.

For complying with all the conditions, the assessment procedure requires *Preference Modelling Information,* which is that one intended to resolve possible undecidable outcomes from the conflicting criteria. In general terms, this information characterize the relations between the criteria, by assigning weights of relative importance to each one of them and within the criteria, expressed as preference functions which reflect on the expected utility change from a performance difference of alternatives in each criterion (Brans & Mareschal, 2005). All this information comprises a generalised criterion with which the outranking flows are calculated, hence determining the performance-based ranking of the assessed alternatives (Brans & Mareschal, 2005).

5.3. Internal Influencers from the Business Motivation Model

The Business Motivation Model (BMM), is a set of built-in concepts which define the core aspects of business plans (OMG, 2015). Thanks to the neutral methodology of the BMM in addition to its simplicity (OMG, 2015), the specification allows to be extended to different organization types. This factor enables its use within the context of this research, where a municipal actor is analysed. The BMM, covers two main aspects within business plans: (1) *Ends* and *Means,* which describe the goals and objectives of an organization, as well as the strategies and tactics for achieving said goals; and (2) Influencers shaping the aforementioned elements, including the assessment of its impact over the organizational ends and means (OMG, 2015).

Figure 2 displays the interrelations of all the elements covered by the BMM. As it can be seen, the model elaborates over a basic cornerstone of organizational practice: *Motivation*. This, encompasses the aspirations of an organization, communicated through its vision, and the plans on how to realize said vision, communicated through its mission (OMG, 2015).

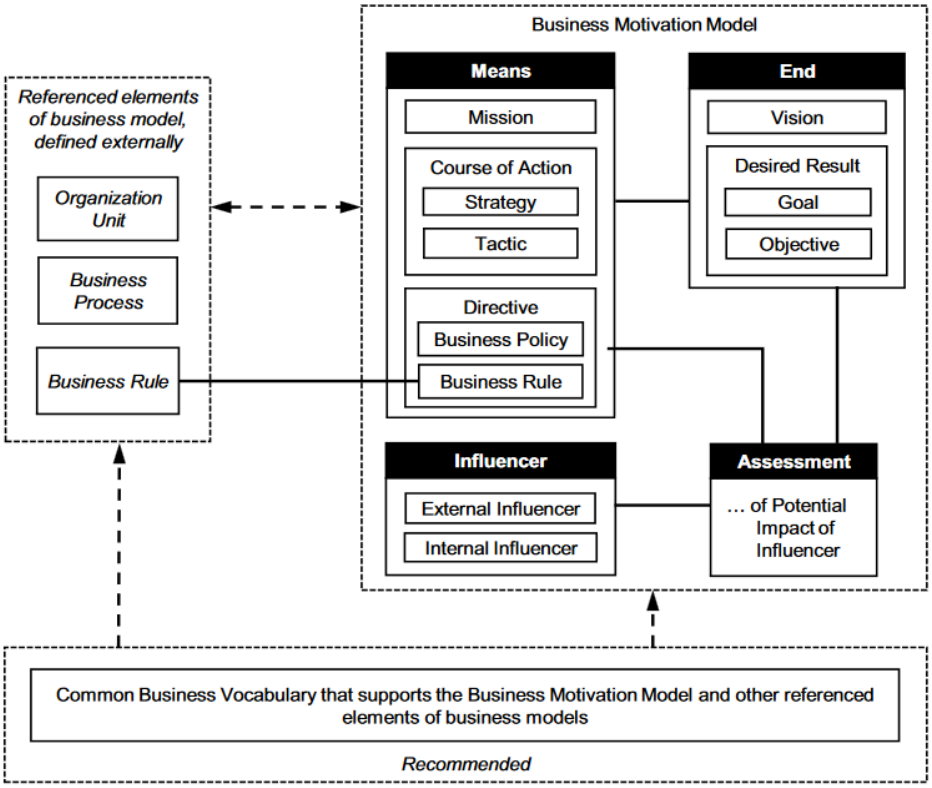

Figure 2: BMM v1.3 Overview – Section 7.3 (OMG, 2015).

The above-mentioned considerations for implementing the BMM within this research are not complete without talking about the *Influencers* category from the model. In general, influencers, as defined by the BMM, represent the elements that can hinder or assist the organization in realizing its aspirations. On those terms, the particular interest from this research lies on the *Internal Influencers,* which are factors and conditions existing within the organizational boundaries (OMG, 2015). The extent of the impact of these factors requires additional assessments, like the one done through SWOT analysis for example (OMG, 2015). Nonetheless, these assessments are out of the scope of this research, as they require a deeper focus on the mechanisms of influence, degree of importance and combined effects of both internal and external influencers, which does not reflect the objectives of this research. Conversely, the research focuses on internal

influencers alone, as a method to characterize the Municipal Capacity Base for promoting the aspiration of the Municipality on moving towards Sustainable Urban Planning.

With this objective in mind, for the categorization process, the research has adopted the default categories described in the BMM document, which are shown in Table 1.

Table 1: Internal Influencers Definitions BMM v1.3 – Section 8.5.2.2 (Table 8.14) (OMG, 2015)

Category	***Description***
Assumption	Something that is taken for granted or without proof.
Explicit Corporate Value	An ideal, custom, or institution that an enterprise explicitly promotes or agrees with (either positive or negative).
Implicit Corporate Value	An ideal, custom, or institution that an enterprise not explicitly declares but is nonetheless understood by some or all of the people in an enterprise.
Habit	A customary practice or use.
Infrastructure	The basic underlying framework or features of a system.
Issue	A point in question or a matter that is in dispute as between contending partners.
Managerial Prerogative	A right or privilege exercised by virtue of ownership or position in an enterprise.
Resource	The resources available for carrying out the business of an enterprise, especially their quality. (Financial, Human, etc.)

6. Research Strategy

The concept of sustainability introduces relational components between a contextual environment and the spatial-temporal dimension (Sala, Ciuffo, & Nijkamp, 2015). Consequently, traditional sciences are not appropriate to support sustainability-related research problems. The purpose of these sciences is to achieve universal generalization (Wieringa, 2014), which cannot be achieved for Sustainability assessment research, due to its need to align the object of study to a particular set of context-specific aspects (Kaur & Garg, 2019).

Moreover, there are different conceptualizations of *sustainability-related* issues which depend on varying environmental constraints and cultural expectations (Brown, Hanson, Liverman, & Merideth Jr., 1987). As a result, sustainability cannot be defined categorically, because determining what constitutes a sustainable state for a particular context does not guarantee any generalization, due to the contested definition and value judgments present in defining sustainability (Bond, Morrison-Saunders, & Pope, 2012).

Consequently, the research over urban sustainable development can be approached through the sciences of the middle range, category to which *Design Science* belongs (Wieringa, 2014). Defined as the investigation of artefacts in a given context, it has as object of study an artefact intended to interact with a problem context, hence improving targeted issues within said context. This implies that the design researcher should therefore study the interaction between artefacts and contexts rather than artefacts and contexts separately (Wieringa, 2014). This project is therefore structured as a Design science research and building over this fact, the *Design Cycle,* as rational-problem-solving process (Wieringa, 2014), was used to give structure to the research strategy depicted in Figure 3.

Each stage within the research entitled a series of activities which generated outcomes. The main outcomes from the research are displayed in ***bold-italics***, while the rest of the intermediate outcomes served as input for subsequent steps along the research project. Following sections briefly describe the methodological considerations for each one of the three main stages of the research. The ***Appendix 01 – Methodology Guide*** contains the full description of the implemented methods, especially those related with consultation and participation procedures within the research process, which can be divided in two main aspects: (i) Data Collection and (ii) Data Analysis.

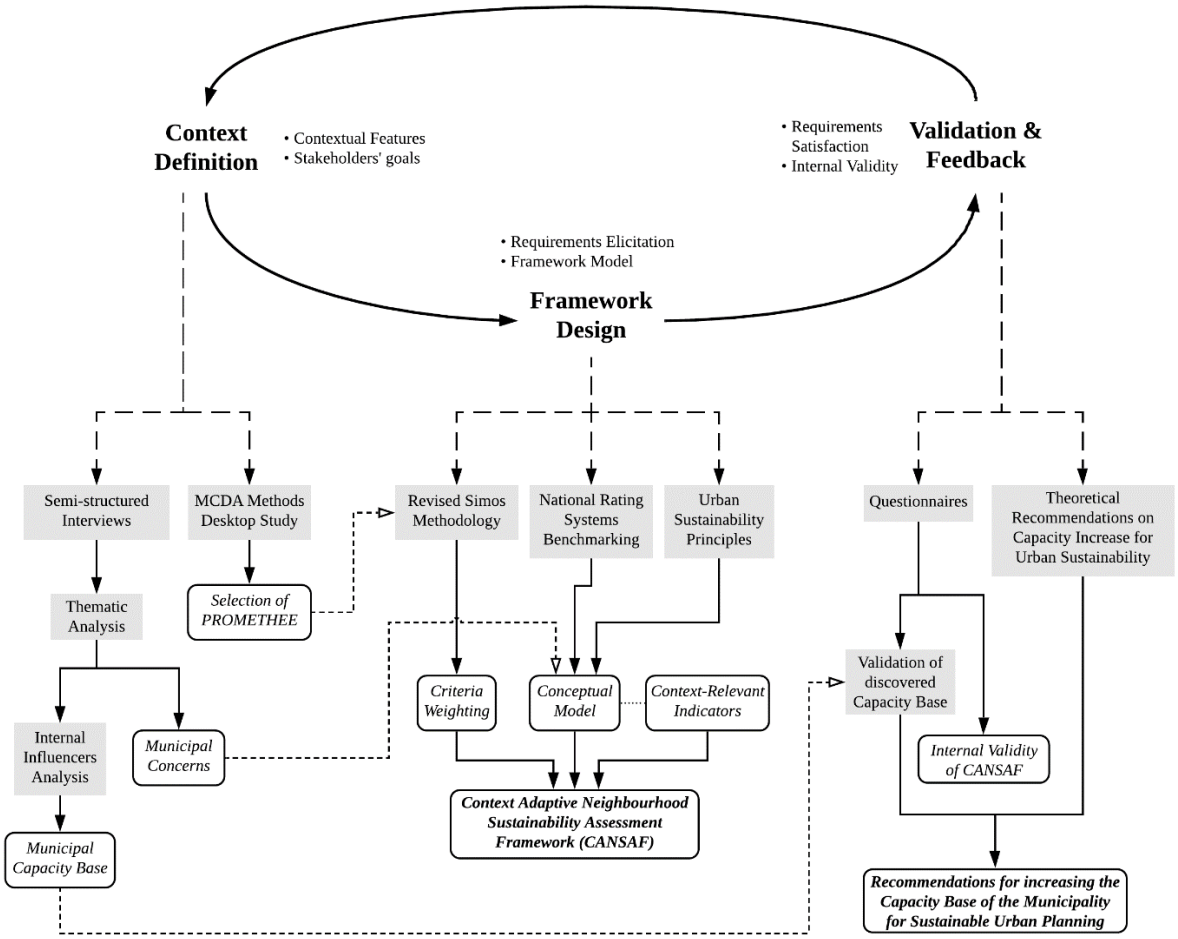

Figure 3: Research Strategy, based upon the Design Cycle (Wieringa, 2014).

6.1. Context Definition Phase

Following the Design Science Methodology (Wieringa, 2014), this first phase comprised the activities of understanding the context of the problem. Moreover, it required the identification of goals from stakeholders and finally deciding over the conceptual grounds in which the design process is going to be rooted in. In this context, this phase intended to answer the following sub-questions of the research development:

1. *What are the particular contextual values and priorities from the Municipality of Apeldoorn, that are relevant for reaching a relevant understanding of sustainability for the built environment?*
2. *What is the most suitable MCDA methodology to comply with a non-reductionist assessment of neighbourhood sustainable development alternatives?*

The identification of contextual values and stakeholders' priorities were considered as intermingled activities. This initial phase followed the hypothesis that an intersubjective approach was suitable for guiding the definition of the assessment criteria as well as the expected outcomes for the proposed framework (Block, van Assche, & Goeminne, 2013). Consequently, the selection of the relevant context-specific information, in addition to the understanding of the desired vision of sustainable development from the municipality, was tackled through qualitative research based on individually administered semi-structured interviews. The interview sample was chosen through judgement sampling, as a means to develop a purposive selection of

respondents. The sample was chosen to reflect on the main knowledge domains within the municipality, by covering the most relevant functional units, for urban built environment development projects: (a) Projects, Real state and Land *(PVG – Projecten, Vastgoed en Grond);* (b) Spatial Living Environment *(RL – Ruimtelijke Leefomgeving); and* (c) Management & Maintenance *(B&O – Beheer en Onderhoud)*.

Once all the data was collected, the analysis was defined as a modified version of the *Iterative Model* presented in Figure 4. This model considers the retroactive effect of specific phases which propagate changes downstream the process, thus generating cyclical dependencies between the performed activities.

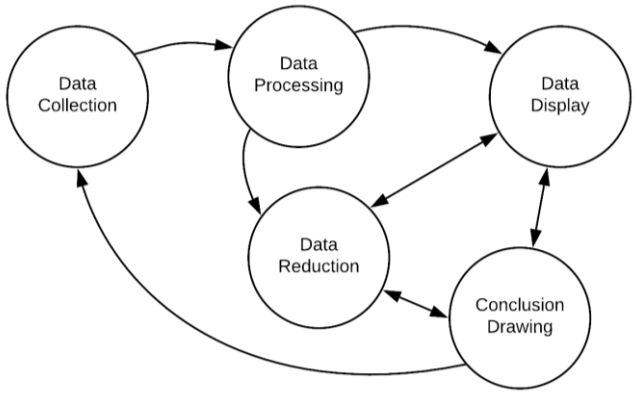

Figure 4: Data Analysis Process - Iterative Model modified from (Miles. & Huberman, 1994)

The initial step for performing the data analysis was the *Data Processing*. This task transformed raw data from the interviews in organized and manageable chunks of information. Subsequently, the *Data Reduction* task was done. Through ***coding*** and ***categorizing*** the collected data this process accomplishes the reduction purposes for this step (Hartmann, 2017). The overall data reduction process is presented in Figure 5.

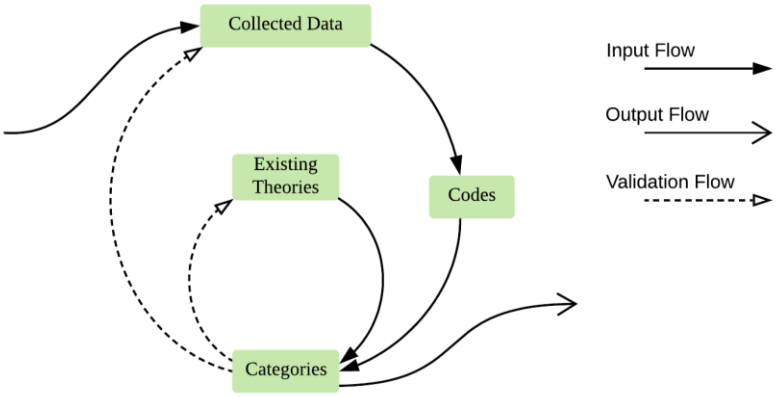

Figure 5: Data Reduction Process – Iterative model

The categorization process was done following the specific research objectives. Consequently, the generated categories reflected three main aspects: (i) Municipal Concerns reflecting the priorities of the Municipal actors, (ii) Institutional Aspects, determining the capacity base of the Municipality as organisation and (iii) Improvement Opportunities, which provide the base for the recommendations outlined in the last phase of the research project.

6.2. Framework Design Phase

The second phase of this research covers the elicitation of functional requirements that will be included into the design task, and the development of the Framework Model that is meant to guide the Neighbourhood Sustainability Assessment process. Consequently, this phase aims to answer the following two sub-questions:

3. *For the context of the city, what are the most relevant indicators to account for a holistic sustainability assessment of neighbourhood development proposals?*
4. *How can a MCDA framework include integration and flexibility into the assessment process?*

As an initial step in the formulation of an NSA model, a desktop study provided general Urban Sustainability Principles which would support the overall definition of the conceptual model over which the framework would be built. Secondly, through literature reviews on National Rating Systems, a reference for benchmarking the definition of the conceptual model was achieved. Lastly, the urban Sustainability principles and benchmarks were confronted against the *Municipal Concerns* gathered in the initial phase of the research. By doing this, the NSA framework definition would tackle external and internal validity concerns. In addition, further internal validation was performed in the final phase of the research. To finalize this stage, an initial list of indicators was synthetized from the benchmarked national rating systems and complemented by using external literature sources on specific assessment topics. The proposed indicators reflected on a compound criterion which included concerns regarding appropriateness in scale and accuracy, as well as measurability and relevance for each concerned phenomenon (Hák, Moldan, & Dahl, 2007).

The data collection and analysis processes were planned as a response to the identified needs to define more flexible and legitimate assessment methods able to reflect on local priorities, the elicitation of requirements was centred in the definition of flexible criteria weighting. For attaining this, an internal consultation plan was implemented, which not only increases the transparency of the assessment model and the outcomes, but also increases legitimacy and sense of ownership of the instrument (Block, van Assche, & Goeminne, 2013).

Hence, for this phase the *Revised Simos Method* was implemented due to its fitness for the elicitation of the weights and relative importance. This method defines all the steps (data collection, management and analysis) to generate a set of ordered and weighted criteria. As such, it reflects on the local priorities gathered an analysed in the previous phase, while adding a flexible definition of their prioritisation structure.

6.3. Validation & Feedback Phase

Finally, the third phase is aligned with the final step of the design cycle: Validation (Wieringa, 2014). In this phase, the research project circled back to address the stakeholders' satisfaction and the potential performance of the proposed artefact for the identified context requirements (Internal Validity). In addition, this phase covered the production of recommendations and considerations that the Municipality of Apeldoorn should focus on, to facilitate the implementation and increase potential benefits in relation to the proposed framework, such comes as the answer of the last sub-question for this research:

5. *What specific considerations should the Municipality of Apeldoorn have in order to facilitate the use of a Neighbourhood Sustainability Assessment framework in the urban planning process?*

For generating the needed information, this section made use of a final round of internal stakeholder involvement, in the form of presentations followed by questionnaires, as instruments to validate and receive feedback directly from the stakeholders. In general, the sampling process followed the notion of circling back over the original respondents, to validate results. This means that the idea of keeping track of the three main knowledge areas within the municipality was preserved.

The aforementioned internal validity monitoring was combined with existing literature on institutional recommendations and action points to increase the capacity base of organisations towards sustainable urban planning. The latter served to provide external validity to the results and align with existing knowledge. Hence, the recommendations for the Municipality were set out with both, a local focus and a global validity check. Finally, supplementary to the answer to the final research sub-question, this section provided useful information for discussion topics, and identification of possible limitations and recommendations for future research initiatives in the field.

7. Results

The present section deals with the display of the outcomes and new knowledge resulting from the research process. Howbeit, the showcase does not reflect neither on the general phasing of the research project nor on the chronological execution of the research tasks. Instead, this section is structured to describe a logical incremental process of knowledge building along the research process, which was depicted by the research strategy (Figure 3). This means that initially the definition of the institutional capacity base of the Municipality is presented. Subsequently, the definition of the NSA framework is described. This topic encompasses first the results on contextual values and priorities from decision-makers. From there, it builds on theoretical principles and rating systems benchmarks to complete the definition of the conceptual model and overall design of the assessment framework. Finally, the results circled back towards the capacity base of the municipality and a set of general recommendations to enhance the institutional capabilities are made. They are meant to allow for a better implementation of NSA processes within urban planning.

7.1. Institutional Environment

Previous research has recognized the importance of including an Institutional dimension in the context of neighbourhood sustainability (Sharifi & Murayama, 2013; Komeily & Srinivasan, 2015; Kaur & Garg, 2019). For this purpose, existing assessment tools have attempted to include institutional concerns in the form of governance capabilities (Sharifi & Murayama, 2013). Nonetheless, the institutional dimension encompasses further elements, namely, organizational structures and cultures (Burch, 2010), human interactions, orientation mechanisms and regulatory frameworks (Komeily & Srinivasan, 2015). All of these elements make the Institutional dimension outgrow the scope of a single sustainability assessment framework or tool. Instead, it represents a broader capacity base (Romero-Lankao & Dodman, 2011), which enables action towards sustainable development and climate adaptation. Hence, Institutional concerns might arise as factors inhibiting the adoption of sustainable assessment tools (Moobela, Price, & Bristow, 2007), rather than aspects that can be evaluated within them. Consequently, as part of the context definition phase, an analysis of the current institutional environment within the Municipality was performed. Useful information was extracted from the performed interviews, allowing the identification of barriers and enablers for the inclusion of sustainability in the urban planning process.

A snapshot of the current institutional status was achieved, thanks to the performed thematic analysis which allowed the coupling of the concept of *Internal Organisational Influencer* covered in section 5.3. Relevant highlighted topics pointed out barriers and enablers which are determining the municipal capabilities for implementing sustainable urban planning practices. In order to provide sound external validity, the results of this analysis were crossed-checked against existing literature on organizational barriers and enablers regarding sustainable construction practices and planning for urban adaptation. The summary of identified barriers and enablers classified according to the internal influencers from the BMM is presented correspondingly in Table 2 and Table 3.

Table 2: Context Definition Phase - Identified Barriers for Sustainable Urban Planning

BMM	*Organizing Theme*	*Basic Theme - Influencer*	*Source*
Explicit Corporate Values	Lacking standardised Directives for project Sustainability inclusion	Late inclusion of Sustainability Concerns in the Project Process	T-067; [3]
Infrastructure	Hindrance on Collaboration among functional Units	Functional units have separated budgets	T-007; T-034; T-033; T-046; T-047; T-090; [3]; [4]
		Low integration between functional divisions due to a Segmented Organizational structure	
		Integral plan development is hindered by budget separation	
		No standardised collaboration practices are implemented among functional units	
		Lack of Systematically Integrated Collaboration Processes	
	BAU approaches to project definition	Traditional Tendering criteria (Time & Cost) are used as regular commissioning procedure	T-072; [1]
	Narrow vision of Sustainability	Asset Management is done through monetary-based analysis	T-025; T-035; T-036; T-073; [1]; [3]
		Environmental concerns in Asset Management are done through CO_2 valuation	
		Social concerns are not reflected in criteria used within Asset Management	
		Social benefits from projects unaccounted in project performance assessment	
	Overlook of interdependencies between Sustainability Dimensions	Circularity, Sustainability and Climate Adaptation Goals are defined independently from each other	T-005; T-051; [1]; [4]
		Sustainability operationalization is divided into separated components	
	Lacking standardised Criteria for project Sustainability inclusion	Sustainability, Circularity and Climate Adaptation objectives are not consistently included as criteria in Project Orders (*Opdracht*)	T-061; T-064; T-088; T-062; T-065; [1]
		Non-standardised inclusion of sustainability criteria in project orders	
		No standardised circularity inclusion criteria are defined for project definition processes	
Issue	Issues for assessing effects of Built Environment on Sustainability dimensions	Valuation of positive/negative effects of the built environment over social variables is difficult	T-028; T-030; T-031; [1]; [4]
		Effects of the built environment on people's health, mood and disposition to interact are unclear	
		The role of Heat stress in generating indirect economic effects is unclear	
	Issues for operationalizing City Goals into measurable project objectives	High Level goals are not easily quantifiable through Project Objectives	T-063; [1];
Managerial Prerogative	Permissive actor-led Sustainability Exclusion	Circularity and Sustainability are excluded from project performance measures on given projects	T-062; T-065; [1]; [3]
		Personal priorities are allowed to exclude Sustainability criteria from given project orders	

References: [1]: (Moobela, Price, & Bristow, 2007); [2]: (Seidel, Recker, Pimmer, & vom Brocke, 2010); [3]: (Burch, 2010); [4]: (Biesbroek, Klostermann, Termeer, & Kabat, 2011)

Table 3: Context Definition Phase - Identified Enablers for Sustainable Urban Planning

BMM	*Organizing Theme*	*Basic Theme - Influencer*	*Source*
Explicit Corporate Value	Internal sustainable working directives	The use of electric-powered assets is encouraged	T-053; [2]
	Organisational learning Strategies	Pilot projects are used as bottom-up Knowledge sources	T-056; T-089; [2]
		Pilot projects are used as prototype tests for Knowledge generation	
	Project-led functional coordination	Built environment adaptation projects are coordinated with built environment maintenance activities	T-027; T-086; [1]; [4]
	Multidisciplinary Project Team implementation	Multidisciplinary Project Team is assembled with members from RL, PVG, *Stedenbouw*, *Bestemmingsplan* and Engineer's Bureau	T-068; T-069; [1]
		Trade-offs and negotiation between disciplines is done during project definition	T-069; [3]; [4]
Infrastructure	Operationalisation of Goals into measurable Objectives	Program Goals are quantified by SMART Objectives	T-004; [1]; [2]
	Coordination through working division overlap	Combination of Functional vs. Geographical unit divisions can provide extended benefits from knowledge sharing	T-058; [3]
	Participative Project Governance approaches	Citizenship involvement is implemented through participation within the municipality	T-029; [4]
	Traceability of City Vision into specific Desired Results	Program Goals on Climate adaptation are aligned with City Goals	T-001; T-002; T-003; T-055; [1]
		Program Goals on Circularity are aligned with City Goals	
		Program Goals on Sustainability are aligned with City Goals	
		Management and Maintenance plans across the functional unit are aligned with the City Goals	
Managerial Prerogative	Project-led improvement of long-term Goals	Innovative projects are allowed to steer the City goals definition and updating process	T-015; [2]
	Flexible use of alternative Project Definition Procedures	Authority from Team Leaders to undergo alternative tendering processes by implementing contractor's Circularity knowledge in the tendering criteria	T-012; T-057; T-070; [1]
		Alternative project definition processes are allowed for pursuing Circularity objectives	
		Team leaders have authority to undergo alternative tendering processes by implementing contractor's Circularity knowledge in the tendering criteria	
	Flexible inclusion of actor-led sustainability concerns	Initial role of Engineer's Bureau in project team enables the inclusion of Sustainability concerns	T-066; T-084; [1]; [3]
		Circularity criteria can be included in early stages of given Projects Processes	

References: [1]: (Moobela, Price, & Bristow, 2007); [2]: (Seidel, Recker, Pimmer, & vom Brocke, 2010); [3]: (Burch, 2010); [4]: (Biesbroek, Klostermann, Termeer, & Kabat, 2011)

The references to the sources of the barriers and enablers were included in both tables. These sources correspond, on one hand, to statements from the conducted interviews (evidences) which can be found in the ***Appendix 02 – Thematic Analysis Results***. The statements in the appendix were given unique codes for facilitating identification tasks. On the other hand, the statements from the interviews are backed-up by existing literature references also included in the tables. These reflect on the results from the performed external validity check.

7.2. Neighbourhood Sustainability Assessment Framework Design

To provide a complete picture of the design process, this section describes the intermediate outcomes and additional information which served as input for the design task. First of all, the framework was designed using existing National Rating Systems which served as references for performing the benchmarking process. Furthermore, the design was based on general urban sustainability principles that guided the structuring process of the framework. Finally, the gathered local priorities were cross-checked and fed into the model to ensure a holistic coverage of NSA areas.

More specifically, the design steps were first focused on the formulation of a conceptual model based on the aforementioned information. Subsequently, the design decisions reflected on the need of the MCDA framework to provide a flexible and context-responsive assessment. As a result, being based on general principles and benchmarks, the framework's design is therefore expected to allow it to reflect on a varied set of contexts. Moreover, responsiveness to local priorities and local conditions is reached through the modelling of customisable criteria importance and the possibility to define flexible list of indicators to reflect on particular context-relevant concerns.

7.2.1. Conceptual Model

The definition of the conceptual model was performed by using input from three main sources of information. Following sub-sections describe the employed sources and a final subsection will describe the composition of the model which represents the orchestration of assorted data input into a design artefact.

7.2.1.1. Local Priorities and Concerns

The initial rounds of interviews provided useful insights on the priorities of the Municipality, what their concerns were in terms of the vision of the city in the coming decades and in the topics of interest within the development of the built infrastructure of the city. The performed thematic analysis guided the extraction of meaningful information from the collected data. A taxonomy of the Municipal concerns and priorities arises as one of the generated results from this process. The 4-pillar model was used to classify each one of the identified themes. In this way, the results show the extent of coverage of Sustainability concerns within the municipality as expressed by the interviewees.

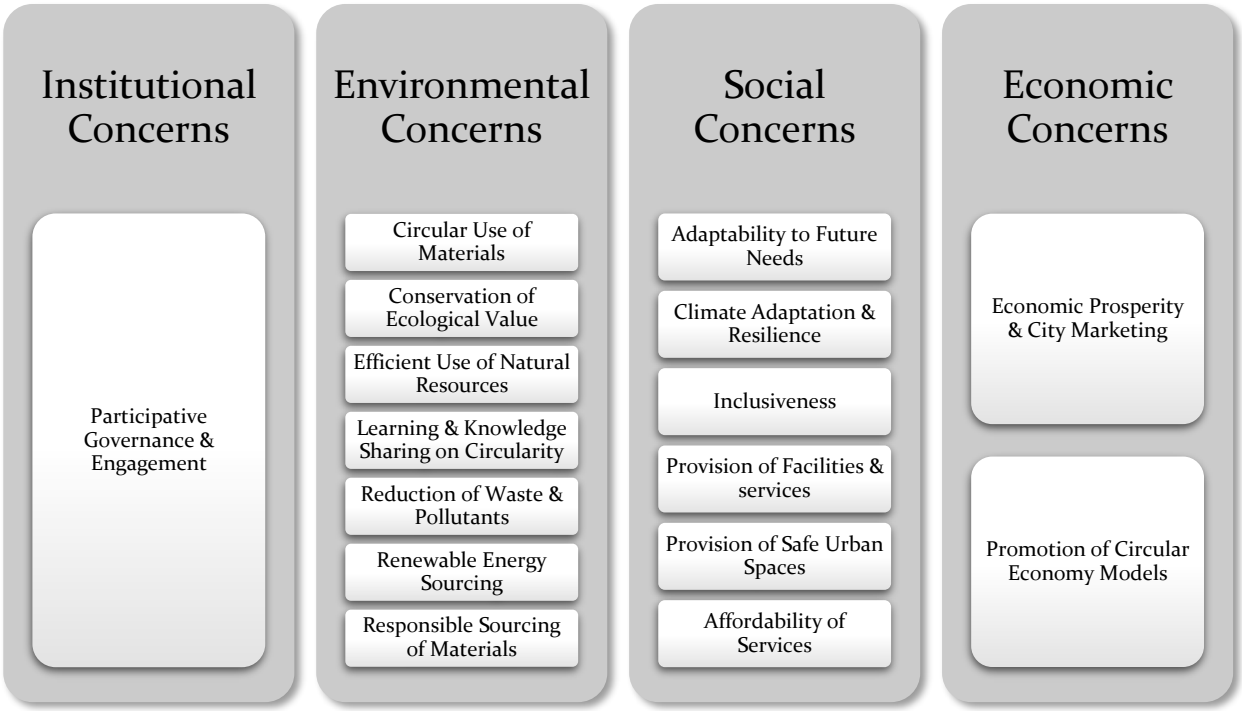

Figure 6: Taxonomy of Municipal Concerns (From Interviews)

Figure 6 shows the resulting taxonomy. Building upon the 4-pillar dimensions, the subsequent levels within the taxonomy are formed by the identified relationships in the thematic analysis. It can be seen that in general terms, municipal concerns are aligned with widely recognized topics, such as Participative governance, circularity, reducing pollution, better use of the available resources, adaptation to future needs, boosting local economy and promoting social mix, cohesion and sense of identity. This taxonomy provides a canvas which allows the covered topics to be brought together and their relations understood.

Nonetheless, it was ascertained through the interviews that the majority of these concerns are not considered in connection with each other, and a fragmented agenda prevails over the future development of the city. This aspect, in agglomeration with additional institutional environment factors are covered in the formulation of the capacity base of the Municipality for facilitating the implementation of sustainable urban planning practices.

7.2.1.2. Guiding Principles

A supporting source of information lies upon general principles on sustainability of the built environment which were covered in literature. Particularly, a systematic review on sustainable urban neighbourhood development principles (Luederitz, Lang, & Von Wehrden, 2013), provided a robust build-up from which the assessment areas for the model could be formulated.

In general terms, it is important to mention that the interconnected nature of the sustainability assessment areas and the complexity of physical systems render the categorization process subject to different results. Even on the face of theoretical basis acting as support for the process.

The most relevant principles used to steer the grouping process cover a wide vision of sustainable development framed towards neighbourhood development. Accordingly, they are listed and briefly described: ***(a) Development of harmonized coupled human-environment systems***. This principle covers the need to maintain the life support functions from the biotic environment, by understanding local features

and the surroundings. ***(b) Develop a sustainable urban metabolism***. This principle deals with the reduction of pollution and waste resulting from human processes. Furthermore, it covers the responsible and efficient use of natural resources and energy. ***(c) Design for local and sustainable material sourcing***. This principle is concerned with the burdens generated from material extraction and product fabrication. Following this principle materials with less embodied energy and resource consumption should be promoted. ***(d) Catering liveable and vibrant neighbourhoods***. Principle promoting mixed land-use, revitalisation of urban areas and enhancing public space through design. Furthermore, it covers aspects of affordability and social integration. ***(e) Promote compact development and integrated mobility***. This principle encourages self-sustaining communities with a reduced need to travel. The provision of amenities and services is vital to achieve this goal. ***(f) Catering resilient neighbourhoods***. Guiding development towards future adaptation and flexibility are the main topics covered by this principle. ***(g) Ensuring democratic governance and residents' empowerment as a means to address neighbourhood challenges***. Administrative efforts aligned with this principle allow to foster collective decision-making and sense of responsibility, enabling greater sustainability targets definition. ***(h) Satisfaction of human needs.*** Principle dealing with quality of life considerations and inclusiveness in access to resources, services and activities (Luederitz, Lang, & Von Wehrden, 2013).

7.2.1.3. Benchmarking

An extensive literature review provided the initial list of existing NSA systems which could be used as benchmarks. Subsequently, the shortlisted set of NSA frameworks and tools was refined based on a criterion of availability and completeness of documentation. As a minimum requirement, the official documentation of each NSA system, published by the issuing entity, must exist and be accessible. Furthermore, concerning the completeness of the information, the documentation should cover at least, the description of the assessment areas, the grouped themes in each one and the description of the individual criteria used for assessing each theme. In addition, outdated or discontinued frameworks were left out from the shortlist, on the grounds of validity of the information and alignment with current best practices. The ***Appendix 03 – Benchmarks Literature Review*** presents the summary of this literature review process. The selected rating systems and their evaluation areas are presented in Figure 7.

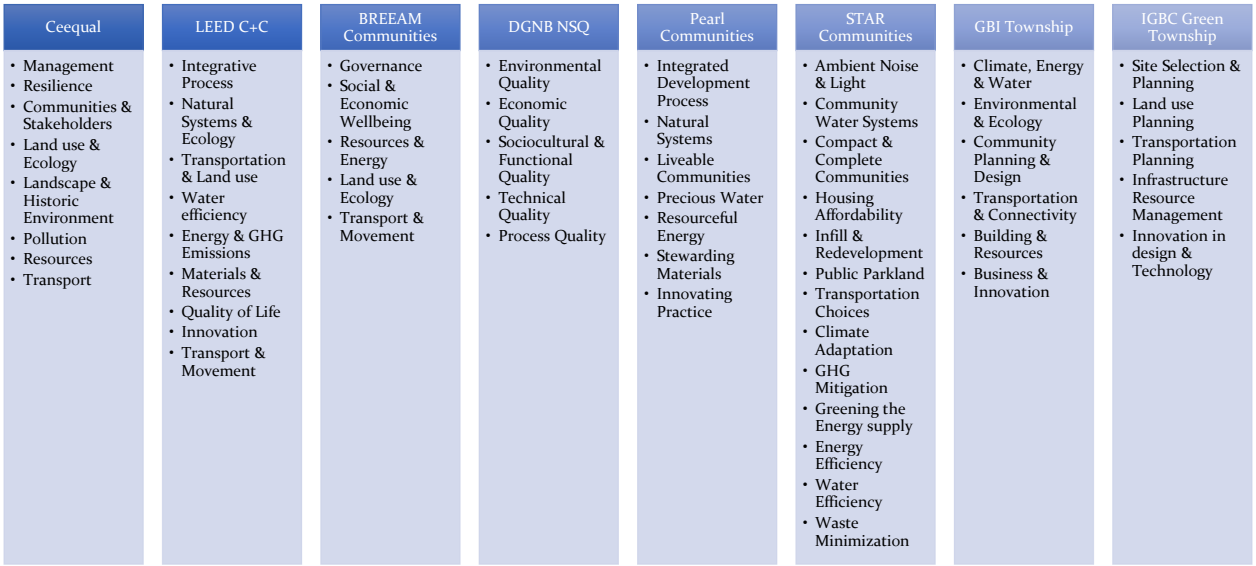

Figure 7: Assessment Areas of the benchmarked National Rating Systems.

The benchmarks provided information for the design process on several aspects. Firstly, on the structure of the frameworks, where all the reviewed rating systems presented a hierarchical structure. This was considered to be a reflection of the assessment of various dimensions of sustainability. Accounting for this multidimensionality implies a grouping criterion for the assessment topics. For each framework, the hierarchy reflected this criterion, so that the assessment themes belonged together. Figure 7 shows a summary of the defined areas for each one of the used rating systems. Nonetheless, their similarity or affinity was assessed over unspecified criteria, making it difficult to trace back the rationale behind the chosen structure, and generating a variability among the reviewed frameworks.

Secondly, the set of used NSA systems served as benchmarks for the selection of an initial proposed list of indicators relevant for *Apeldoorn*. This list, far from being a fixed one, should be seen as a guide for future implementation initiatives. The indicators included in this list, pursued to be efficient, for this, they were evaluated on their credibility in terms of scientific validity, legitimacy for potential stakeholders and salience regarding the relevance for decision-makers (Hák, Moldan, & Dahl, 2007, p. 10). Further criteria of data availability and monitoring processes were not considered. Due to its scientific nature, this research attempted to provide an "ideal" set of indicators in relation to the NSA process. Consequently, the list of indicators was not constructed on the basis of existing data, as it has been recognised that many SA projects are constrained by the availability of relevant and reliable data (Hák, Moldan, & Dahl, 2007, p. 10). Nonetheless, these issues are subject of discussion as they impact the applicability of any indicator-based assessment tool, for the need to balance the costs of monitoring with the capacity for policy implementation (Hák, Moldan, & Dahl, 2007).

7.2.1.4. Model Composition

Having the 4-pillar model as high-level Sustainability guideline, the model was composed in a hierarchical structure. The four dimensions entitle the top level, followed by the evaluation areas on the intermediate level and finally the allocation of the related assessment themes within each proposed area in the lower level. Furthermore, it was aligned with the identified benchmarks and sustainable neighbourhood development principles, while reflecting on the discovered information from the *Municipal Concerns* gathered and analysed during the Context Definition Phase of the project.

The use of all sources of information as references facilitated the creation of a holistic assessment according to the 4-pillar model. With this, a varied set of contexts can benefit from the model thanks to the generalizability achieved by the conceptual model. On one side, the benchmarks allowed to align with best practices, hence, reflecting on a vision on strong sustainability and appropriately scoped assessment criteria. On the other side, the inclusion of particular concerns and the vision of the future of the municipality's internal stakeholders, allowed the inclusion of tailored criteria that reflected these concerns. The resulting conceptual model is structured as a three-tier hierarchy, which is summarized in Table 4 and diagrammed in Figure 8.

Table 4: Conceptual Model – Hierarchical Structure: Dimensions – Areas – Themes.

Dimension	*Evaluation Areas*	*Assessment Themes*
Institutional	(A1) Integrated Project Management & Participative Governance	Integrated Planning & Design
		Consultation & Engagement
		Sustainable Building Guidelines & Incentives
Environmental	(A2) Reduction of Polluting agents	Construction & Demolition Waste Management
		Noise, Light & Air pollutants reduction
		Water and Soil quality conservation
	(A3) Efficient use of Natural resources & Energy	Land value conservation & efficient use of existing Infrastructure
		Efficient Water use patterns & Management
		Renewable Energy Sources
		Energy use patterns & Strategies
		Circular use of Materials & Responsible sourcing
	(A4) Conservation of Ecological value	Natural Systems Assessment & Management
		Biodiversity Conservation
Social	(A5) Climate Adaptation & Resilience	Heat Island Effect Management & Outdoor thermal comfort
		Sustainable stormwater and flood management
		Flexibility & Adaptability to Future needs
	(A6) Quality of Life & Provision of Amenities and Services	Diverse Housing Provision
		Healthy, safe & Appealing Urban spaces
		Mixed land use for Provision of facilities and services
		Cultural & Historic Heritage
	(A7) Inclusiveness & Social Equity	Housing & Transport Affordability
		Accessibility & Connectivity
		Walkability & Bikeability
		Promotion of alternative modes of transport
		Inclusive Design
Economic	(A8) Project Feasibility	Financial Viability Assessment
	(A9) Local economic Impacts	Impacts on local economy development
		Promotion of Circular Economy Models

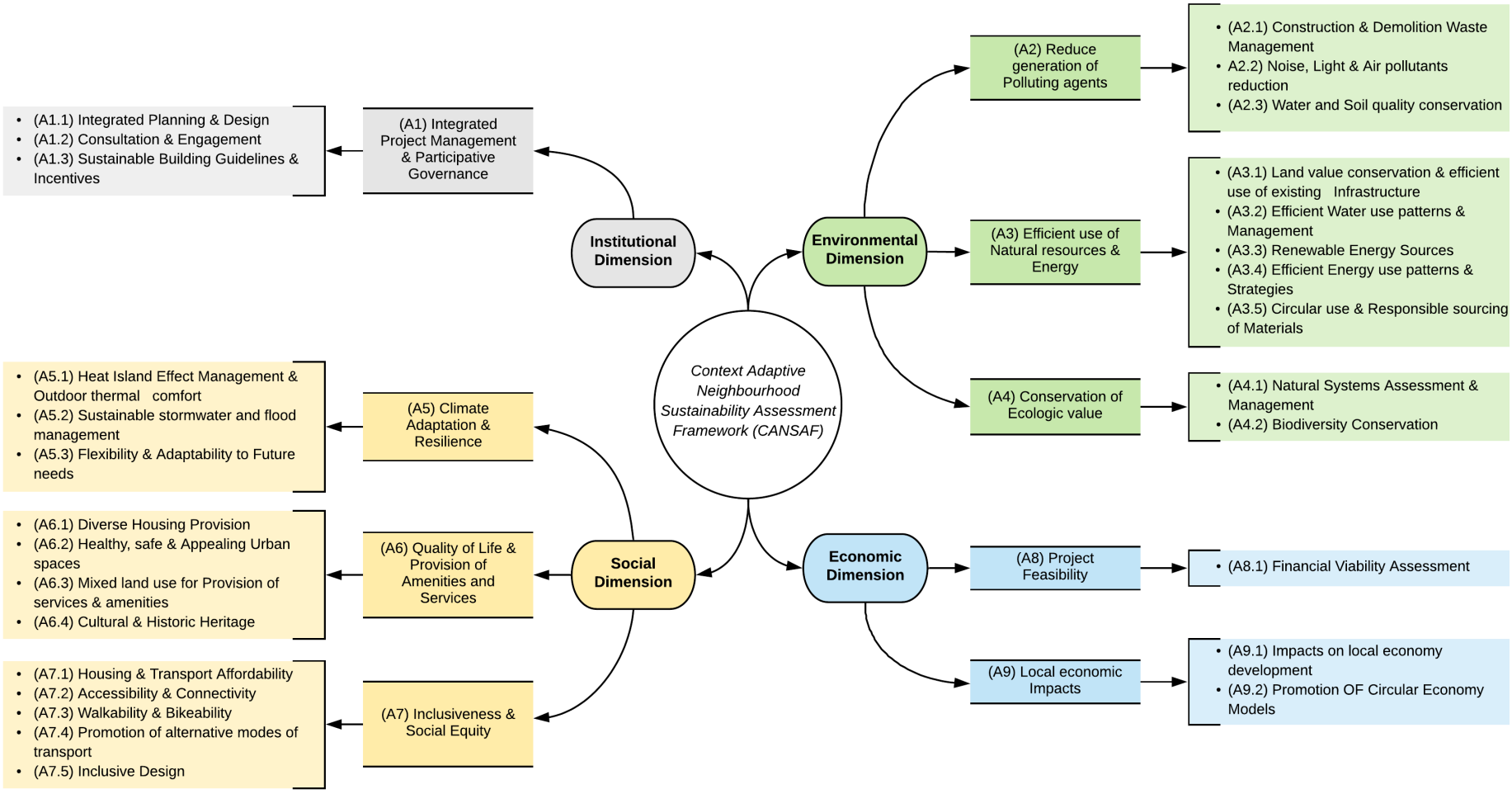

Figure 8: Conceptual Model proposed for CANSAF

7.2.2. Context Adaptive Neighbourhood Sustainability Assessment Framework (CANSAF)

The previously described conceptual model, in conjunction with the distilled list of indicators and the inclusion of the local priorities through the preference modelling information for the PROMETHEE outranking flows, conform the proposed **C**ontext-**A**daptive **N**eighbourhood **S**ustainability **A**ssessment **F**ramework (CANSAF). This framework represents one of the major outputs from this project, reflecting directly on the fulfilment of the proposed research objective. Figure 9 shows a simplified representation of the model, including the three main components it entails.

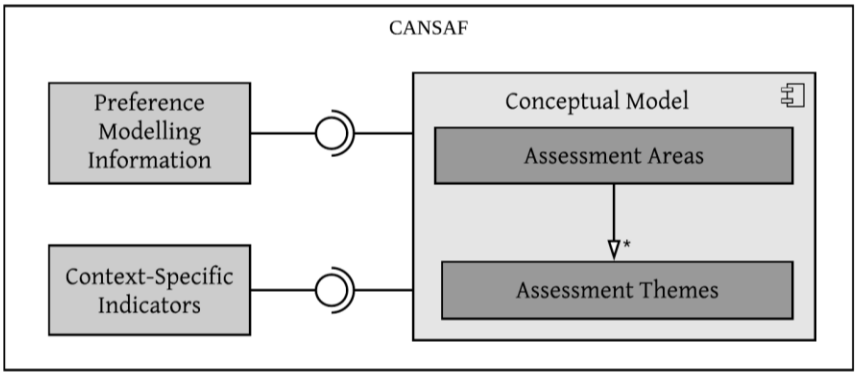

Figure 9: Simplified representation of CANSAF through a Components Diagram.

As Figure 9 displays, the core of CANSAF lies in the conceptual model which is composed by evaluation areas and themes associated with each of those areas. In addition, CANSAF is composed by two other decoupled elements: The *Preference Modelling Information* and the *Context-Specific Indicators*, which are linked to the conceptual model through interfaces. An interface represents a link that requires the decoupled elements to comply with the conceptual model and provide the suitable information to populate it, aligning with the assessment areas and themes. This interface, however, does not require fixed values. By doing so it represents the flexibility provided by CANSAF to be customised to local and context-dependent information.

As mentioned before, the Context-Specific Indicators were proposed for the Municipality of Apeldoorn as a study case for the model. Nonetheless, CANSAF foresees the possibility of adding, removing or modifying the indicator list according to particular needs or contexts in which the neighbourhood planning process is immersed. In addition, the preference modelling information is not imposed over the model. The definition of the criteria importance and preference functions is designed to allow inclusion of local concerns. For the study case of the Municipality of Apeldoorn, however, a proposed preference modelling information was elicited through the *Revised Simos Method*.

7.2.2.1. Preference Modelling Information

CANSAF bases its assessment process on a PROMETHEE method, which requires the definition of Preference Modelling Information to be used in the definition of the outranking flows between the assessed alternatives. In the context of the research development, this information was gathered through the *Revised Simos Method*. The order and specific weights for each one of the evaluation areas from the conceptual model come as an outcome of this indirect method. Figure 10 displays the results from the implementation of the *Revised Simos Method* with decision-makers from the PVG, RL and B&O units within the *Gemeente Apeldoorn*.

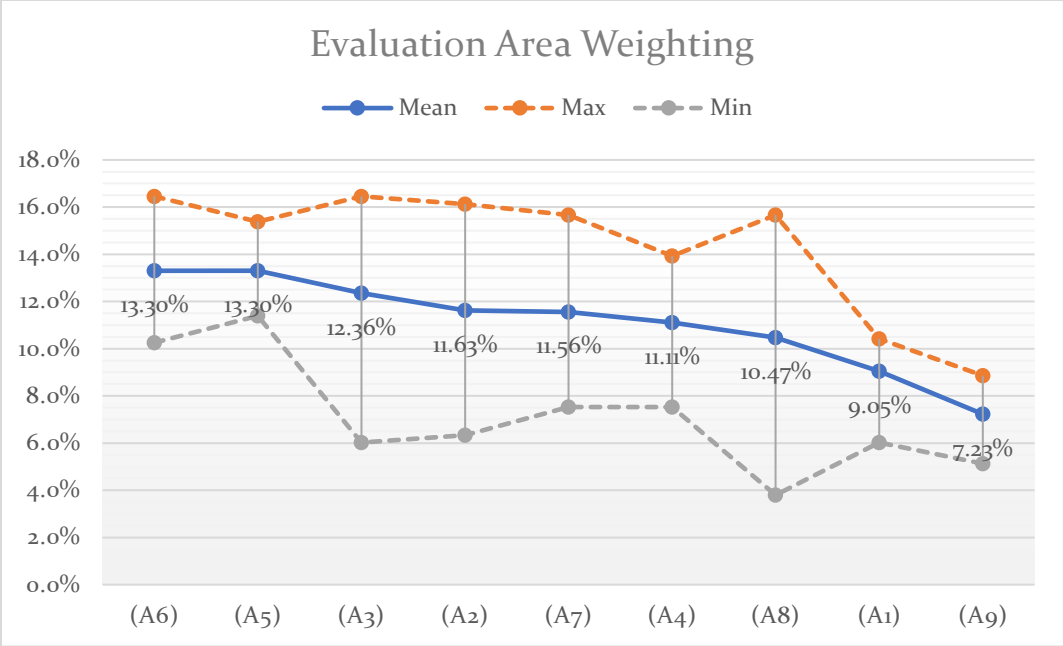

Figure 10: Evaluation Area Weighting. (Mean, Max & Min values)

The maximum and minimum values in Figure 10 illustrates the different professional perceptions of actors from PVG, RL and B&O units who are involved in urban planning and project definition processes. This reflects an underlying variability in the perceived importance from different decision-makers. Nonetheless, the implementation of techniques such as the *Revised Simos Method* used in this research, allows to include these varied visions and incorporate them into a unified outcome. Table 5 presents a summary of the ordered weighting results, including the evaluation area number and name.

Table 5: Mean Evaluation Area Weigth Results

	Evaluation Area	Mean weight
(A6)	Quality of Life & Provision of Facilities and Services	13.30%
(A5)	Climate Adaptation & Resilience	13.30%
(A3)	Efficient Use of Natural Resources & Energy	12.36%
(A2)	Reduce Generation of Polluting Agents	11.63%
(A7)	Inclusiveness & Social Equity	11.56%
(A4)	Conservation of Ecological Value	11.11%
(A8)	Project Feasibility	10.47%
(A1)	Integrated Project Management & Participative Governance	9.05%
(A9)	Local Economic Impacts	7.23%
		100.00%

7.2.2.2. Context -Specific Indicators

As outlined before, the definition of the indicators was mainly supported by the benchmarked rating systems. Nonetheless, this task made use of external sources when additional information was deemed necessary. The selection process was based on their relevance for the Apeldoorn's context, appropriateness in scale and accuracy and measurability (Hák, Moldan, & Dahl, 2007). Furthermore, the comparability between alternatives was considered in their definition. From the existing rating systems, it was determined which specific indicators were worth to be included, and which ones required adaptation or extra considerations to fit into the particular context. For instance, by adapting them to the European legal framework.

The result, which conforms one of the components of CANSAF, is an extensive list describing the indicators, their measurement units and possible additional information to be considered. This list is proposed to reflect on the context of the Municipality of Apeldoorn as a case study and it is presented in ***Appendix 04 – Proposed Indicators for Apeldoorn as Case Study***.

7.3. Enhancing the Institutional Capacity Base

As a last element within this results section, some particular paths of action are proposed, supported by information gathered from the initial semi-structured interviews performed during the Context Definition Phase of the research. Overall, they conform a desired status of the Municipality as institution. An institution well-suited to convert capabilities into concrete change action (Burch, 2010), generating a mobilisation capacity (Polk, 2011). For this reason, the analysis procedure was aligned with the BMM internal influencers, as these influencers cover the institutional dimensions that impact the realisation of organisational objectives (OMG, 2015). Table 6 shows the results of the analysis of the *improvement opportunities* extracted from the interviews. These are aligned with existing literature on change management enablers within organizational environments. This applies for change-oriented action towards sustainable development within urban planning practice.

Table 6: Context Definition Phase - Identified Improvement Opportunities for Sustainable Urban Planning

BMM	***Organizing Theme***	***Basic Theme***	***Source***
Explicit Corporate Value	Attitudes promoting change and innovation	Reducing Risk-adverse and conservative mentality can boost pace of change and innovation.	T-016; [3]; [4]
	Leadership	Promotion of personal responsibility as a driver for change	T-018; [1]; [2]; [3]
Implicit Corporate Value	Interiorize motivation and sense of urgency for change and innovation adoption	Need to avoid unresponsiveness to change demands	T-017; [2]; [3]
		Need to develop pride and sense of purpose as motivators for stimulating change	T-059; [2]; [4]
		Need to increase awareness on a personal basis, to promote change adoption and innovation	T-081; [4]
Infrastructure	Coordination of objectives for integrative Urban Planning	Need to work on a combined agenda (Sustainability + Circularity + Climate Adaptation)	T-006; [3]; [4]
	Guidelines and Principles for Sustainability	Need for guidelines and principles on Sustainability & Circularity	T-082; [2]; [4]
	Long-term multidisciplinary Coordination	Need to Integrate built environment projects with long-term initiatives/programs	T-032; [1]; [3]; [4]
	Financial Integration	Need to achieve financial coordination to allow Circularity, Sustainability & Climate adaptation to be included in project definition	T-074; [1]; [4]

References: [1]: (Moobela, Price, & Bristow, 2007); [2]: (Seidel, Recker, Pimmer, & vom Brocke, 2010); [3]: (Burch, 2010); [4]: (Biesbroek, Klostermann, Termeer, & Kabat, 2011)

The results presented above are a proof of the recognition of the current institutional capacity base, and the identified possibilities to steer organisational change towards the inclusion of sustainability as a target in urban planning. It is important to mention that these features correspond to internal aspects of the Municipality as organisation. The subsequent Discussion section examines the extended institutional arena of the Municipality and comments on further implications for its capacity base and preparedness for engaging in urban sustainable development.

8. Discussion

This section compiles in a logical order an assorted set of discussion topics which emerged along the different steps of the research process. Consequently, the discussion is aligned with the main outcomes presented in the research strategy, to reflect on their significance and validity. The following discussion topics are analysed in reference to existing knowledge found in literature in connection with the results from the Validation & Feedback phase of the research.

8.1. The Institutional arena of Municipal Actors

As described earlier in this document, the scope and features of the institutional dimension as capacity base for Sustainable Development were tackled through the internal organisational environment. This fact was aligned with a three-tier analysis framework proposed by Nykvist & Nilsson (2009). This research dealt with the factors that could be located in the Micro- and Meso- levels of the analysis framework. Hence, the findings with regard to this topic conform a snapshot of the organisation from within its boundaries. As a result, external influencers and linkages with wider societal values and policy networks, which reflect the Macro-level from the aforementioned framework (Nykvist & Nilsson, 2009), fell out of the scope of analysis of the research.

Nonetheless, the nature of the Municipality as a governmental actor, rises the need to discuss these factors, due to their importance and ability to impact the organisational environment. In addition, it has been recognized that institutional conditions for enabling climate action, and by extension, for enabling sustainable urban development, go far beyond the enhancement of the capacity base and require the inclusion of political leadership and transfer of resources as enabling factors for improving urban governance processes (Castán Broto, 2017).

Congruent with the aforementioned external factors, the validation round with municipal decision-makers revealed the importance of existing external influencers over the Municipal action. On one first instance, the power of the political agendas was mentioned. This is evidenced through the characteristic short-termed objectives definition from political actors, exacerbated by the constant change in political parties/mindsets guiding their definition. These shortcomings, originated outside the organisational boundaries, evolve in barriers for sustainable action, as the lack of long-term perspectives reveal lack of awareness and commitment from political actors to address Sustainability in urban development initiatives (Sourani & Sohail, 2011).

An additional mentioned factor came from the existence of funding restrictions for Municipal action. In general terms, strict control and expenditure audits, hinder the implementation of sustainable-oriented projects, as they usually represent higher initial costs in comparison to those related to Business as Usual (BAU) projects. The imposition of restrictions on expenditure of Municipal actors represent a major hindrance for complying with the need of delivering sustainable outcomes. This issue results from the influence of financial auditors, who, through monetary-based assessments, are not yet able to understand the added value of a sustainable approach, thus remaining reluctant to accept the associated higher initial capital costs (Sourani & Sohail, 2011).

Finally, the need to implement adequate frameworks for inter-organisational collaboration was stressed. This factor covers the creation of a shared resource base, in coordination with suitable spaces for dialogue and deliberation. By doing this, a more integrative approach is reachable, thanks to the use of network processes able to accommodate different cross-sectoral policy framing and multi-level interdependencies (Polk, 2011).

8.2. Fitness of CANSAF as decision-support tool

Sharifi & Murayama (2013) proposed an analysis framework which specifies a set of features to assess the competence of NSA tools to respond to the implications of Sustainable Development in the context of sustainable urban planning. This framework was used to guide the assessment of the capacity of CANSAF to aid the decision-making process. This decision follows the fact that assessing CANSAF against existing analysis frameworks provides a stronger external validity and enables comparability with further research initiatives in the field. Moreover, engaging with decision-makers from PVG, RL and B&O units in the Municipality, provided a review of the internal validity of the CANSAF.

The proposed analysis framework makes use of seven evaluation areas, in order to determine the capabilities of NSA tools to guide sustainable planning. Each one of them are briefly covered as part of the present discussion.

8.2.1. Sustainability Coverage

This topic reflects on the degree to which the NSA tools comprehensively accounts for the multidimensional understanding of sustainability in an integrated way (Sharifi & Murayama, 2013). On this topic, it is clear that the use of the 4-pillar model provides the sound base for allowing CANSAF to accommodate multidimensionality into the assessment of the ability of neighbourhood initiatives to deliver sustainable outcomes.

Nonetheless, a topic of discussion arises from the balance of the inclusion of each dimension into the assessment process. This concern has been covered by a number of scholars, who recognize the need for balance and the current lack of it in the existing assessment systems (Bond, Morrison-Saunders, & Pope, 2012; Sharifi & Murayama, 2013; Holden, Linnerud, & Banister, 2014; Komeily & Srinivasan, 2015; Kaur & Garg, 2019). In this context, a balanced approach would result in the implementation of the four pillars of the sustainability model in an equitable manner. However, this has not been reached, arguably due to the disparity in available knowledge to assess each dimension (Komeily & Srinivasan, 2015).

The results from this research, nonetheless, indicate that the unbalance on accounting for the 4 pillars, evidenced through their relative weights, is highly sensitive to the amount of evaluation areas connected to each pillar. Conversely to the hypothesis of unequal degree of knowledge regarding each dimension, it is the diversity of the topics associated with each one of them which drives this perceived unbalance. This might be exacerbated by the exclusive attribution of the themes to one single dimension when in reality many of the assessment themes might be associated with more than one pillar (Komeily & Srinivasan, 2015).

8.2.2. Inclusion of pre-requisites

This theme is assessed in terms of the definition of strategies to assure the achievement of the expected performance levels (Sharifi & Murayama, 2013). In this context, CANSAF provides support for an action perspective, by defining two types of indicators. One of them is performance-oriented, thus reflecting on the compliance criteria in the assorted assessed topics. Howbeit, a second type of indicators fall into an action-oriented perspective. These provide a guide for decision-makers towards the strategic planning within the definition of each initiative. As a result, the product or asset would be more likely to fulfil with the performance measures defined alongside.

8.2.3. Adaptation to locality

This topic is concerned with whether or not the NSA tool considers context-specific needs and priorities in the assessment process (Sharifi & Murayama, 2013). Being one of the guiding research questions, this topic is covered by the characteristics of CANSAF, which are the result of all the design considerations along the

research. Described in detail in earlier sections, the design principle for CANSAF was the inclusion of contextual features and local priorities. In response to this, the framework not only allows the inclusion of a flexible set of indicators for performing the assessment, but also accommodates the vision and perceptions from the decision-makers who are entitled to implement the framework. This result is achieved thanks to two main factors. First, by implementing a PROMETHEE method it automatically requires the *Preference Modelling information.* Second, with the use of a transparent indirect method, such as the *Revised Simos*, in which decision-makers without a high degree of knowledge on MCDA methods can determine the prioritization of evaluation areas.

8.2.4. Weighting and Prioritization

This topic evaluates the rigorousness of the methods used by the NSA tool to define the weighting and ordering criteria (Sharifi & Murayama, 2013). In connection to the former topic, the research project envisioned the use of the Revised Simos Method, due to its capacity to facilitate the elicitation of the criteria importance from decision-makers. As such, it covers the issues of robustness of the collected information, in which by using an indirect method of ordering, inconsistencies in the resulting weights are avoided. Secondly, it provides a semantic to the decision-makers, in which the prioritization process can be understood in terms of the assessed areas and not in direct connection with the MCDA specific parameters and terminology. This participative approach increases the legitimacy and ownership that decision-makers develop towards the framework (Anguelovski & Carmin, 2011), hence increasing the success rate of its implementation.

8.2.5. Participation

This topic is concerned with the mechanisms used by the NSA tool to involve different stakeholders in both, the development and operational stages (Sharifi & Murayama, 2013). In this context, the development of the framework made use of a participative approach constrained to the decision-makers within the Municipality of Apeldoorn. Due to the limited availability of resources (i.e. time, HR, etc.), for the implementation of the research project, the inclusion of additional stakeholders, namely citizens and third parties, was unviable. Nonetheless, a future operational stage of the framework, would provide tools for allowing a participative approach for the NSA process, as it incorporates citizen consultation and extended third party involvement in the urban planning process.

8.2.6. Presentation of results

This evaluation criterion deals with the ways in which the NSA tool presents the results of the assessment process (Sharifi & Murayama, 2013). Given that CANSAF is still in a conceptual phase, the development of the output format and other ways of communicating the results were out of the scope of this research. In general terms, the evaluation output is the ranking of alternatives according to their ability to increase Neighbourhood Sustainability. Further considerations about this topic exist over the implementation of CANSAF as a tool, where the provision of information could include disaggregated performance of alternatives through charts (i.e. radar chart).

8.2.7. Applicability

The final evaluation focus hovers over the practical considerations included in the NSA tool and the strategies used to make the tool more applicable (Sharifi & Murayama, 2013). On one side, the involvement of decision-makers and potential users in the development of the tool increases its applicability (Jensen & Elle, 2007). Nonetheless, given that it is still in a conceptual stage, the considerations about the implementation of CANSAF need to further address the applicability issue, by reflecting on the ease of use, user friendliness and other visual design features (UX). The aforementioned features are particularly relevant if CANSAF were to be implemented as a computer-based assessment tool.

A different aspect related to the applicability of the tool is the selection of indicators. This topic was addressed during the design process by compiling an initial list of indicators suited to reflect the contextual features of the city (Sharifi & Murayama, 2013). This list is not by any means fixed, but it represents an initial proposed operationalization of the framework. In this regard, the selection of indicators was guided by considerations that impact the applicability of the tool, such as the degree of coverage, relevance, scientific validity and comparability among alternatives (Hák, Moldan, & Dahl, 2007; Sharifi & Murayama, 2013; Økland, 2015). Considering its operational stage, the Municipality should engage in institutionalizing the efforts for generating suitable data and monitoring programs, as the lack of these hinder the assessment of goals and targets (Jensen & Elle, 2007). In addition, the measurability of indicators is associated with the availability of information (Økland, 2015) and the format in which it is stored (Jensen & Elle, 2007). All these aspects determine the ability to implement wider and more exhaustive sustainability assessment methodologies. It can be concluded that the decision-making process cannot materialize the full potential of any assessment methodology if there are not enough data providing minimal quality and completeness features.

9. Conclusion

The objective of this research study was to develop a conceptual NSA framework to be used as decision-support tool in the urban planning process. This objective was constrained by the need to incorporate local values and priorities and context-specific information as a means to provide flexibility and relevance to the assessment process. Pursuant to accomplishing this goal, the research project combined the *Design Science Methodology* with MCDA methods, due to their potential to deal with NSA problems. They provide a sound methodology for finding compromise solutions to multicriteria tasks, where often it does not exist one alternative able to optimise all the criteria at the same time (Brans & Mareschal, 2005). Moreover, for rendering the problem manageable, the constrained objective was approached through a series of questions meant to build upon each other to generate the final outcomes of the research. The answers to those questions are reflected upon in this section.

Initially, for attaining the research goal it was necessary to understand the contextual features and local priorities of the Municipality. This was achieved by mapping the elicited information through the 4-pillar model of sustainability, as a method for rationalising and matching it with state-of-the-art benchmarks for urban sustainability. Nonetheless, some particular concerns worth underpinning revolve around three main topics. The first one is the desire of the Municipality to strengthen the urban governance process by adopting transparent and inclusive decision-making processes. The second one is the desire to promote the city as a quality urban area, by means of resilience building and future adaptive capacity. Finally, the trust in Circularity as a means not to only reduce the amount of pollutants, but also to more effectively manage natural resources. In consequence, CANSAF was designed to allow the inclusion of these topics in coordination with benchmarks and a science relevant knowledge base. Moreover, the considerations of context-relevant information allowed the definition of an initial set of indicators. On top of the general considerations for the coverage of the multidimensional concerns of sustainability and science validity, the selection of indicators took into account the relevance for the particular context in which the assessment would be performed.

Additional design considerations dealt with the particular MCDA methodology which best served the intended objective of allowing the modelling of local preference profiles while minimising reductionism in the assessment process. The coordination of these requirements guided CANSAF to be designed as a PROMETHEE-based framework. Generally speaking, the outcomes of a PROMETHEE framework are

supported by preference modelling information (Brans & Mareschal, 2005). Hence, by exploiting this feature, CANSAF provides flexibility to the assessment process by allowing the decision-makers to input their professional viewpoint. As this implied the orchestration of different decision-makers' priorities, the project proposed indirect methods, namely the Revised Simos. These methods provide tools to facilitate the elicitation process while allowing decision-makers to build a realistic semantic background (Papathanasiou & Ploskas, 2018). Following this process, local priorities could be included, so that the resulting assessment framework benefits from higher relevance and legitimacy regarding the desired context of implementation.

Finally, the research project inquired on the potential factors that the municipality should consider in order to facilitate the implementation of NSA tools to support the urban planning process. This concern was tackled bound to the concept of institutional capacity building. In this context, organisational factors were identified, and categorised as barriers or enablers for its influence over the shifting of municipal practices towards sustainable urban development. Th aforementioned factors conformed the current capacity base for sustainable action (Romero-Lankao & Dodman, 2011), upon which improvement opportunities were researched. These were translated into recommendations for guiding organisational change to facilitate the use of NSA tools such as CANSAF. The initial set of recommendations to increase the organisational capacity base, set the focus on the abatement of risk-adverse mentality, and unresponsiveness to change demands. By doing so, values like leadership and sense of responsibility are allowed to rise, pursuant to reduce the power of status quo and boost the adoption of innovation and change. The second set of recommendations aim to changes in the infrastructural features of the municipality which determine their processes and ways of working. Taking as a base a change in organisational structure, towards a less fragmented one (i.e. Matrix structure), higher coordination and collaboration within the organisation could be reached. As a consequence, the municipality would be able to define combined agendas to accommodate the multidimensionality of sustainability, boost knowledge sharing and finally attaining financial integration, which would provide an enhanced resource base to fund the initiatives resulting from the aforementioned combined agendas.

10. Limitations & Recommendations

Initially, this section describes some identified practical limitations for the potential future application of CANSAF. To finalise, recommendations for future research on the field are highlighted.

10.1. Practical Limitations

To begin with, the elicitation of criteria importance does not consider weight differences between the individual themes coupled to each of the evaluation areas. This behaviour results from the fact that criteria importance information was elicited over the broad evaluation areas of the conceptual model in the core of CANSAF. This decision reflected a trade-off between comprehensibility of the elicitation process and resource intensity against granularity of information. A longer and much more time-consuming process could have been implemented to go into the detail of each theme of the corresponding evaluation areas. Nonetheless, this approach was dismissed as it required not only a higher degree of involvement from the decision-makers, but also could lead to a reduction in the understanding and clarity regarding the process and their own priorities. Ranking a larger number of topics is more likely to become a confusing task, consequently affecting the reliability of the results.

The importance of a wider participation in the decision-making process, and particularly in the development of the built environment has been agreed on by scholar and political actors alike (WCED, 1987; Kidd, 1992;

UN, 1992; Burby, 2003; Polk, 2011). Howbeit, the way in which this research project was defined, constrained the participation opportunities to decision-makers within the sphere of the Municipality of Apeldoorn as organisation. This impacts the development phase of CANSAF as a context adaptive framework, which could benefit from expanding the boundaries of participation by accommodating the visions of a wider range of stakeholders, namely those ones included in what Burby (2003) has defined as the *Iron Triangle* composed by Businesses, Neighbourhood groups and Government Officials. Notwithstanding, the operational stages of CANSAF promote a broader and continuous stakeholder involvement, as it increases the chances of success of long-range planning efforts, reducing litigation and facilitating public support for the decision-making process towards sustainability (Vos, 2007).

As a final topic to be discussed within the limitations of CANSAF, there is the fact that it doesn't accommodate the issue of Neighbourhood type, which might generate differences in the prioritization of evaluation areas. Despite reflecting on the adaptation to locality by incorporating context-relevant information and local concerns, CANSAF overlooks possible differences coming from typology of neighbourhoods. The tailored assessment scheme is currently meant to be applied to the whole Municipality, although further customization of NSA tools should arise from considering the type of development to be assessed (Sharifi & Murayama, 2013).

10.2. Recommendations for Future Research

The recommendations for future research projects in the field of NSA, and particularly in the practical implementation of CANSAF are aligned with the identified limitations of this research. Firstly, the considerations on the applicability of the framework are primal for its success in supporting urban planning. This means that as a precondition for its application, sound monitoring and data collection strategies must be developed, to ensure the availability of data to feed the model. This requires a collaboration between actors within the building sector, but leaded by the Municipality as governmental representative.

On a more research-oriented perspective, future research should inquire on methods to automate the elicitation of criteria importance, while maintaining the realistic semantic understanding for decision-makers. By doing so it will assist in reducing the use of resources in this process, while increasing the flexibility of its assessment.

In connection with this topic, there is a latent need to study possible arenas for dialogue and debate. Catering to stakeholder participation in the definition of the assessment tools, the inclusion of the definition of the criteria weighting profiles can make the assessment much more context-sensitive, relevant and practical (Retzlaff, 2009). Consequently, the generation of widespread interest from external stakeholders should be a topic of study (Anguelovski & Carmin, 2011), as part of the improvement of the urban governance of local authorities.

The final recommendation targets the need to reflect on the issue of development type, which has been recognized as important to provide deeper relevance to the NSA usage (Sharifi & Murayama, 2013). In connection with an enhanced flexibility of CANSAF, which was discussed as the result of automating the criteria elicitation, further research could deepen in the formulation of Neighbourhood profiles. First, by defining a typology of neighbourhood, through the identification of relevant differentiating variables that characterize them. Subsequently, by studying the features and objectives guiding each type of them and matching the criteria importance to reflect those objectives and expected performance. Doing this would generate a much more granular adaptability, able to boost a widespread use of the tool in a much more varied set of contexts.

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Camilo Andrés Ramírez Rincón

Guide of Appendixes

1. Introduction

This appendix details the planning and design processes of the implemented research methodologies along the project. First, the **Data Collection Program** is covered, by describing its two generic main steps: *(i) Plan*: defining the features of the required data and the sampling methodology; and *(ii) Instrument Development*: outlining the implementation of interview protocols and guides (Boyce & Neale, 2006). Second and last, the implementation of the **Data Analysis process** is described. This topic reflects on the application of the procedural aspects required to obtain meaningful information and conclusions from the collected data.

There are implications from the defined phasing for the project which impact these methodological aspects. Namely, for the Context Definition and the Validation & Feedback phases, the data analysis is based on a qualitative approach. These two, are guided by the *Iterative Model* (Miles. & Huberman, 1994). For the Framework Design phase, a quantitative component arises from the application of the *Revised Simos Method*. The resulting data from the method, is not qualitative in nature, thus the need to differentiate this phase from the other two, as for data analysis aspects concern.

2. Data Collection Program

As part of the research design process, the alignment of the research objective with the selection of appropriate data collection methods plays a vital role for generating the desired outcomes. The present research objective comprises the definition of a MCDA Neighbourhood Sustainability Assessment Framework to be used as a decision-support tool in the Urban planning process, including the insights from the Municipality of Apeldoorn.

In accordance with the nature of the project as a design science research, the need to understand the context of the problem is latent. For defining an artefact capable of providing benefits to the Municipality, it is important to understand the context it is intended to interact with. Moreover, resulting from the same fact, the knowledge context of the project belongs to the scope of the sciences of the middle range. This means that there are limited generalizations that can be reached, which are not of universal validity, but that represent generalizable knowledge about specific set of objects or contexts under realistic conditions (Wieringa, 2014). Consequently, there is no need to attain statistical relevance for this study, which implies that the specific required information is not meant to represent a general population, but in this case, to reflect on the enlightened opinions and knowledge of a particular set of experts (decision and policy makers, designers, project leaders, etc.). This fact justifies the selection of *Judgment Sampling* method, which is part of the *Purposive Sampling* techniques. This technique is precisely suited for gathering knowledge and opinions of specific actors with a particular set of skills and expertise (Hartmann, 2017), which makes it compatible with the purpose and set-up of this project.

The specific contents and consideration for the Data Collection program were defined for each of the already mentioned phases of the project. Namely, the program specify in detail the Plan and the Instrument Development subprocesses.

2.1. Context Definition Phase

The Context definition phase represents the initial set of activities for the research. Specifically, in alignment with the Design Cycle, this first stage seeks to understand the Problem Context and the Stakeholders' Goals. The latter can be understood as *requirements* for the design of the framework, under the *Design Science theory* (Wieringa, 2014). Under this theory, a requirement is decided by the researcher, by identifying the context attributes that the designed artefact must improve, in order to contribute to given stakeholder goals (Wieringa, 2014). Following these considerations, the Plan and the Instrument Development are devised as follows.

2.1.1. Plan

Investigation of institutional values, and other institutional environmental features could constitute on its own a separated research. Nonetheless, the 4-pillar model proposed as a guiding principle of this research project makes necessary the investigation of institutional patterns and features for obtaining a glance of its status and capabilities. The institutional dimension has been identified to enable sustainable development action by managing the interactions between the traditional triple-bottom line (Economy, Environment, Society) (Sharifi & Murayama, 2013). Consequently, the initial phase of this research needs to accommodate unstructured data from diverse sources. Thus, the research strategy selection was steered towards a Qualitative Methodology, reliant in semi structured interview-based data collection methods. This subsection describes the implemented specific data requirements and sampling strategy, both mandatory elements in the definition of a generic data collection program (Boyce & Neale, 2006).

2.1.1.1. Data Requirements

This initial phase encompasses two main objectives, which can be translated into data requirements. The first one is to determine the overall vision of the municipality, as part of the problem context. This can be translated in the need to have a deeper understanding of the strategic planning of the municipality and the decision-making process undertaken in relation to the built environment initiatives and programs. Secondly, to determine the specific goals behind the definition of urban development projects (rationale). As a data requirement this represents the features and considerations of different functional units within the municipality in regard to the materialization of the high-level strategic objectives.

2.1.1.2. Sample

For this first phase, as outlined before an approach of semi-structure interviews was chosen, implemented individually. The sample was determined following a judgement sample. The list of interviewees reflects a thorough revision of the professional staff within the municipality of Apeldoorn. This review had two main objectives: (1) To identify the suitable roles/positions who could provide a comprehensive view of the Municipality labour in the urban planning field by representing linkages between policy level and operational level. (2) To achieve an exhaustive coverage of the functional units, gathering knowledge from all the possible relevant functional units, while keeping track of trade-offs with time and resource availability. Resulting from the aforementioned sampling review an initial list of interviewees is presented in Table A1-1.

Table A1-1: Context definition Phase – Judgement Sampling result (First Iteration)

Organization	Role/Function
Beheer & Onderhoud (*Management & Maintenance*)	Vakspecialist wegen en kunstwerken (*Specialist Road and Infrastructure assets*)
Ruimtelijke Leefomgeving - Programmeren & Beleid (*Spatial Living Environment - Planning & Policy*)	Bedrijfsleider Energiek Wonen-winkel (*Energy Manager – Residence & Commerce*)
Beheer & Onderhoud (*Management & Maintenance*)	Regisseur Openbare Ruimte (*Director of Public Space*)
Ruimtelijke Leefomgeving - Programmeren & Beleid (*Spatial Living Environment - Planning & Policy*)	Strategisch adviseur Fysieke Leefomgeving (*Strategic advisor Physical Living Environment*)
Beheer & Onderhoud (*Management & Maintenance*)	Eenheidsmanager (*Unit Manager*)
Projecten, Vastgoed & Grond (*Projects, Real Estate & Land*)	Eenheidsmanager (*Unit Manager*)
Strategisch management (*Strategic Management*)	Eenheidsmanager (*Unit Manager*)

In addition, a second iteration of the review process was conducted considering the input from the initial sample, resulting in a second selection of interviewees to be added to the sample (Table A1-2).

Table A1-2: Context definition Phase – Judgement Sampling addition (Second Iteration)

Organization	Role/Function
Projecten, Vastgoed & Grond (*Projects, Real Estate & Land*)	Projectleider A *(Project Leader A)*
Ruimtelijke Leefomgeving - Programmeren & Beleid *(Spatial Living Environment - Programming & Policy)*	Strategisch adviseur Fysieke Leefomgeving *(Strategic advisor Physical Living Environment)*
Projecten, Vastgoed & Grond (*Projects, Real Estate & Land*)	Teammanager *(Team Manager)*

2.1.2. Instrument Development

As mentioned before, the chosen data collection approach for this phase is Interview administering. This process was envisioned to be implemented in an individual basis. In addition, the process was conceived to be done through a semi-structured approach. This decision implies the need to provide a structure for the interview, which was followed, but allowing the respondents to steer the interview according to their particular expertise through open-ended questions and customized probes for them.

Furthermore, interview administration requires de definition of an interview protocol, which in conjunction with the interview guide conform the instruments for the data gathering process within this phase (Boyce & Neale, 2006).

2.1.2.1. Interview Protocol

The protocol conforms the rules that guide the administration of the interview. In general terms it covers three main aspects: (i) Introductory set-up for the interview; (ii) Procedural aspects during the interview; (iii) Interview conclusion and potential further proceedings concerning the interviewee (Boyce & Neale, 2006).

Introductory Set-up

For this particular project the introductory set-up was conceived first to introduce the identity of the researcher, as well as the institutional affiliations with both the University of Twente and the Municipality of Apeldoorn. Moreover, the introduction of the interview is used to familiarize the interviewee to the topic of the research project, and to illustrate the objectives and intended outcomes of the overall project as well as for the interview results. An additional planned aspect is the consent regarding voice recording for the

interview. This goes in agreement with the data collection procedure defined below. Finally, this section allows for thanking the interviewee for their involvement and time allocation on giving the interview.

Procedural Definition

Considering the semi-structured nature of the interview, the probes and follow-up questions varied from case to case. Nonetheless, the general guideline is defined to avoid intrusion from the researcher, allowing the interviewee to state his ideas and answers as freely as possible. Follow-up questions are encouraged in addition to probes for further inquiring about topics that might be relevant.

Concerning the data collection method, voice recording is performed. Moreover, notes gathering serves as backup for the recording. The notes include a preparation phase where the researcher, prior to the interview, annotates the name and position of the interviewee and the direct organizational affiliation (if known). During the interview, the notes reflect only the most relevant aspects and might include additional connections between external data and some of the provided answers.

Interview conclusion

The final step of the interview protocol covers a final appreciation rendering for the information and knowledge shared by the interviewee. Furthermore, it helps to explain the following steps of the project concerning the following phases: Framework design and Validation.

2.1.2.2. Interview Guide

The implementation of a meaningful and insightful interview depends widely in the planned guide for the administration of the semi-structured program. The definition of the guide covered the use of open-ended questions to encourage particular knowledge to be added by the interviewee. Furthermore, it included considerations on avoiding the use of negative framing or leading questions, in order to reduce the chance of biasing the respondents' attitudes and answers.

Finally, the language barrier was anticipated, and the mitigation technique applied was the inclusion of a Dutch/English term reference table, covering technical concepts that might be difficult to translate on open conversation. The ***Appendix 01.1 – Interview Guide (Context Definition)*** shows the proposed guide, which has been updated and complemented with input from stakeholders of the project, namely, supervisors from the University of Twente and Apeldoorn's Municipality.

2.2. Framework Design Phase

2.2.1.1. Plan

Aligned with the ideas presented in previous sections of this document, the development of the second phase required a quantitative approach. Nonetheless, the generic components of a data collection program (Boyce & Neale, 2006) were respected, for the sake of uniformity and robustness of the overall data collection along the whole research.

a. Data Requirements

The Framework Design phase, as a subsequent step within the design cycle, needs to provide congruency and build upon the results obtained in the Context Definition phase. Accordingly, the data requirements from this second phase comply with the Preference Modelling Information for the development of a PROMETHEE assessment methodology. The preference modelling information comprises two main data needs: (1) Information between the criteria and (2) information within the criteria (Brans & Mareschal, 2005). An initial

elicitation of criteria importance provides the needed information for the first of the two aspects. Moreover, the definition of preference functions procures the information to the second aforementioned data need. For the scope of this project, the preference functions are described from a state-of-the-art practice perspective. Consequently, the specific formulation of preference functions parameters for each of the criteria falls out of the scope of the project. They entitle the consultation of stakeholders who need to be identified prior to the implementation of the proposed model, which in this stage is still at a conceptual phase, thus, not ready for such implementation.

Criteria Importance

As the problem statement outlined, current assessment tools and framework make use of fixed criteria importance. This fact is expected to generate criticism and lack of legitimacy towards the implementation of such frameworks by specific actors, who might deem the predefined fixed allocation of importance as a subjective and questionable process. Reflecting on this issue and to allow the inclusion of priorities from directly involved decision-makers, the elicitation of criteria is an important step towards generating legitimacy and representativeness for the proposed sustainability assessment framework.

A desk study prior to the selection showed that there are several methodologies for implementing the criteria elicitation. These varied in difficulty, time consumption and human resource intensity. Accordingly, due to existing time constrains and low availability of human resource committed to the development of this research (i.e. policy-makers, project leaders, etc.), the ***Revised Simos Method*** was chosen over other available alternatives. In its regular implementation, this methodology is administered through face to face sessions. Nonetheless, in response to the low dedicated availability of internal stakeholders suitable for this project, the elicitation process was transformed and implemented through an online questionnaire. This was possible, not only thanks to the features of the Revised Simos, but also thanks to the existence of flexible online questionnaire services.

The Revised Simos Method is widely used for aiding in the elicitation of weights in Multi-criteria decision-making problems. This method, can be classified as an indirect elicitation method, as the involved decision-makers do not explicitly state a weight themselves, but are rather guided through a process of expressing preferences which results much more intuitive and easier to understand (Papathanasiou & Ploskas, 2018).

The methodology can be summarized in the following steps:

1. Evaluation items are placed in individual “cards”, which are given to the decision-maker.
2. The decision-maker ranks the evaluation items from the least important to the most important.
3. Evaluation items with the same relative importance can be placed together in an “importance group”.
4. Additional white cards are given to the decision-maker. These cards represent larger importance differences between subsequent item cards in the ordered set.
5. The decision-maker can add one or more white cards between item-cards, to express a bigger importance gap. As an indication of this differentiation, two successive item-cards, imply an importance gap of one unit, noted as u. Accordingly, two item-cards separated by one white card, imply that between them there is an importance gap of $2u$. And so forth.
6. Finally, the decision-maker indicates the absolute importance gap between the top priorities and the least important item-card(s). This gap is represented by a number, which indicates how many times the top priorities are more important than the least important ones. This ratio is a parameter for the calculation process and is noted as z.

As a result of the aforementioned process, the data requirements can be summarized as two: (1) The ordered set of item-cards including eventual white cards representing bigger importance gaps within the order of evaluation topics, and (2) The parameter *z* indicating the ratio of absolute difference between the extremes of the ordered set of items.

b. Sample

Once again following the criteria for a Purposive sampling procedure, the targeted participants for this stage of the project build over the baseline sample of interviewees from the Context Definition Stage. Nonetheless, this stage requires the input from additional actors who are directly involved in the definition, planning and implementation processes of the urban development projects and programs from the municipality. Under this premise, the aim of the purposive sample for this stage of the research project is to achieve information saturation, with a sample which reflected the visions of the three main units involved in the Development of the Built Environment of the Municipality, namely Projects, Real State and Land *(Projecten, Vastgoed en Grond)*, Spatial Living Environment *(Ruimtelijke Leefomgeving)* and Management & Maintenance *(Beheer & Onderhoud)*. By doing so, assuring the consideration of the varied perspectives within the internal stakeholders of the municipality. For this reason, and through a second purposive sampling, the additional participants for the Framework definition phase are chosen and the total sample is summarized in Table A1-3.

Table A1-3: Framework design Phase – Judgement Sampling result

Organization	Role/Function
Projecten, Vastgoed & Grond - Projectmanagement *(Projects, Real Estate & Land – Project Management)*	Senior Projectmanager *(Senior Project Manager)*
Projecten, Vastgoed & Grond - Ingenieursbureau *(Projects, Real Estate & Land – Engineering office)*	Projectleider *(Project Leader)*
Projecten, Vastgoed & Grond - Ingenieursbureau *(Projects, Real Estate & Land – Engineering office)*	Senior Directievoerder *(Senior Director)*
Beheer & Onderhoud (*Management & Maintenance*)	Vakspecialist wegen en kunstwerken (*Specialist Road and Infrastructure assets*)
Beheer & Onderhoud (*Management & Maintenance*)	Regisseur Openbare Ruimte (*Director of Public Space*)
Beheer & Onderhoud (*Management & Maintenance*)	Eenheidsmanager (*Unit Manager*)
Ruimtelijke Leefomgeving - Programmeren & Beleid (*Spatial Living Environment - Planning & Policy*)	Bedrijfsleider Energiek Wonen-winkel (*Energy Manager – Residence & Commerce*)
Ruimtelijke Leefomgeving - Programmeren & Beleid (*Spatial Living Environment - Planning & Policy*)	Strategisch adviseur Fysieke Leefomgeving (*Strategic advisor Physical Living Environment*)
Ruimtelijke Leefomgeving - Programmeren & Beleid *(Spatial Living Environment - Programming & Policy)*	Strategisch adviseur Fysieke Leefomgeving *(Strategic advisor Physical Living Environment)*

2.2.1.2. Instrument Development

The data requirements for this phase, as outlined in the plan subsection are subjected to pressing time and resource availability restrictions. The low availability of resources signified an issue in the development of the instruments to be implemented.

Timewise, research projects are meant to be developed in, usually tight, schedules, this fact, on its own comprises a restriction. Consequently, it is not viable to follow an individual face-to-face interview administering for this phase. Resource-wise, the individual members of the sample follow a completely individual-based agenda, with few gaps for additional activities, as participating in this project might entitle.

Thus, the coordination and administering process is bound to be timely and spread over a long time-span, making it unviable. These considerations guided the design of the protocol described below.

a. Questionnaire Protocol

Means of Administration

The administering method was defined as online questionnaire. This decision is grounded on the already covered restrictions on time and resource availability. In addition, online questionnaires provide tools for ensuring data quality during the collection process and extend the reach to all the members of the sample.

Nonetheless, it generates a latent risk of no-response. For dealing with this risk, the researcher considered appropriate to initiate the participant involvement with a previous step in which higher actors in the municipality hierarchy, with direct influence over the required participants, were contacted beforehand. This high-level actor would be given an introduction of the purpose of the questionnaire and would be asked to introduce the researcher with the targeted actors. Hence, a previous disposition from the actors was generated, increasing the chances of participation, ergo the response rates for the questionnaire.

Time to Completion

The expected time to completion was set in around 15 minutes. This time, represents a short investment in any participant's agenda, minimizing the risk of no-participation. Furthermore, the language barrier was anticipated, thus, incorporating in the design of the questionnaire, translation of specific terms and important concepts that participants might find difficult to grasp if mentioned in English alone. Finally, an instruction video was developed by the researcher, covering step-by-step the filling of the questionnaire, thus managing the possible perceived complexity of the task and clarifying the expected information from the participants.

b. Questionnaire Guide

The questionnaire protocol was implemented over the *Google Forms* platform. Hereby, a short description of the sections in which it was divided, and their respective contents. Moreover, ***Appendix 01.2 –Criteria Elicitation Questionnaire (Framework Design)*** presents a printout of the guide. For its development a language barrier was anticipated, and important terms and specific concepts were included both in English are in Dutch for increasing the comprehension from the respondents, as well as the response rates.

Background – Purpose of the Project

This section contains a short explanation of the overall purpose of the research. Moreover, it describes specifically the purpose of the second Phase of the project as well as the importance of gathering the required information.

Instructions

This section has two parts. The first one contains the general instructions summarized through a step-by-step video guide. The video was developed through an online tool: *PowToon*[1], and later exported as a YouTube video[2] to the researcher's channel on this same platform.

[1] Welcome screen of the online platform: https://www.powtoon.com/. Accessed on June 2019.
[2] Link to the published video: https://www.youtube.com/watch?v=YSt85c_bqWo. Accessed on June 2019.

Furthermore, it presents a summary of the proposed evaluation areas and the general topics contained in each one of them. By doing this, the participants had the overall idea of the assessment framework and got a better understanding of what each area was evaluating regarding the built environment of the city.

Criteria Importance

This section was aligned with the *Modified Simos Method*. The first question inquired upon the perceived importance of each evaluation area when compared to the rest. For achieving this, the question emulated the behaviour of the face-to-face administered method. Initially by introducing the notion of Importance Groups, to which more than one evaluation area could belong, implying that those areas within a given group would receive the same degree of importance. Lastly, the notion of *with cards* was implemented to a limited extend, by allowing respondents to leave empty importance groups between evaluation areas, to reflect on bigger importance differences. The limitation of this approach consisted on the number of white cards that a respondent might introduce in its answer, as the amount of importance groups was fixed according to the amount of evaluation areas. Thus, the number of white cards available, would diminish proportionally to the amount of evaluation areas placed in separate importance groups.

The question was presented in a graphically sound radio-button matrix, which allowed the visualization of almost all required information. The need to scroll vertically was entirely avoided and the need for horizontal scroll was limited. In addition, it included the restriction of assigning each evaluation area to one and only one importance group, avoiding mistakes in the filling process. Finally, it allowed the respondents to assign different evaluation areas to the same importance group, thus emulating the behaviour of the *Simos Method* data collection procedure.

The second question within this section, covered the relative importance difference between the top importance group and the least important one. This parameter was discovered as relevant for assigning the real importance scores to the different criteria. The interpretation of this parameter corresponds with how many times should you multiply the lowest importance, to match that of the highest importance group. This fact was presented graphically, with a qualitative scale (2: Two times as important; 3: Three times as important; 4: Four times as important and 5: Five times as important). An additional open field was included, to allow respondents who perceived a higher importance difference between the extreme groups of the set.

2.3. Validation & Feedback Phase

2.3.1.1. Plan

In general terms, there are three main objectives when talking about Validation research; (a) **Reliability**: This topic covers the concerns about the objectivity and neutrality with which a research process is conducted. Mainly reflects on the degree of influence of the researcher and the implemented methods over the phenomena and the conditions of an inquiry. (b) **Internal Validity**: This topic covers concerns of authenticity, plausibility and adequacy of the findings and conclusions from the research process. It is usually assured by determining how the original informants perceive the accuracy of the findings, and if coherent explanations arise when there are discrepancies. (c) **External validity**: The last topic deals with issues of generalizability of the findings. It reflects on the extent to which the conclusions from a study are congruent, connected or confirmatory pf prior theory (Miles. & Huberman, 1994, pp. 278-279).

Now, for the purposes of this study, within Design Science, the main objective of Validation research is to understand the potential effects of the artefact in its intended problem context, if it were to be implemented (Wieringa, 2014). In agreement with this objective, the Validation phase was devised in two steps.

The first step is related with the discovered institutional barriers, enablers and improvements opportunities, which came as outcomes from the Context Identification phase. These were subject of an external Validity check, while they were developed, to see of the findings reflected existing theories. Nonetheless, the concerns of Internal validity were entirely dependent on the considerations of informants within the municipality, thus requiring their involvement.

Secondly, the validation of the conceptual model, on first instance was done through benchmarking over existing rating systems, thus providing a sound base for external validity. Nonetheless, the concerns of internal validity required additional involvement, reason why an expert panel was developed to gather the specific opinions on the degree of fulfilment of the requirements of the municipality. Hence, reflecting on the adequacy and context-relevance of the proposed conceptual model.

a. Data Requirements

Following the described plan, there were two separate data requirements sets. For the first step, the required data can be summarized into two groups: (1) Information concerning Plausibility and (2) Information concerning Adequacy (Miles. & Huberman, 1994). The first group, applied to the barriers and enablers, reflected on the degree of recognition of the presented topics in the municipality's working context, and for the improvement opportunities it reflected on the perceived relevance for the municipal context. Accordingly, for the second group, adequacy was assessed in terms of the potential importance of each presented topic to generate organizational change towards Sustainable practices implementation.

For the second step within the overall validation phase, the data requirements, while reflecting an Internal validity check, were driven by the compliance with context-relevant information, and the extent to which the artefact, was potentially able to fulfil the requirements (Wieringa, 2014) discovered during the Initial phase of the research project.

b. Sample

Considering that the validation process required to loop back over the opinions of the original informants (Miles. & Huberman, 1994), the original sample was preserved, and only additional extra respondents were addressed to allow the inclusion of actors from the municipality who were not directly involved in the initial phase of the project. The rationale behind this is to avoid a tunnel vision effect on the results and confirm that the presented conclusions and findings can be recognized from a wider portion of the Municipal taskforce. The resulting sample, product of a judgement sampling process is summarized in Table A1-4

Table A1-4: Sample Result (Validation & Feedback Phase)

Organization	Role/Function
Beheer & Onderhoud (*Management & Maintenance*)	Vakspecialist wegen en kunstwerken (*Specialist Road and Infrastructure assets*)
Ruimtelijke Leefomgeving - Programmeren & Beleid (*Spatial Living Environment - Planning & Policy*)	Bedrijfsleider Energiek Wonen-winkel (*Energy Manager – Residence & Commerce*)
Beheer & Onderhoud (*Management & Maintenance*)	Regisseur Openbare Ruimte (*Director of Public Space*)
Ruimtelijke Leefomgeving - Programmeren & Beleid (*Spatial Living Environment - Planning & Policy*)	Strategisch adviseur Fysieke Leefomgeving (*Strategic advisor Physical Living Environment*)
Beheer & Onderhoud (*Management & Maintenance*)	Eenheidsmanager (*Unit Manager*)

Projecten, Vastgoed & Grond (*Projects, Real Estate & Land*)	Eenheidsmanager (*Unit Manager*)
Strategisch management (*Strategic Management*)	Eenheidsmanager (*Unit Manager*)
Projecten, Vastgoed & Grond (*Projects, Real Estate & Land*)	Projectleider A *(Project Leader A)*
Ruimtelijke Leefomgeving - Programmeren & Beleid *(Spatial Living Environment - Programming & Policy)*	Strategisch adviseur Fysieke Leefomgeving *(Strategic advisor Physical Living Environment)*
Projecten, Vastgoed & Grond (*Projects, Real Estate & Land*)	Teammanager *(Team Manager)*
Projecten, Vastgoed & Grond - Projectmanagement *(Projects, Real Estate & Land – Project Management)*	Senior Projectmanager *(Senior Project Manager)*
Projecten, Vastgoed & Grond - Ingenieursbureau *(Projects, Real Estate & Land – Engineering office)*	Senior Directievoerder *(Senior Director)*
Projecten, Vastgoed & Grond - Ingenieursbureau *(Projects, Real Estate & Land – Engineering office)*	Directievoerder *(Senior Director)*

2.3.1.2. Instrument Development

Validation research is normally developed through a number of research methodologies. Expert opinions, Single-case experiments and Technical action research (Wieringa, 2014). From the abovementioned methods, single-case experiments and technical action research imply the use of a prototype model of the artefact, which is used within a controlled real scenario and context to understand its performance in terms of the functional demands (Wieringa, 2014). Considering the time constraints of the overall research project, a validation process using any of these two methods is unviable. For this reason, a validation method consisting on expert opinions and stakeholder feedback is selected.

a. Validation Questionnaire Protocol

As it has been indicated earlier, the Validation phase was divided into two sections. The first one covering the Institutional Influencers identified as barriers, enablers and improvement opportunities for allowing the integration of Sustainability Assessment tools to steer the Urban Planning Process. The second one, to understand the potential performance of the proposed model to comply with the requirements within the municipal context.

The means of administration were not limited to one single channel. Both implemented Questionnaires were delivered through physical and digital copies upon availability of the each one of the members of the sample. This is true as well for the Institutional report which accompanied the first questionnaire. Concerning the time to completion, there was an estimated time of 20 min for both activities in the first step of validation, reading and filling in the questionnaire. In addition, a time of 10 min was deemed suitable for the completion of the second questionnaire, which was visually aided with the diagram of the conceptual model.

b. Validation Questionnaire Guide

Two separate guides were developed for each one of the particular targets of validation.

Institutional Validation Guide

The guide for this part of the validation process contains the following sections: (i) **Institutional Report**: The results of the identified institutional aspects is presented in a short report. The report contains an introduction and a summary of the identified barriers, enablers and improvements opportunities. (ii) **Questionnaire Introduction**: explanation on the purpose of the questionnaire and the expected outcomes. (iii) **Questions**: The questions are formulated for each one of the Categories within the Barriers, Enablers

and Improvement Opportunities separately. This avoids the risk of over generalization. The individual themes within the categories were not inquired individually. Doing this would have generated an extensive list of questions which would have, not only, hampered the willingness of the sample members to reply to it, but also, reduced the quality of the responses for demanding too much time to complete. Moreover, the Questionnaire was administered on a mixed basis, paper and digital copies of both the report and the questionnaire. This was done to facilitate the overall reading and filling process. ***Appendix 01.3 – Institutional Report Questionnaire (Validation & Feedback)*** depicts the implemented guide for this step.

Conceptual Model Validation Guide

The validation of the conceptual model was done using the base of the diagram which represented the model. By doing this, the members of the sample were able to assess each one of the assessment topics according to the relevance for the Municipal context, while being aware of the individual themes covered by each one of them. ***Appendix 01.4 – Conceptual Model Questionnaire (Validation & Feedback)*** presents the implemented guide.

3. Data Analysis

3.1. Context Definition Phase

This sub-section first presents the components of Data Analysis as an iterative model, where the different activities form a cyclical process. This can be explained by the fact that issues of data reduction, display and conclusion drawing can have retroactive effects while successive analysis episodes follow each other. As a result, qualitative analysis can be represented as an iterative process. **Error! Reference source not found.** illustrates the dynamics of the process. In addition, each step is revised in detail in subsequent subsections.

3.1.1. Data Processing

After the Data collection process itself, Data Processing can be considered the initial step for performing a successful data analysis. As defined in the interview protocol, primary sources of information are initially gathered through voice recording, in addition, important elements from the interviewee responses are collected through handwritten notes along the session. These are unstructured data storing methods, which call for the need of data processing to convert them into usable and workable data formats for posterior analysis. For the recorded data, the processing protocol is defined as follows:

i. Answers to the warm-up questions, including the background and other information concerning the interviewee were not subject to formal transcript. Instead, the answers were extracted from the interviewee response speech.
ii. Core answers were processed by generating an *intelligent verbatim* transcript from the response speech. This means that the words, intention and original messages were preserved, whilst removing the false starts, stutters, filler speech, word repetition, idiosyncrasies and interjections (Boyce & Neale, 2006). With this method all relevant information and terminology remains unaltered, but distracting elements are removed, thus allowing to analyse the contents of the responses in an easier and clearer way.

3.1.2. Data Reduction

Due to the qualitative nature of the proposed interview processes, the amount of collected data is large. Hence, as a precondition for the data analysis process, a reduction process needs to be performed. Coding and categorization are the two steps intended to serve that purpose (Hartmann, 2017).

3.1.2.1. Coding

It is the analytic process of labelling specific units of text to allow them to be rearranged and integrated for subsequent categorization. The aim of coding is to facilitate the analysis and posterior drawing of meaningful conclusions from the coded data (Hartmann, 2017). Coding entitles the selection of a suitable *coding framework*. This process can be theory-led, based on emergent issues arising from the text itself or from a combination of both. Once the coding framework is chosen, it is used to dissect the gathered data into codes (Attride-Stirling, 2001). Both steps are described below.

Definition of the Coding Framework

A coding framework is defined through specific criteria, called units (i.e. words, sentences, themes, etc.). A coding unit must represent the overall idea of the text it seeks to code, so that its meaning is not altered, and no relevant information is left out (Hartmann, 2017). Considering this, *thematic coding* is usually implemented, thanks to the ability of themes for representing the expression of an idea or assertion about a particular topic (Hartmann, 2017).

Reflecting on the aforementioned aspects, *thematic coding* is chosen as framework for this first step of the data reduction process. Nonetheless, the heterogeneous nature of data, generates an impact on both the definition of the codes as well as the process of populating each one of them. Despite this, a generic definition of the coding framework is proposed, based mostly on the possibility of emergent issues to arise from the text. In this context, a theme unit was defined as a statement, containing an assertion, value judgment or fact concerning any of the relevant concepts related to this research project. This means that the coding framework is data driven and does not rely on preestablished theoretic themes, but rather reflect on arising relationships and concepts from the respondents.

Text dissection using the Coding Framework

This step was performed in an iterative process of revision, satisfying the needed to consolidate the data into representative coding units without losing detail caused by excessive generalizations. It is important to mention that this process entitles a big interpretative endeavour, thus the results from this process are not unique, and different researchers, might come to different coding results, nonetheless, the process was done as unbiased and objectively possible.

3.1.2.2. Categorization

It is the process of arranging and classifying information according to a given set of coding units (Hartmann, 2017). This process was performed through Thematic Networks analysis. It conforms a suitable method for organizing qualitative information, facilitating the structuring and depiction of themes (Attride-Stirling, 2001) within the collected information. Consequently, it systematizes the extraction of *Basic Themes*, which are the low-order premises evident in the text. It helps in defining *Organizing Themes*, which summarize more abstract principles coming from groups of basic themes. And finally, facilitates the identification of *Global Themes*, which are super-ordinate themes encapsulating principal metaphors in the text (Attride-Stirling, 2001).

Moreover, the categorization process can follow an inductive approach (from the collected data) or be performed deductively (from existing theories), depending on the existence of these base theories. When existing theories are available, they can be used to form the initial categories deductively and further revision and refinement can be done inductively as the research process advances (Hartmann, 2017). The categorization process helps in the detection of patterns and relationships between the categorised data, through the process of populating, updating and refining basic, organizing and global themes (Attride-Stirling, 2001).

The performed categorization process followed the 4-pillar *Strong Sustainability Theory* as conceptual base for the formation of basic themes and their potential abstraction into organizing themes. Nonetheless, refinement and updating was done inductively, using the gathered data. These include the coded data from the interviews described on this document, in conjunction with the data extracted from secondary sources like strategic plans, reports and other official documents from the municipality. Finally, the Global themes were founded on the specific objectives of this research, in which the following aspects are of prime importance: **(i) Municipality Concerns**, these are covered by the Design cycle, reflecting on the goals of the stakeholders, thus representing a desired status (future). Their extraction represent a mandatory aspect within the development of a design science research (Wieringa, 2014). Furthermore, they serve as information base for the Framework Design Phase; **(ii) Institutional Aspects**, this global theme encapsulates all identified elements which conform the current status (present) of the municipality, therefore determining its capability as institutional agent of incorporating Sustainability changes in the Urban Planning process; **(iii) Improvements Opportunities**, these represent the directions of enhancement already identified by relevant actors within the Municipality. Hence, they can be interpreted as means for going from the current status to the desired one and are the supporting base for the set of recommendations for enhancing the Capacity Base towards the inclusion of Sustainability in the Urban Planning decision process.

3.1.3. Data Display

Data Display constitutes the second major step in the process of qualitative data analysis (Hartmann, 2017). A display can be defined as a tool which organizes, compresses and assembles information, thus providing guidance into the drawing of conclusions and further decision over possible courses of action (Miles. & Huberman, 1994, p. 11). Consequently, this step provides visual insights on the reduced data, to facilitate the identification of patterns and causal relationships in the concepts contained by the data. It has been found that better displays facilitate valid qualitative analysis processes, this means that finding suitable representations for the information plays a vital role for advancing through the data analysis. Hence, this step is mainly based in the use of diagrams, charts, matrices, graphs and networks for displaying data in an organized and accessible way (Miles. & Huberman, 1994, p. 11), according to the purpose of the analysis. Therefore, such feature facilitates the drawing of conclusions and subsequent mapping of data relations and dependencies.

3.1.4. Conclusion Drawing & Verification

This step can be viewed as the final analytical activity in the process and constitutes the essence of data analysis (Hartmann, 2017). This step is mostly concerned with identifying the meaning of the previously identified patterns and relationships. Furthermore, its concerned with noting regularities that can explain patterns, causal flows and propositions (Miles. & Huberman, 1994; Hartmann, 2017). In this sense, this step is composed by two aspects. Initially the drawing of conclusions following the aforementioned purposes.

Consecutively, conclusion verification takes place. This can be done in form of reviews of previous steps and information; however, more robust verification can include the use of intersubjective consensus, which seeks for internal/external validity among colleagues or stakeholders. The later form of verification aims to test drawn conclusions for validity and confirmability from domain experts or directly interested parties (Miles. & Huberman, 1994).

3.2. Framework design phase

The data analysis process for the second phase of the project does not align with a Qualitative Data Analysis process. As described in the Data Collection Program above, this second phase is based upon the *Modified Simos Methodology*, which is applied for quantitative data gathering regarding specific objectives of elicitation of criteria importance. This section follows the aforementioned methodology in the conversion of the raw data into the final criteria importance that comprised the decision base for the proposed framework.

Moreover, this section describes the theoretical considerations for defining the *Preference Functions* required for the compound criteria used by the PROMETHEE outranking process.

3.2.1. Criteria Weighting

The process of data collection for the *Revised Simos Method* outlined in subsection a above, provides data which indirectly reflects on the Criteria weighting. This means that a transformation process needs to be performed to convert the indirect data into relevant weighting information to be used as input for the model. This process consists of two main steps (Papathanasiou & Ploskas, 2018), which are briefly described.

3.2.1.1. Non-normalized Weights

The collected data can be characterized as follows. From a finite amount (n) of evaluation categories, each decision-maker generates a set of finite ordered criteria importance groups, the number of groups or ranks would be ($\tilde{n}$), where $1 \leq \tilde{n} \leq n$, as ranks can contain more than one category.

As mentioned before, the basic unit of importance difference between successive ranks was denoted as (u), and the parameter of absolute difference between the first and the last rank was denoted as (z).

With these clarifications, the set of non-normalized weights can be denoted as:

$$k = (k_1, k_2, \dots, k_{\tilde{n}})$$

An additional parameter representing the number of white cards between each pair of successive ranks is denoted as ($e_r{}'$). With this parameter, the following definitions are given:

$$\begin{cases} e_r = e'_r + 1\ ;\ \forall r = 1,2,\dots,\tilde{n}-1\ ;\ e'_1 = 0 \\ u = \dfrac{z-1}{\sum_{r=1}^{\tilde{n}-1} e_i} \end{cases}$$

Making use of these two parameters, the non-normalized weights can be calculated as follows:

$$k_r = 1 + u \sum_{i=0}^{r-1} e_i\ ;\ e_0 = 0$$

3.2.1.2. Normalized Weights

The set of normalized weights can be described with the following expression:

$$k^* = (k_1^*, k_2^*, \dots, k_{\tilde{n}}^*)$$

Once the non-normalized weights have been calculated, an additional parameter representing the number of evaluation categories belonging to each rank is denoted as (c_i). Both these parameters are used to calculate the normalized weights using the following expression:

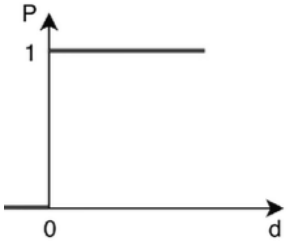
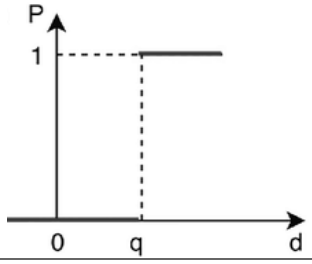
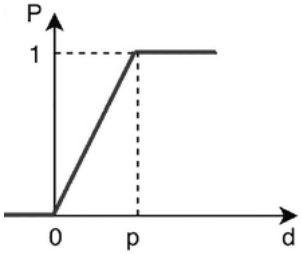
$$k_r^* = \frac{100}{\sum_{i=1}^{\tilde{n}} c_i k_i} k_r$$

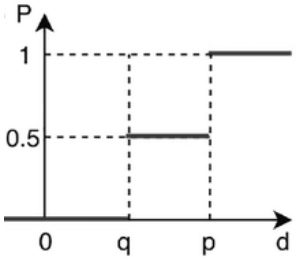
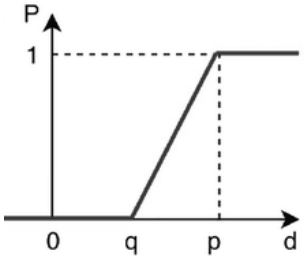
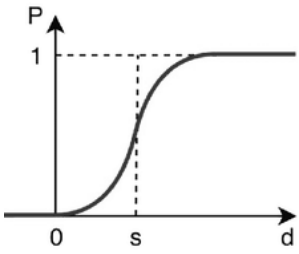
The normalized weights represent the result of the application of the method. They can be directly applied to the MCDA model, as they entitle a degree of importance represented by a percentage. The coded calculation process is presented in ***Appendix 01.5 – Simos Methodology MATLAB Implementation Code.***

3.2.2. Preference Function Definition

As outlined earlier, the preference functions were analysed from the perspective of current practices. In this context, literature and previous experience have led to a set of regular shapes which help characterize the preference functions. These common shapes are depicted in Table A1-5 with their corresponding parameters.

Table A1-5: Types of Generalised Preference Criteria (PROMETHEE SOURCE)

Generalised Criterion	Definition	Parameters
Usual Criterion 	$P(d) = \begin{cases} 0 & d \le 0 \\ 1 & d > 0 \end{cases}$	---
U-shape Criterion 	$P(d) = \begin{cases} 0 & d \le q \\ 1 & d > q \end{cases}$	***q*** – Threshold of Indifference
V-shape Criterion 	$P(d) = \begin{cases} 0 & d \le 0 \\ d/p & 0 \le d \le p \\ 1 & d > p \end{cases}$	***p*** – Threshold of absolute preference

Level Criterion 	$P(d) = \begin{cases} 0 & d \le q \\ 1/2 & q \le d \le p \\ 1 & d > p \end{cases}$	$\boldsymbol{q}$ – Threshold of Indifference $\boldsymbol{p}$ – Threshold of absolute preference
V-Shape with Indifference Criterion 	$P(d) = \begin{cases} 0 & d \le q \\ \dfrac{d-q}{p-q} & q \le d \le p \\ 1 & d > p \end{cases}$	$\boldsymbol{q}$ – Threshold of Indifference $\boldsymbol{p}$ – Threshold of absolute preference
Gaussian Criterion 	$P(d) = \begin{cases} 0 & d \le 0 \\ 1 - e^{\frac{-d^2}{2s^2}} & d > q \end{cases}$	$\boldsymbol{s}$ – Inflection point of the preference function. Corresponds to an intermediate value between $\boldsymbol{q}$ and $\boldsymbol{p}$

Considering the generalised criteria in existing literature and in consultation with relevant stakeholders for the project, it was realised that the usability and understandability of the preference functions were directly related with the number of parameters that the decision-makers needed to fix. For this reason, the *Usual Criterion* entitles the most intuitive and straight forward alternative. Nonetheless, the *V-shape criterion* represents an increasing appeal proportional to the difference in alternatives' performance which can be a desirable feature when expressing preferences. With only one parameter to fix, this criterion could be a fair trade-off to be considered for the implementation of the model outcome of this research project.

3.3. Validation & Feedback Phase

The final phase of the project is aimed to provide internal validity and feedback over the obtained results during the previous two phases. On one side its purpose is to provide *Verification* for the contextual information and general requirements gathered from the Context Definition Phase. On the other side, it aims to provide feedback upon the design process which gave as outcome the Conceptual Sustainability Assessment Model. For these results, it reviewed the fitness for purpose of the proposed framework. Assessing the compliance with the priorities and requirements from the municipality and the alignment with the particular context in which the assessment framework intends to be used. In this way, the data analysis for

this third phase represents the last step from the *Iterative Cycle*: ***Conclusion Drawing & Verification*** described above in this document.

3.3.1. Institutional Capacity Base

As it has been mentioned, the institutional capacity base was characterised through a set of barriers and enablers for sustainable urban planning in the Municipality. Both were categorised accordingly using the Internal Influencers standard categories from the BMM (OMG, 2015). Equally, the base for the proposed recommendations, synthesised as improvement opportunities, followed the same data analysis process.

This phase relies on an extended stakeholders' base to provide a sound feedback loop over the results. On top of the original decision-makers interviewed during the Context Definition phase, additional professionals were added to provide insights from people who were not involved in the development of the project, thus aiming to include an external viewpoint, still within the boundaries of the organisation, but outside the boundaries of the research itself.

The process followed descriptive statistics principles to collect insights regarding the Likert Scales used in the questionnaire. This was complimented by the open questions which provided additional comments and relevant information to be considered in the discussion section. The latter did not follow a formal data analysis process, instead it was used to feed the discussion topics relating the comments with literature and theory on particular subjects as the extended institutional arena of Municipal actors.

The data analysis process translated the original scale into a numeric one (1 to 5), upon which the mean and the mode could be calculated. Hence, reflecting on the overall perceptions of the involved decision-makers. These perceptions were assessed to fulfil two main relevant objectives for the Validation Phase. Firstly, to evaluate the confirmability of the presented information. This being understood as the importance of the covered topics within each Internal Influencer category in the context of organisational change towards Sustainability. Secondly, to reflect on the Validity of the statements. This refers to the recognition of the addressed topics within each internal Influencer Category for the context of the organisation. Both objectives conform the desired aspects to test in the pursue of internal validity (Miles. & Huberman, 1994).

Table A1-6 - Scale Conversion

# Scale	Original Scale
1	Strongly Disagree
2	Disagree
3	Undecided
4	Agree
5	Strongly Agree

Using the translated scale, the data processing consisted in simply assessing the degree of importance perceived for each of the identified internal influencers categories and the recognition of said aspects in the organisational environment of the municipality. This process allowed to recognize where the focus should be placed in the definition of the recommendations. In addition, it helped to create awareness within the Municipal human resource base about the dynamics of the working processes, mind-sets and the available ways of driving change. The summary of this process is presented in Table A1-7

Table A1-7: Validation Questionnaires Data Processing Summary

		Validity		Confirmability	
		Mean	***Mode***	***Mean***	***Mode***
Barriers	Explicit Corporate Values	4,17	5	3,33	4
	Infrastructure	4,50	4	4,50	4
	Issues	3,83	5	4,33	4
	Managerial Prerogatives	4,17	4	3,50	3
Enablers	Explicit Corporate Values	3,83	4	3,67	4
	Infrastructure	4,50	4	3,83	3
	Managerial Prerogatives	3,67	3	3,83	4
Improve	Explicit Corporate Values	4,33	4	4,17	4
	Implicit Corporate Values	4,17	5	4,00	4
	Infrastructure	4,17	4	4,00	4

3.3.2. Validation of CANSAF's Conceptual Model

The validation of the model was performed as a final aspect within the stakeholders' involvement process. The se was devised to assess the perceived relevance of each of the proposed evaluation areas, to effectively reflect on Urban Sustainability concerns in the context of Neighbourhood (re)development initiatives. This assessment was performed by the Unit Manager of the Projects, Real State and Land unit. In this context, representing the authority within the unit. For these reasons being chosen to perform this task and provide the final insights. The results of this assessment are presented in Table A1-8:

Table A1-8: Conceptual Model Validation Summary

	Evaluation Area	**Likert Scale Choice**
(A1)	Integrated Project Management & Participative Governance	Strongly Agree
(A2)	Reduce Generation of Polluting Agents	Strongly Agree
(A3)	Efficient Use of Natural Resources & Energy	Strongly Agree
(A4)	Conservation of Ecological Value	Agree
(A5)	Climate Adaptation & Resilience	Agree
(A6)	Quality of Life & Provision of Facilities and Services	Agree
(A7)	Inclusiveness & Social Equity	Strongly Agree
(A8)	Project Feasibility	Agree
(A9)	Local Economic Impacts	Agree

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1. Background & functions

1. What's your educational background and area of expertise?
2. For how long have you worked in the municipality?
3. What functions do you perform as part of your job?

2. Specific professional activities

4. What are the strategic goals set by the City Council regarding the development of the built environment?
   4.1. ***Probe:*** How is Sustainability represented in those goals?
   4.2. ***Probe:*** How do the goals relate with Climate adaptation?
   4.3. ***Probe:*** How is Circularity accounted for in the formulation of the goals?
5. What is the mission of the unit you work in?
6. How do the objectives of the functional unit you work in, help in materializing the strategic goals?
7. How is the regular operation of the unit you work in? (Working Process)
8. What type of projects/programs are developed within the functional unit you belong to?
   8.1. ***Probe:*** Can you describe some of these projects?
9. How is the collaboration process between the (sub) units when developing a project?
10. Can you describe how the planning process goes for a regular project implemented by your functional unit?
    10.1. Who is the main promotor in the conception phase of the projects?
    10.2. How is the interaction with other functional units?
    10.3. ***Probe:*** In which way is this planning process considering environmental impacts?
    10.4. ***Probe:*** To what extent is the planning process applying social policies/guidelines for improving social interaction and diversity?
    10.5. ***Probe:*** In which way is the planning process promoting economic development for its area of influence?

3. Final Thoughts

11. How do you visualize the city of Apeldoorn in the future (Timespan of 20-30 years)?
12. Is there any additional information you might want to add?

Terminology Guide (Dutch/English)

Nederlands	English
Circulariteit	Circularity
Klimaatadaptatie	Climate Adaptation
Duurzaamheid	Sustainability
Beheer en onderhoud	Management & Maintenance
Openbare ruimte	Public Space
Kunstwerken (tunnels, bruggen, etc.)	Infrastructure Assets* (tunnels, bridges, etc.)
Ruimtelijke Leefomgeving	Spatial Living Environment
Bereikbaarheid en Mobiliteit	Accessibility & Mobility
Stadsplanning	Urban Planning
Milieu	Environment
Aanbesteding	Tendering

Neighbourhood Sustainability Assessment as Decision Support Tool for Urban Planning

This short Questionnaire seeks to gather the priorities of the Gemeente Apeldoorn for evaluating Sustainability in future Urban development projects.

* Required

1. **Email address** *

Background - Purpose of the Project

The purpose of the project is the development of a Neighbourhood Sustainability Assessment (NSA) framework adapted to the city's context and suitable to be used by the Gemeente Apeldoorn in future Urban development projects. With this objective, the first one of two steps was the definition of nine evaluation areas. The areas will be covered in more detailed below.
Now, the second step consists of understanding the importance of those evaluation areas for the actors involved in urban projects definition. This, with the purpose of reflecting on the internal context and particular needs of Apeldoorn in relation to its Urban Infrastructure/Environment.

Instructions

Please watch the following short video to better understand how to answer this questionnaire.

Video: Step by step guide for filling in this questionnaire

http://youtube.com/watch?v=YSt85c_bqWo

Proposed Evaluation Areas

Integrated Project Management & Participative Governance (*Geïntegreerd projectmanagement en participatief bestuur*)	• Integrated Planning & Design • Consultation & Engagement • Sustainable Building Guidelines & Incentives
Reduction of Polluting agents (*Vermindering van vervuilende stoffen*)	• Construction & Demolition Waste Management • Noise, Light & Air pollutants reduction • Water and Soil quality conservation
Climate Adaptation & Resilience (*Klimaataanpassing en veerkracht*)	• Heat Island Effect Management & Outdoor thermal comfort • Sustainable stormwater and flood management • Flexibility & Adaptability to Future needs
Efficient Use of Natural resources & Energy (*Efficiënt gebruik van natuurlijke hulpbronnen en energie*)	• Land value conservation & efficient use • Water use patterns & Management • Renewable Energy Sources • Energy use patterns & Strategies • Circular use of Materials & Responsible sourcing
Conservation of Ecological value (*Behoud van ecologische waarde*)	• Natural Systems Assessment & Management • Biodiversity Conservation
Quality of Life & Provision of Facilities and Services (*Levenskwaliteit & levering van faciliteiten en diensten*)	• Diverse Housing Provision • Healthy, safe & Appealing Urban spaces • Mixed land use for Provision of facilities & services • Cultural & Historic Heritage
Inclusiveness & Social Equity (*Inclusiviteit en sociale rechtvaardigheid*)	• Housing & Transport Affordability • Accessibility & Connectivity • Walkability & Bikeability • Promotion of alternative modes of transport • Inclusive Design
Project Feasibility (*Project Haalbaarheid*)	• Financial Viability Assessment
Local economic Impacts (*Lokale economische gevolgen*)	• Impacts on local economy development • Promotion of Circular Economy Models

Criteria Importance

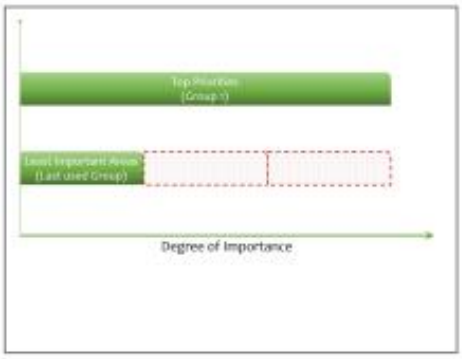
2. **Indicate the importance of each Evaluation area by matching it to an Importance Group** *

Remember: (i) Multiple evaluation areas can be assigned to the same Importance group. (ii) Leave empty importance groups if the perceived importance difference between areas is too big; (iii) You do not need to use all of the groups, only the ones you consider necessary; (iv) Do not place the same evaluation area in more than two groups.
Mark only one oval per row.

	Group 1 (Top Priorities)	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9
Geïntegreerd projectmanagement en participatief bestuur	◯	◯	◯	◯	◯	◯	◯	◯	◯
Vermindering van vervuilende stoffen	◯	◯	◯	◯	◯	◯	◯	◯	◯
Klimaataanpassing en veerkracht	◯	◯	◯	◯	◯	◯	◯	◯	◯
Efficiënt gebruik van natuurlijke hulpbronnen en energie	◯	◯	◯	◯	◯	◯	◯	◯	◯
Behoud van ecologische waarde	◯	◯	◯	◯	◯	◯	◯	◯	◯
Levenskwaliteit & levering van faciliteiten en diensten	◯	◯	◯	◯	◯	◯	◯	◯	◯
Inclusiviteit en sociale rechtvaardigheid	◯	◯	◯	◯	◯	◯	◯	◯	◯
Project Haalbaarheid	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lokale economische gevolgen	◯	◯	◯	◯	◯	◯	◯	◯	◯

3. **Indicate how much more important are the Top Priorities (Group 1) in relation to the Least important areas (Last chosen group)** *
Mark only one oval.

2



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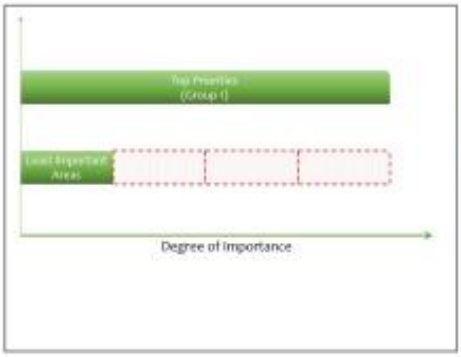

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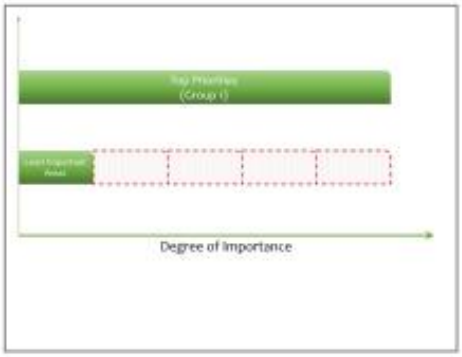

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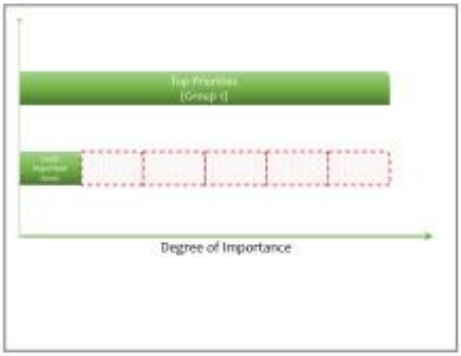


6

Other: _____

Send me a copy of my responses.

1. Introduction

This questionnaire is developed as an instrument for validating the results presented in the ***Institutional Assessment Report.*** These regard the identification and classification of barriers and enablers for sustainable urban planning within the Municipality. In addition, a shortlist of possible desired actions is included as part of the report.

The questionnaire intends to gather reviews from involved participants about the presented findings, as a method to reduce threats to internal reliability of the results (Brink, 1993). For doing this, the questionnaire will be divided in three parts: (a) Institutional Barriers, (b) Institutional Enablers and (c) Improvement Opportunities. Within each part, questions will be formulated to reflect on the contents of the results. The questions are formulated to know two main review topics: (i) The degree of recognition of the presented topics in the municipality's working context. This means, how much does the identified barrier/enabler is effectively perceived by the respondent. (ii) The degree of importance that the respondent gives to each identified topic. These statements determine the perceived influence that each mentioned topic actually has over the inclusion of sustainability in Urban planning processes.

2. Questions

2.1. Institutional Barriers

For each of the following statements about the identified institutional barriers, please indicate your level of agreement according to the presented scale:

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The identified **Explicit Corporate Values** are present within the Municipality as a working organization.					
The identified **Explicit Corporate Values** are important topics to be addressed in organizational change towards Sustainability.					
The identified **Infrastructure** aspects are present within the Municipality as a working organization.					
The identified **Infrastructure** aspects are important topics to be addressed in organizational change towards Sustainability.					
The identified **Issues** are present within the Municipality as a working organization.					
The identified **Issues** are important topics to be addressed in organizational change towards Sustainability.					
The identified **Managerial Prerogatives** are present within the Municipality as a working organization.					
The identified **Managerial Prerogatives** are important topics to be addressed in organizational change towards Sustainability.					

2.2. Institutional Enablers

For each of the following statements about the identified institutional enablers, please indicate your level of agreement according to the presented scale:

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The identified **Explicit Corporate Values** are present within the Municipality as a working organization.					
The identified **Explicit Corporate Values** are important topics to be addressed in organizational change towards Sustainability.					
The identified **Infrastructure** aspects are present within the Municipality as a working organization.					
The identified **Infrastructure** aspects are important topics to be addressed in organizational change towards Sustainability.					
The identified **Managerial Prerogatives** are present within the Municipality as a working organization.					
The identified **Managerial Prerogatives** are important topics to be addressed in organizational change towards Sustainability.					

2.3. Improvement Opportunities

For each of the following statements about the identified improvement opportunities, please indicate your level of agreement according to the presented scale:

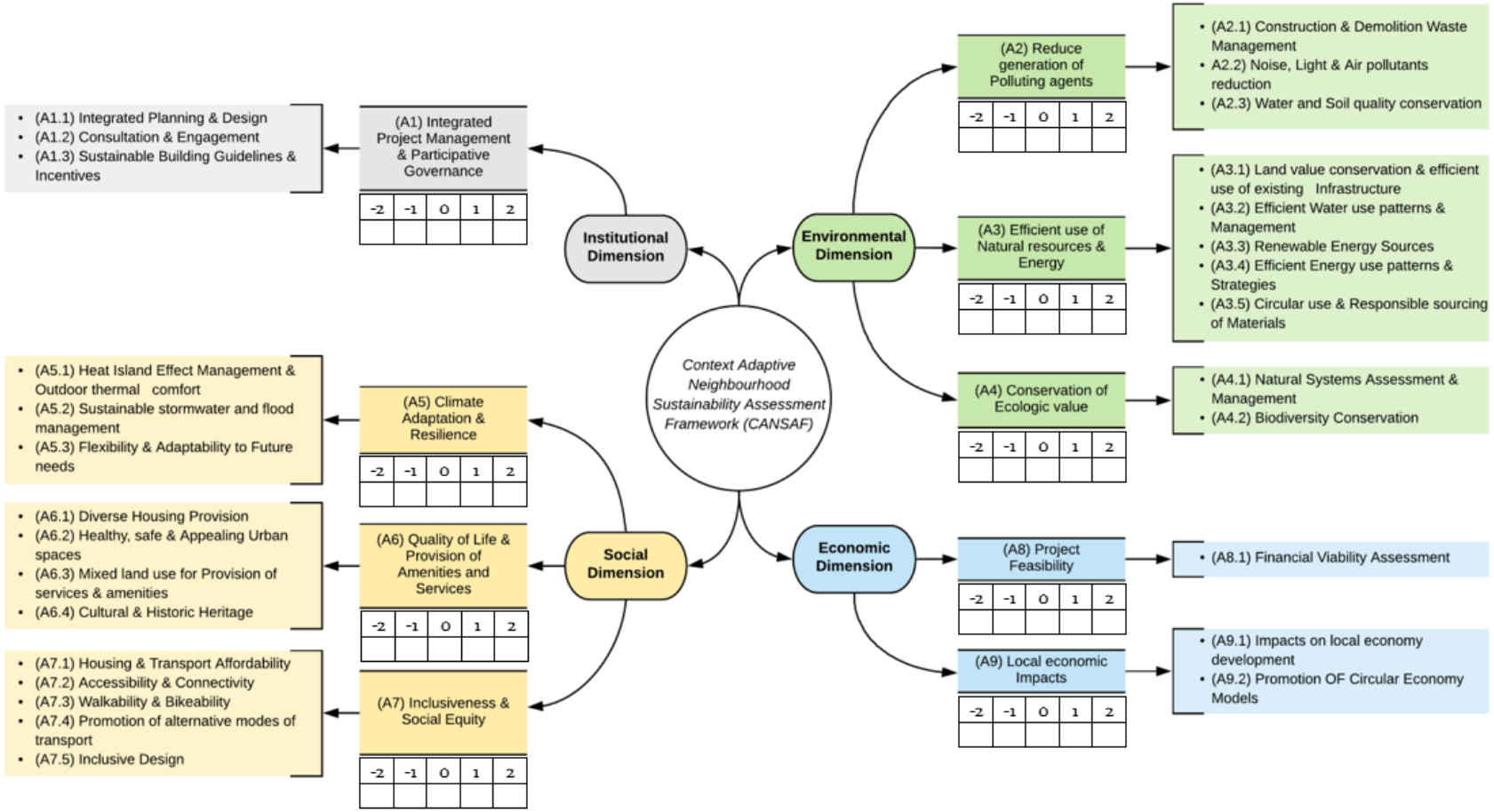
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The identified **Explicit Corporate Values** adequately represent a means of enhancing institutional capabilities of the Municipality.					
The identified **Explicit Corporate Values** are important topics to be addressed in organizational change towards Sustainability.					
The identified **Implicit Corporate Values** adequately represent a means of enhancing institutional capabilities of the Municipality.					
The identified **Implicit Corporate Values** are important topics to be addressed in organizational change towards Sustainability.					
The identified **Infrastructure** aspects adequately represent a means of enhancing institutional capabilities of the Municipality.					
The identified **Infrastructure** aspects are important topics to be addressed in organizational change towards Sustainability.					

2.4. Additional Comments

Additional important topics that you perceive happening in municipality's context which were left out of the presented barriers/enablers and improvement opportunities.

Relevance of Identified Areas to Reflect on Urban Sustainability Concerns

Please use the scale under each evaluation area, to indicate, in your opinion, how well each of the presented areas is able to reflect on Urban Sustainability Concerns in the context of Neighbourhood (re) development. The assessment should reflect on the themes that make part of each evaluation area. Please, find the legend for the scale at the end of the page.



Legend:

-2	-1	0	1	2
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

Concerns that should be added to the Conceptual Model

Please, indicate if there are evaluation areas that, in your opinion, should be included as part of the presented conceptual model and that were not included in it. In addition, comment on the themes that were included within each evaluation area, on their relevance and possible need to cover additional themes.

Additional Comments

Please include any additional comments regarding the evaluation areas or the topics covered by each one of them.

```
%% REVISED SIMOS METHOD - NEIGHBOURHOOD SUSTAINABILITY ASSESSMENT AS DECISION SUPPORT TOOL FOR
% URBAN PLANNING: Context Adaptive Neighbourhood Sustainability Assessment Framework (CANSAF)
% CEM MSc Thesis Project - Criteria Importance Weight Function
% Implemented by: Camilo A. Ramirez Rincon
% Reference & Source Code: (Papathanasiou & Ploskas, 2018)

%%  Function w = simos(g,z):
%   Inputs:
%   g = Cell array with the importance order of all evaluation areas, from
%       the least important to the top priorities (including white cards.
%   z = Parameter indicating how many times more important are the top
%       priorities in comparison with the least important criteria (I1=z*In)
%   Outputs:
%   w = Normalized weights of each evaluation area

function [w] = simos(g,z)

    %   n_cards =   # of white cards;
    %   pos     =   # of position ranks
    %   c       =   # of criteria in each rank
    n_cards = 0;
    pos = 0;
    c = [];
    % Get Size of cell array of importance groups
    sg = size(g);

    for i = 1:sg(1)
        aux = g{i};
        if aux ~= 'w'
            n_cards = n_cards + length(aux);
            pos = pos+1;
            c = horzcat(c,length(aux));
        end
    end

    % Calculate U
    U = (z-1)/pos;
    % Calculate vector e
    e = ones(1,pos);
    counter = 0;
    for i = 1:sg(1)
        aux = g{i};
        if aux ~= 'w'
            counter = counter + 1;
        else
            e(1,counter)= e(1,counter) + 1;
        end
    end

    % Calculate the non-normalized weights k
    k = ones(1,pos);
    totalk = k(1,1)*c(1,1);

    for i = 2:pos
        s = sum(e(1:i-1));
        k(1,i) = 1 + U*s;
        totalk = totalk + k(1,i)* c(1,i);
    end

    % Calculate the normalized weights w (for each ranking group)
    w = zeros(1,pos);
    for i = 1:pos
        w(1,i) = k(1,i) * (100/totalk);
    end
end
```

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-001	R&L	Aligned goals of climate adaptation working programs and board objectives.	Traceability of City Vision into specific Desired Results	Institutional Aspects	*our goals for climate adaptations have to fit in those strategic goals*
T-002	R&L	Aligned goals of Circularity working programs and board objectives.	Traceability of City Vision into specific Desired Results	Institutional Aspects	*But also, that's also true for circularity and sustainability*
T-003	R&L	Aligned goals of Sustainability working programs and board objectives.	Traceability of City Vision into specific Desired Results	Institutional Aspects	*But also, that's also true for circularity and sustainability*
T-004	R&L	Operationalization of Strategic goals into SMART goals	Operationalization of Goals into measurable Objectives	Institutional Aspects	*So that's how we translate from a higher level to the lower level, to make it also possible to work with it*
T-005	R&L	Circularity, Sustainability and Climate Adaptation Goals are defined independently from each other	Identification of interdependencies between Sustainability Dimensions	Institutional Aspects	*circularity, climate adaptation and sustainability are three goals, not one goal and every part has its own explanation and not working together yet*
T-006	R&L	Need to work on a combined agenda (Sustainability + Circularity + Climate Adaptation)	Coordination of objectives for integrative Urban Planning	Improvement Opportunities	*I want to combine these three to show everybody that if you want to really achieve something you need to work on these three together and not separated, they are linked together*
T-007	R&L	Functional units have separated budgets	Factors influencing Collaboration among functional Units	Institutional Aspects	*it is the separation of the budgets, where the money is coming from, that's a difficulty*
T-008	R&L	Prioritization of flood and drought resilience.	Climate Adaptation and Resilience	Municipality Concerns	*Climate adaptation is high goal now, because of the lack of water in the summer time, or too much water in one time*
T-009	R&L	Prioritization of managing the Heat Island Effect.	Climate Adaptation and Resilience	Municipality Concerns	*The Heat stress is a big one*
T-010	R&L	Reducing CO_2 levels	Reduction of Waste and Pollutants	Municipality Concerns	*CO_2 is a very big one. Is maybe even bigger than climate adaptation*
T-011	R&L	Definition of what Circularity entitles	Learning & Knowledge Sharing on Circularity	Municipality Concerns	*rising now is circularity, because nobody knows exactly what it is, you cannot grab it, you don't know what it is*
T-012	R&L	Authority from Team Leaders to undergo alternative tendering processes by implementing contractor's Circularity knowledge in the tendering criteria	Flexible use of alternative Project Definition Procedures	Institutional Aspects	*His knowledge, how determined he is to make this project as circular as possible within the limits and boundaries that we gave him*
T-013	R&L	Reduce Concrete & Demolition Waste (CDW)	Reduction of Waste and Pollutants	Municipality Concerns	*Concrete and Demolition waste (CDW) Is about we want to make more circular, so how do we do that?*
T-014	R&L	Knowledge sharing and collaboration for Circularity	Learning & Knowledge Sharing on Circularity	Municipality Concerns	*What can we learn from them, how can we work together to do that?*
T-015	R&L	Innovative projects are allowed to steer the City goals definition and updating process	Project-led improvement of long-term Goals	Institutional Aspects	*These projects make that the city council think about the goals and redirect the goals that they now have. These projects are front-runners*

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-016	R&L	Reducing Risk-adverse and conservative mentality can boost change pace and innovation.	Attitudes influencing change and innovation adoption	Improvement Opportunities	*why don't we turn on the nudge a little bit higher? We can achieve so much more than we now do. We are so scary about innovation, or contracting and everything has to be carefully weighted*
T-017	R&L	Need to avoid unresponsiveness to change demands	Attitudes influencing change and innovation adoption	Improvement Opportunities	*Doing nothing is also a risk. Cause everything stays the same*
T-018	R&L	Promotion of personal responsibility as a driver for change	Leadership	Improvement Opportunities	*you need to take the responsibility yourself*
T-019	B&O	Enhance Biodiversity in Apeldoorn	Conservation of Ecological Value	Municipality Concerns	*We want to be climate adaptive in Apeldoorn, I was part on building that strategy on my former role. It is now more diverse, including managing heat in cities and biodiversity*
T-020	B&O	Heat Island Effect Management	Climate Adaptation and Resilience	Municipality Concerns	*we want to enhance biodiversity in our town*
T-021	B&O	Water Management through soft structures	Climate Adaptation and Resilience	Municipality Concerns	*so, the strategy is to build more green areas in our city, that enhances both heat adaptation and biodiversity, and also helps with water management*
T-022	B&O	Enhancing high quality greenery for city promotion as good living place	Economic Prosperity & City Marketing	Municipality Concerns	*the city is well, quite green, so compared to other cities is not that big of a problem. But we want to enhance that aspect of our city, to promote our city as being a nice city to live in*
T-023	B&O	Supply of housing spaces at lower prices than in the Randstad area	Social Equity & Affordability	Municipality Concerns	*we want to be the next city, for nice living, outside the Randstad*
T-024	B&O	Climate Adaptation and Sustainability as marketing drivers	Economic Prosperity & City Marketing	Municipality Concerns	*So that's why we have those goals about climate adaptation and sustainability.*
T-025	B&O	Asset Management is done through monetary-based analysis	Narrow vision of Sustainability	Institutional Aspects	*put a value, literally a monetary value on those higher goals or values, in that way, in your decision-making*
T-026	B&O	Rain water infiltration in the ground	Climate Adaptation and Resilience	Municipality Concerns	*when we renew part of the public space, we try to go another way with rain water. Infiltrate that in the ground*
T-027	B&O	Built environment adaptation projects are coordinated with built environment maintenance activities	Factors influencing Collaboration among functional Units	Institutional Aspects	*And we renew our public space every 40 years, just from a technical perspective, then the asphalt has to be renewed, the stone pavement needs to be renewed, so that's the moment to include other goals*
T-028	B&O	Valuation of positive/negative effects of the built environment over social variables is unclear	Issues for assessing effects of Built Environment on Sustainability dimensions	Institutional Aspects	*It's harder to put a value on*
T-029	B&O	Citizenship involvement is implemented through participation within the municipality	Suitability of Project Management approaches for Delivering Project Quality	Institutional Aspects	*the way how you manage projects, make it people part of the solution, giving information, or what are we going to do, ask if they have problems, they want to see solved*
T-030	B&O	Effects of the built environment on people's health, mood and disposition to interact are unclear	Issues for assessing effects of Built Environment on Sustainability dimensions	Institutional Aspects	*choose how to make people more healthy or more happy, but it's hard to know how far will you go in your public space to do that*

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-031	B&O	The role of Heat stress in generating indirect economic effects is unclear	Issues for assessing effects of Built Environment on Sustainability dimensions	Institutional Aspects	*what does it mean if the city is too hot at night and you don't get enough sleep and your productivity is low the other day*
T-032	B&O	Need to Integrate built environment projects with long-term initiatives/programs	Multidisciplinary Collaboration	Improvement Opportunities	*But with those programs you have to create a long-time involvement, I think, to really help people to be less lonely, or participate In their neighbourhood*
T-033	B&O	Low integration between functional divisions due to a Segmented Organizational structure	Factors influencing Collaboration among functional Units	Institutional Aspects	*As I said before, we have a segmented organization, so the managing of public assets is one part of the organization. There is a whole other part of the organization that manages the social aspects of our people*
T-034	B&O	Functional units have separated budgets	Factors influencing Collaboration among functional Units	Institutional Aspects	*We try to work together but, there is no money flowing from the social program into asphalt or concrete, and otherwise also not*
T-035	B&O	Environmental concerns in Asset Management are done through CO_2 valuation	Narrow vision of Sustainability	Institutional Aspects	*Sustainability I have, for example, but I have an indicator, which it is CO_2, but that is a very small perspective for sustainability*
T-036	B&O	Social concerns are not reflected in criteria used within Asset Management	Narrow vision of Sustainability	Institutional Aspects	*But in social indicators, not loneliness, not inclusiveness, yes, what else do we have? Or the way in which people are involved in their neighbourhood*
T-037	R&L	Ecological footprint reduction through reduction in CO_2 emissions	Reduction of Waste and Pollutants	Municipality Concerns	*to reduce carbon dioxide emissions by 25% in 2022*
T-038	R&L	Ecological footprint reduction through the reduction in the use of raw materials by 25% in 2022	Efficient use of Natural Resources	Municipality Concerns	*to reduce the use of virgin materials, virgin natural resources also by 25% in 2022*
T-039	R&L	Reduction in water consumption for companies/citizens/agriculture and the municipality itself	Efficient use of Natural Resources	Municipality Concerns	*reducing water and working with water is another program that I work on, but is all related*
T-040	R&L	Implementation of the Circular Estaffete Program	Learning & Knowledge Sharing on Circularity	Municipality Concerns	*to facilitate they can learn from each other and share knowledge*
T-041	R&L	Development of Business models for circularity	Promotion of Circular Economy Models	Municipality Concerns	*for this project that I mentioned last, they are trying to develop a business model on how it can work*
T-042	B&O	Durability of used materials reduce maintenance costs	Promotion of Circular Economy Models	Municipality Concerns	*For me it's more about the lifespan of the material. The longer it lasts, the better*
T-043	B&O	Inclusion of Safety concerns for the users	Provision of Safe Urban Spaces	Municipality Concerns	*because it concerns the safety of our users*
T-044	B&O	Old asphalt reuse in new bottom/between layers	Reduction of Waste and Pollutants	Municipality Concerns	*Asphalt is about the old-made asphalt roads. We do this primarily in the bottom layers or between layers*
T-045	B&O	CDW reuse for foundations of concrete cycling paths	Reduction of Waste and Pollutants	Municipality Concerns	*This is a cycling path; this asphalt is laid on a foundation of old broken buildings*

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-046	B&O	Integral plan development is hindered by budget separation	Factors influencing Collaboration among functional Units	Institutional Aspects	*For those projects, they have different interests and budgets, but we try to do an integral plan*
T-047	B&O	No standardised collaboration practices are implemented among functional units	Factors influencing Collaboration among functional Units	Institutional Aspects	*For those projects, they have different interests and budgets, but we try to do an integral plan*
T-048	B&O	Coping with CDW	Reduction of Waste and Pollutants	Municipality Concerns	*How do you cope with waste*
T-049	B&O	Social Inclusion considerations in the built environment	Inclusiveness	Municipality Concerns	*What can you do with inclusion*
T-050	B&O	Increase the share of renewable energy sources	Renewable Energy sourcing	Municipality Concerns	*The use of sustainable energy*
T-051	B&O	Operationalization of Sustainability through functional division	Identification of interdependencies between Sustainability Dimensions	Institutional Aspects	*that's also a very broad subject and it's made smaller into divisions*
T-052	B&O	Economic value of organic wastes (leaves)	Promotion of Circular Economy Models	Municipality Concerns	*we can compost them, and that compost gets used in all of the city*
T-053	B&O	Use of electric machinery within B&O	Internal working directives fostering Sustainability	Institutional Aspects	*we are switching now to electric power. We always used diesel power and now, with our tools, with our vehicles, with our buildings we go to electric power*
T-054	B&O	Enhance social interaction and public activities with public space interventions	Social Equity & Provision of Facilities/Services	Municipality Concerns	*you have to make places in the public space where people can meet, where people can sport, where people can play. It means we give extra care to those places who are already a bit left behind*
T-055	B&O	Management and Maintenance plans across the functional unit are aligned with the City Goals	Traceability of City Vision into specific Desired Results	Institutional Aspects	*but we always want that the plan here can relate to the plan here, can relate to the plan here, and also can relate to the goals of the city*
T-056	B&O	Pilot projects are used as bottom-up Knowledge sources	Organizational learning Strategies	Institutional Aspects	*we see those pilots or new ways of working and we pick them up and we say, this works, let's spread it out through the whole unit, lets make them bigger by communicating about them*
T-057	B&O	Alternative project definition processes are allowed for pursuing Circularity objectives	Flexible use of alternative Project Definition Procedures	Institutional Aspects	*with circularity, is that we said: Ok, it's not going fast enough, let's make a separate study in which we pinpoint the top-ten most potentially successful projects*
T-058	B&O	Combination of Functional vs. Geographical unit divisions can provide extended benefits from knowledge sharing	Factors influencing Collaboration among functional Units	Institutional Aspects	*And mostly the more specialised people don't know the surrounding area that well and on the other side here is more much knowledge about that specialised function. So, in an ideal world that's great, and sometimes, maybe in 10% pf the cases, you get conflict*
T-059	B&O	Need to develop Pride and sense of contribution as motivators for promoting change	Attitudes influencing change and innovation adoption	Improvement Opportunities	*I'm not only doing this work, no, I'm part of something bigger, and making the city better, we also think that pride is important because it can be stimulant for people to do their job.*

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-060	B&O	Get a proper understanding of the future needs within the public space	Adaptability to future needs	Municipality Concerns	*we are not just maintaining the public space, we are really adding something. We are much more looking towards the future, what it's necessary*
T-061	PVG	Sustainability, Circularity and Climate Adaptation objectives are not consistently included as criteria in Project Orders (*Opdracht*)	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*sustainability, climate adaptation or circularity, everything is the same, is not named in the project order*
T-062	PVG	Circularity and Sustainability are excluded from project performance measures on given projects	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*Also, circularity. Is not in every project that we use it, because some things we do it by ourselves*
T-063	PVG	High Level goals are not easily quantifiable through Project Objectives	Operationalization of Goals into measurable Objectives	Institutional Aspects	*Therefore, the strategic goals for the city council are too far away from us*
T-064	PVG	Non-standardised inclusion of sustainability criteria in project orders	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*sustainability, climate adaptation or circularity, everything is the same, is not named in the project order*
T-065	PVG	Personal priorities are allowed to exclude Sustainability criteria from given project orders	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*like sustainability, is more like to infiltrate the rainwater and that kind of stuff, that we do by ourselves*
T-066	PVG	Advisory role of Engineer's Bureau in project team enables the inclusion of Sustainability concerns	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*In the first stage of the project we are more like advisors, then we can also bring it in*
T-067	PVG	Late inclusion of Sustainability Concerns in the Project Process	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*I think it's more when I get the project, I think more about it. […]*
T-068	PVG	Multidisciplinary Project Team is assembled with members from R&L, PVG, Stedenbouw, Bestemmingsplan and Engineer's Bureau	Suitability of Project Management approaches for Delivering Project Quality	Institutional Aspects	*So, making the plans is RL, but a client is PVG, is a project manager of PVG, and he has me for IB, but also, he has here Stedenbouw Bestemingplan and also IB and I am a part of it, here*
T-069	PVG	Trade-offs and negotiation between disciplines is done during project definition	Suitability of Project Management approaches for Delivering Project Quality	Institutional Aspects	*When they give more space to the building companies, we earn more money, so our incomes are increasing, but also there's less green, less public space, so together we make a decision, and there in that initial phase, we search together which combination is the best for the city, but also in time, in planning*
T-070	PVG	Authority from Team Leaders to undergo alternative tendering processes by implementing contractor's Circularity knowledge in the tendering criteria	Flexible use of alternative Project Definition Procedures	Institutional Aspects	*this project was unique because we didn't have a price, we didn't want a price, we wanted the best contractor who matched our ideals of what with thought of circularity*

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-071	PVG	Knowledge acquired from contractor to be used as learning potential for the municipality	Learning & Knowledge Sharing on Circularity	Municipality Concerns	*Yes, and we wanted a contractor that … with us. We want to learn. As organization we want to learn from it.*
T-072	PVG	Traditional Tendering criteria (Time & Cost) are used as regular commissioning procedure	Suitability of Project Management approaches for Delivering Project Quality	Institutional Aspects	*Yes, lowest price or combination of planning and price*
T-073	PVG	Social benefits from projects unaccounted in project performance assessment	Narrow vision of Sustainability	Institutional Aspects	*the social cohesion in the neighbourhood, yes how do you measure it?*
T-074	PVG	Need to achieve financial coordination to allow Circularity, Sustainability & Climate adaptation to be included in project definition	Need for Financial Integration	Improvement Opportunities	*But it cannot remain only as a strategy, or a plan, but they need to arrange everything (including financial aspects), to achieve change and actually realize the plans*
T-075	R&L	Need to adapt the public space to future climate problems	Climate Adaptation and Resilience	Municipality Concerns	*the biggest part in public space is to adapt space to future climate problems, because climate is changing*
T-076	R&L	Importance of flood and drought resilience.	Climate Adaptation and Resilience	Municipality Concerns	*Risks for flooding, more rain etc. Also, for more dry periods and urban heating*
T-077	R&L	Importance of managing the Heat Island Effect.	Climate Adaptation and Resilience	Municipality Concerns	*Risks for flooding, more rain etc. Also, for more dry periods and urban heating*
T-078	R&L	Longer life-span of clay materials as replacement for concrete products	Responsible Material Sourcing	Municipality Concerns	*We know that good clay and bricks they can be more than 100 years old because they stay better*
T-079	R&L	Local production of clay products for replacing concrete ones	Responsible Sourcing of Materials	Municipality Concerns	*So, we are thinking about changing the pavement in more circular material. For example, in Holland we need a lot of clay baked pavement. Do you know what it is? Because it's more local material, we bake it in Holland. We have industries that bake bricks*
T-080	R&L	Production process concerns for clay products as replacement of concrete	Responsible Sourcing of Materials	Municipality Concerns	*In sustainability terms you think in the whole range of steps to make bricks it takes a lot of carbon dioxide because they are baked, they use fuels for baking the clay*
T-081	R&L	Need to Increase awareness on personal ways of contributing to promote change and innovation	Attitudes influencing change and innovation adoption	Improvement Opportunities	*I think it's very important. Many people are not aware of that they have possibilities to contribute to more sustainability*
T-082	R&L	Need for guidelines and principles on Sustainability & Circularity	Guidelines and Principles for Sustainability	Improvement Opportunities	*So, the first thing is to make aware, to make examples, help them with examples, try and make errors, to develop a way of thinking by trial and error. But you can help them with principles to make …*
T-083	R&L	Life-cycle considerations in material selection	Circular Use of Materials	Municipality Concerns	*So, the chain thinking, not only chain in steps, but also the chain in time. Do you understand? … Yes, The Life cycle, you know the right words. But there is another thing that we help to develop circular principles*

Id.	*Unit*	*Basic Theme*	*Organizing Theme*	*Global Theme*	*Evidence*
T-084	R&L	Circularity criteria can be included in early stages of given Projects Processes	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*a design that involves circular thinking, so we try to introduce circular thinking in the redesigning of this area*
T-085	R&L	Change of heating systems for innovative ideas (Heat from surface water?)	Renewable Energy sourcing	Municipality Concerns	*The way we want to connect these two is that we think that we can use surface water for heating. The energy in surface water, the surface water is in average 10 degrees or something, so you can take some heat out of the water*
T-086	R&L	Built environment adaptation projects are coordinated with built environment maintenance activities	Factors influencing Collaboration among functional Units	Institutional Aspects	*we not only do this heating system, but we also change public space, because we are already thinking about renewing the public space, redesigning.*
T-087	R&L	Managing and dealing with people's expectations and reluctancy to change	Participative Governance & Engagement	Municipality Concerns	*Yes, that's quite complex, because it's not only an engineering thing but it is also social, mental social thing*
T-088	R&L	No standardised circularity inclusion criteria are defined for project definition processes	Degree of Consistency in inclusion of Sustainability Objectives in Project Scope.	Institutional Aspects	*There is not a system to ensure that they make a circular redesigning of it, we only hope that they are trying to include circular thinking in the design. But there is not a system that makes it sure*
T-089	R&L	Pilot projects (like City Loops) are used as trial and error tests for Knowledge generation	Organizational learning Strategies	Institutional Aspects	*But this City loops project will help us to make it more a part of engineering and including a normal part of engineering. So, it's trial and error.*
T-090	R&L	Lack of Systematically Integrated Collaboration Processes	Factors influencing Collaboration among functional Units	Institutional Aspects	*there is interaction, but it is not systematically integrated. It is more about people who understand each other, because they know what you want to reach*
T-091	R&L	Parks and areas specific for given age groups	Provision of Facilities & Services	Municipality Concerns	*You can try to make places specific for these group of youngsters, where they can do their things, then you are also social*
T-092	R&L	Urban redevelopment should consider the provision of different services for the community	Provision of Facilities & Services	Municipality Concerns	*So, when you are redesigning an area you also need to think about services, you have to think about which pays, about social systems, about economical services, health services and the services are economical of importance*

Year	*Citation*	*Title*	*Type of research*	*Indicator Frameworks Used*	*Chosen?*	*Main Reason for Exclusion*
2008	(Hunt, Lombardi, Rogers, & Jefferson, 2008)	Application of sustainability indicators in decision-making processes of urban regeneration projects	Case Study	BREEAM	No	Building Scope Framework
				ISIS Charter	No	Insufficient documented information
				Eco-Homes	No	Building Scope (Mainly housing)
2010	(Fernández-Sánchez & Rodríguez-López, 2010)	A methodology to identify sustainability indicators in construction project management - Application to infrastructure projects in Spain	Literature Review	ISO-21929-1	No	Building Scope Standard
2010	(Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010)	Measuring the Sustainability of Cities: An analysis of the use of local indicators	Meta-Analysis	17 Studies for multiple Cities & Regions	No	City Scope - Unstructured sets of indicators
2011	(Shen, Ochoa, Shah, & Zhang, 2011)	The Application of Urban Sustainability Indicators	Case Study	IUSIL	No	City Scope - Not Built environment specific indicators
2012	(Hayes, Metje, Chapman, & Rogers, 2012)	Sustainability assessment of UK street works	Literature Review	CEEQUAL	Yes	
				SPeAR	No	Inaccessible documentation
2015	(Komeily & Srinivasan, 2015)	A need for balanced approach to neighbourhood sustainability assessments - A critical review and analysis	Literature Review	LEED-ND v4.0	Yes	* Included but updated to LEED C+C v4.1
				BREEAM Communities	Yes	
				DGNB-NSQ	Yes	
				CASBEE-UD	No	Inaccessible documentation
				Pearl Community for Estidama	Yes	
2017	(Ali-Toudert & Ji, 2017)	Modelling and Measuring Urban Sustainability multi-criteria-based systems: A challenging issue	Literature Review	CASBEE UD	No	Inaccessible documentation
				LEED ND	Yes	* Included but updated to LEED C+C v4.1
				BREEAM Communities	Yes	
				DGNB-NSQ	Yes	
				Green Star Communities	No	Inaccessible documentation

2018	(European Commission , 2018)	In-depth Report - Indicators for Sustainable Cities	Literature Review	European Green City Index	No	Only Environmental Sustainability
				European Green City Tool	No	Insufficient documented information
				European green Leaf Award (Green Capital)	No	Not Available
				EEA Urban Metabolism Framework	No	Not Available
				Reference Framework for Sustainable Cities	No	Not Available
				STAR Communities Rating System	Yes	
				Urban Sustainability indicators (Eurofound)	No	Outdated
				DGNB Certification system	No	Building Scope
				Eco2 Cities Initiative (World Bank)	No	City Scope - Not Built environment specific indicators
				Green cities Programme (OECD)	No	City Scope - Not Built environment specific indicators
				National Australian Built Environment Rating System (NABERS)	No	Building Scope
				SDEWES Index	No	City Scope - Not Built environment specific indicators
2019	(Kaur & Garg, 2019)	Urban Sustainability Assessment Tools - A Review	Literature Review	CASBEE-UD	No	Inaccessible documentation
				BREEAM Communities	Yes	
				GBI Township	Yes	
				LEED-ND	Yes	* Included but updated to LEED C+C v4.1
				IGBC Green Township	Yes	

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Neighbourhood Sustainability Assessment as Decision Support Tool for Urban Planning

Appendix 04 – Proposed Indicators for Apeldoorn as Case Study

Institutional Dimension

(A1) Integrated Project Management & Participative Governance

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A1.1) Integrated Planning & Design	(A1.1.1) Demographic Assessment [1]	Description of the population demographics. This includes: age cohorts (i.e. under 18 years, from 18 to 64 and 65 and over). Sociocultural groups (i.e. migrants, religious groups, ethnic composition, linguistically isolated). In addition, document the history of development of the area and current land-use patterns	Dichotomic variable: **Yes** - For the existence of the Demographic Assessment complying with the minimal conditions. **No** - Otherwise	Existing demographic studies can give compliance of this criterion if they are still up to date (Less than 3 years old) and have a suitable scope.	Actions
	(A1.1.2) Integral Planning Team	Multidisciplinary assemble of professionals aimed to enable sustainable neighbourhoods through early cooperation between project-relevant technical disciplines. This team must be composed of: (1) a Coordinator and at least other three experts in Urban Planning, Architecture, Open space and landscape, Energy, Economic Development, Traffic. Additional involvement of professionals depends on specific objectives/requirements of the development. The additional disciplines include Wildlife conservation, Geology, Water management, Urban Climate, Legal advice, Real state, Sociology, etc.)	Trichotomy variable: **2** - For the assemble of multidisciplinary team with the required experts plus the additional disciplines; **1** - For the assemble of multidisciplinary team with only minimum required areas of expertise. **0** - Otherwise	One same professional can perform in more than one role or area of expertise.	Outcomes
	(A1.1.3) Integral Objective Definition	Definition of specific ecological, economic and sociocultural project goals during het planning phase of the project. These goals need to be reflected in binding contracts and quality standards stablished for the project execution (design and construction).	Dichotomic variable: **Yes** - For the definition of integral objectives across ecological, economic and sociocultural dimensions. **No** - Otherwise		Actions
	(A1.1.4) Construction Management Plan	Management plan aimed at the reduction of local environmental impacts associated with the construction practices. This plan covers a Considerate Behaviour Scheme, for dealing with the relations with neighbours, complaints management and on-site health and safety. In addition, local impacts over noise, light and air quality derived from construction practices are identified and procedures planned for their reduction/mitigation.	Dichotomic variable: **Yes** - For a Construction Management Plan complying with the minimal requirements. **No** - Otherwise		Actions
(A1.2) Consultation & Engagement	(A1.2.1) Public Consultation Plan	Assessment of appropriate stakeholders and definition of consultation mechanisms to allow participation during the planning phase of the project. The results from ***A1.1.1*** guide de planning of the consultation mechanisms. As a minimum, the consultation plan should cover the impacts of the development during construction and following completion, as well as, consultation on design quality and maintenance aspects.	Dichotomic variable: **Yes** - For a Consultation Plan complying with the minimum requirements. **No** - Otherwise		Actions

	(A1.2.2) Community Engagement Plan	Definition of mechanisms for continued community participation through all relevant project phases. Additionally, identification of opportunities for Community facility management. This can be achieved through cooperation between external public or private actors and members of the community interested in developing the management structures and programs.	Dichotomic variable: **Yes** - For a Community Engagement Plan complying with the minimum requirements. **No** - Otherwise		Actions
(A1.3) Sustainable Building Guidelines & Incentives	(A1.3.1) Sustainable Building Guidelines	Development of Sustainable Building guidelines for new or existing private buildings, aligned with ISO 21929-1 or equivalent standard. This will provide the means for communicating the requirements for design, construction and operation for private developments/projects.	Dichotomic variable: **Yes** - For a set of guidelines complying with the minimum requirements. **No** - Otherwise		Actions
	(A1.3.2) Sustainability Incentives	Definition of incentives schemes for encouraging private parties to engage in sustainable building practices. The schemes can be implemented as a selection or combination of incentives like, but not limited to: (i) expedited permitting processes, (ii) height and density bonus increase, (iii) tax credits, and/or (iv) permitting fee reductions.	Dichotomic variable: **Yes** - If the Incentive Scheme is planned and set in place. **No** - Otherwise		Actions

Environmental Dimension

(A2) Reduce generation of Polluting agents

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A2.1) Construction & Demolition Waste Management	(A2.1.1) Pre-demolition & Renovation Waste Audit	Advanced inspection of demolition projects for materials inventory. Assessment of quality, health and safety issues should be covered in compliance with Dutch certification scheme: BRL SVMS-007	Dichotomic variable: **Yes** - if the Waste Audit is complying with the minimal conditions. **No** - Otherwise		Actions
	(A2.1.2) Site Waste Management Plan	Documentation on planning and monitoring of waste identification, separation and collection. Additionally, plan over the Waste Hierarchy. Must be in coordination with ***A1.1.4*** and aligned to the European Construction and Demolition Waste Management Protocol.	Dichotomic variable: **Yes** - For a Site waste management plan complying with the minimum requirements. **No** - Otherwise		Actions
	(A2.1.3) Inert Waste Diversion Performance	Extent to which inert waste from construction and demolition tasks can be diverted from landfills as final disposing location. Based on European Waste Framework Directive 2008/98/EC.	Percentage of total inert waste diverted from landfilling as final disposal destination [%]	Calculation: by Volume [m3] or by Weight [T]. Consistent along the process.	Outcomes
	(A2.1.4) Hazardous Waste Management	Assessment for identification of hazardous materials. The results used for developing a suitable on-site management plan (segregation and storage) to avoid the contamination of otherwise inert materials. Furthermore, disposal on adequate hazardous management facility.	Dichotomic variable: **Yes** - If the Hazardous Waste Management plan is complying with the minimum conditions. **No** - Otherwise		Actions

(A2.2) Noise, Light & Air pollutants reduction	(A2.2.1) Identification of Light sensitive areas	Assessment of the neighbouring areas that might suffer negative impacts from light trespass and visual blight. This includes roads, residential and institutional buildings and areas of natural value (affected fauna).	Dichotomic variable: **Yes** - For the existence of the Demographic Assessment complying with the minimum conditions. **No** - Otherwise		Actions
	(A2.2.2) Light Pollution Assessment	Assess the potential adverse effects from light fixtures within the development. Namely, light trespass over neighbouring sensitive areas, visual blight from light reflections (signs) and pollution to the night sky.	Luminance [cd/m2]; Sky quality meter.		Outcomes
	(A2.2.3) Light Pollution Reduction	Define and implement a lighting design guide to set thresholds for public space lighting levels and physical design measures aimed to reduce adverse effects in sensitive areas. Align with local regulations (i.e. NPR 13201:2018	Dichotomic variable: **Yes** - For the existence of the Light Design guide, complying with minimum requirements. **No** - Otherwise		Actions
	(A2.2.4) Identification of Noise sensitive areas	Assessment of neighbouring areas that qualify as noise sensitive. This includes institutional buildings (i.e. hospitals, schools, government offices, etc.), recreational areas, residential zones and areas of natural value (affected fauna).	Dichotomic variable: **Yes** - For the existence of the Noise Sensitive Areas Identification Report. **No** - Otherwise		Actions
	(A2.2.5) Noise Pollution Assessment	Measure sound levels in identified sensitive areas (public and private) coming from different sources within the development: traffic, rail, industrial activities, etc.)	Equivalent Continuous Sound Level [dB(A)]		Outcomes
	(A2.2.6) Noise Pollution Measurement and Reduction	Define a Noise Reduction plan to control nuisance from noise sources over public and private exposure zones. Include noise reduction, zoning and/or noise isolation measures to comply with noise thresholds. Align with local regulations (i.e. Environmental Management Act - AVT04/VR71809)	Dichotomic variable: **Yes** - For the existence of the Noise Reduction Plan complying with the minimum requirements. **No** - Otherwise		Actions
	(A2.2.7) Local Air Quality Assessment	Assessment of the potential emissions of air pottants as a result of O&M activities. This include, but are not limited to, transport-related emissions, commercial activities and industrial/agricultural processes contemplated within the development.	Particulate matter (PM10, PM2.5); Ozone (O_3); Nitrogen dioxide (NO_2); Sulphur Dioxide (SO_2); Carbon Monoxide (CO); Benzene (C_6H_6); volatile organic compounds (VOC); Arsenic (As); Cadmium (Cd); Lead (Pb); Nickel (Ni); Carbon dioxide (CO_2) [µg/m3] Benzo[a]pyrene (BaP) [ng/m3]	Annual average; daily average; Max 1h value. The most harmful air pollutants in terms of damage to ecosystems are ozone (O_3), ammonia (NH_3) and nitrogen oxides (NOx).	Outcomes
	(A2.2.8) Air Quality Performance Plan	Define an air quality assurance plan, to define measures aimed to reduce the production of air degrading substances. Set thresholds for different air pollutants and reduce the exposure to nocive	Dichotomic variable: **Yes** - For the existence of the Noise Reduction Plan complying with the		Actions

		substances resulting from potential sources. Align with local regulations (i.e. EU Ambient Air Quality Directive 2008)	minimum requirements. **No** - Otherwise		
	(A2.2.9) Embodied Global Warming Potential [2]	Evaluation of the generation of Green House Gases (GHG) embodied in the materials for the construction process. The evaluation method must comply with a Life Cycle Assessment (LCA), covering as a minimum, the Extraction and Transportation of raw materials as well as the Manufacturing into finished products and Transportation of final products into the construction site.	Total Carbon equivalent Intensity [kgC02-eq/m2]	Intensity is calculated over Gross floor area (GFA) of the development. Assuring comparability across projects of different sizes.	Outcomes
(A2.3) Water and Soil quality conservation	(A2.3.1) Soil & Ground Water Pollution Assessment	Assess soil status baselines and projected Soil and ground water Pollution Levels resulting from the operation of the development. This is particularly important for developments which include industrial and/or agricultural processes.	Heavy Metals: Arsenic [As], cadmium [Cd], Cooper [Cu], mercury [Hg], lead [Pb] and Zinc [Zn]; Acidification: [pH]; Eutrophication: Sulphates and Nitrates concentrations;	(JRC Science Hub, 2016)	Outcomes
	(A2.3.2) Land Pollution Control Requirements	Provide a prevention and/or remediation measures plan for on-site soil management and repurposing. Including appraisal, design and implementation procedures. Align with local regulatory frameworks and internationally accepted standards.	Dichotomic variable: **Yes** - For the existence of the Land Pollution Control Plan complying with minimum requirements. **No** - Otherwise		Actions
	(A2.3.3) Fresh Water Pollution Assessment	Assess fresh and ground water pollution baseline and potential from the implementation of the project.	Water Framework Directive (WFD) - Water Quality Classes [I-V]; Nitrates concentration.	(I) Very good/reference; (II) Good; (III) Moderate; (IV) Unsatisfactory; (V) Poor	Outcomes
	(A2.3.4) Fresh water Pollution Control Requirements	Upon need, design an update plan for the design, to prevent adverse effects on water quality. This includes the avoidance of pollutants in stormwater run-off, and drink water systems. Implement remediation measures and align with local regulatory frameworks or international standards (i.e. Water Framework Directive - WFD).	Dichotomic variable: **Yes** - For the existence of the Water Pollution Control Plan complying with minimum requirements. **No** - Otherwise		Actions
	(A2.3.5) Embodied Acidification Potential [2]	Evaluation of the acidification potential (AP) embodied in material selection for the development. These are resulting from production processes with the capacity to increase water/soil pH. Substances with high AP are Nitrogen Oxides (NOx), Ammonia (NH_3), Hydrogen Fluoride (HF) and Sulfuric Acid (H_2SO_4) among others. The evaluation method must comply with a Life Cycle Assessment (LCA), covering as a minimum, the Extraction and Transportation of raw materials as well as the Manufacturing into finished	Total Sulphur Dioxide Equivalent Intensity [$kgSO_2$-eq/m2]	SO_2 is the standard substance for assessing AP. Equivalence is based on individual indexes for each contributing substance. Intensity is normalized through GFA for comparability purposes (Kim & Chae, 2016).	Outcomes

		products and Transportation of final products into the construction site.			
	(A2.3.5) Embodied Eutrophication Potential [2]	Evaluation of the Eutrophication Potential (EP) embodied in the manufacturing process of the materials for the construction process, which have the capacity to generate abnormally high levels of nutrients (nitrates and sulphates) in water bodies (eutrophic processes). Substances with high EP are Phosphate (PO_4^{3-}), Nitrogen Oxides (NOx) and Ammonia (NH_3) among others. The evaluation method must comply with a Life Cycle Assessment (LCA), covering as a minimum, the Extraction and Transportation of raw materials as well as the Manufacturing into finished products and Transportation of final products into the construction site.	Total Sulphur Dioxide Equivalent Intensity [$kgSO_2$-eq/m2]	PO_4^{3-} is the standard substance for assessing EP. Equivalence is based on individual indexes for each contributing substance. Intensity is normalized through GFA for comparability purposes (Kim & Chae, 2016).	Outcomes

(A3) Efficient use of Natural resources & Energy

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A3.1) Land value conservation & efficient use of existing Infrastructure	(A3.1.1) Land value conservation Assessment	Degree of usage of previously developed land. Namely as Brownfield or Greyfield Areas. This favour the conservation of Greenfield (high natural value), avoiding its use for building projects. In addition, the reduction of urban sprawl and suburbanization patterns.	Brownfield + Greyfield ratio over total development area. [%]	Aligned with land use section	Outcomes
	(A3.1.2) Urban infill Redevelopment Assessment	Measure of the use of land located in areas already targeted for urban expansion. These areas enjoy existing infrastructure (services and utilities) and neighbour existing urban usage land.	Area boundary connectivity: Percentage of the boundary of the development that is adjacent to existing urban use land [%]	The connectivity criteria: Boundary of the development that is not neighbouring natural, forestry or agricultural areas. [Connected Contour/Total boundary contour]	Outcomes
	(A3.1.3) Existing Infrastructure Reuse Plan	An assessment of the existing buildings and other infrastructure assets is done, to determine the possibilities to reuse existing structures within the redevelopment plan. The criteria for the assessment include, conservation of local identity, location and condition of existing structures, potential repurposing of existing buildings and infrastructure). This is done in coordination with ***A2.1.1*** for potential material reuse/recycling.	Dichotomic variable: **Yes** - For the existence of the Reuse assessment report and plan, complying with minimum requirements. **No** - Otherwise	Aligned with conservation of local identity	Actions
(A3.2) Efficient Water use	(A3.2.1) Embodied Water Usage	Water Footprint Assessment of the materials required for the construction processes of the development. Water footprint represents the embodied water consumption upstream the supply chain of the required materials for the project	Blue Water Footprint [m3 H2O]; Green Water Footprint [m3 H2O]	(Hoekstra, Chapagain, Aldaya, & Mekonnen, 2011)	Outcomes

patterns & Management	(A3.2.2) Operation and Maintenance Water Usage	Measure of the expected water consumption of the development from potable water sources. This includes all occupancy-related activities and maintenance (cleaning) activities.	Water consumption intensity [m3/m2]	Projected drinking water volume use/Total floor area	Outcomes
	(A3.2.3) Water Harvesting Design Considerations	Measure of the influence of water harvesting considerations in the design of the development. Covers the use of hard surfaces within the development for collecting rain water for reuse.	Percentage of hard surfaces that allow water harvesting [%]	Ratio of hard surfaces enabled for rain collection from the total hard surfaces within the development	Outcomes
	(A3.2.4) Water Strategy	Definition of a water strategy aimed to reduce water consumption of the development. This strategy needs to be integrated into the design phase by revising efficiency of water fixtures, appliances and landscaping. The Strategy must cover the analysis of present and future water supply/demand for the development and set consumption targets (withdrawal) for avoiding pressure over hydric sources.	Dichotomic variable: **Yes** - For the existence of the Water Strategy, complying with minimum requirements. **No** - Otherwise		Actions
(A3.3) Renewable Energy Sources	(A3.3.1) Renewable Energy Consumption share	Measure of the amount of demanded energy for the development that is supplied through renewable energy sources. These can be located on-site or off-site the development area.	Percentage of renewable energy [%]		Outcomes
	(A3.3.2) On-site Renewable Energy Generation	Measure of the efficiency of the energy supply covering the demand from the development. On-site energy production, reduce the storage and transmission losses associated with off-site energy sources.	Ratio of Source Energy Use Intensity (EUI) (kWh/m2): [Source EUI with On-site generation/ Source EUI without On-site generation] [%]	Source energy represents the total amount of primary energy that is converted into secondary energy to operate the development. It covers transmission, delivery, and production losses	Outcomes
(A3.4) Efficient Energy use patterns & Strategies	(A3.4.1) Energy Consumption	Measure of the expected average energy use intensity from the development. This include all interior or exterior assets for lighting, irrigation, temperature control, etc.	Projected Average yearly EUI [kWh/m2]	Energy Use Intensity is chosen as an indicator for allowing comparability between developments of different sizes	Outcomes
	(A3.4.2) Energy Consumption Reduction Plan	An assessment of the design opportunities for reducing energy consumption from the development. This includes the selection of energy-efficient equipment for operation /maintenance phases. Furthermore, the consideration of opportunities for incorporating renewable/low-carbon/zero-carbon energy sources. Finally, the plan covers measures for reducing energy consumption during construction. This includes considerations on energy efficiency (energy labels) and energy type on facilities and equipment, for the selection of contractors.	Dichotomic variable: **Yes** - For the existence of the Energy Consumption Reduction Plan, complying with minimum requirements. **No** - Otherwise		Actions

(A3.5) Circular use & Responsible sourcing of Materials	(A3.5.1) Top-soil re-use Performance	As a measure of the resource consumption reduction, the degree of beneficial reuse of top-soil, from a nearby source, to be used on-site or taken to a close-by destination	Percentage of top-soil reused on-site or stored for beneficial reuse. [%]	Possible destinations are soil banks that provide and receive soil for future beneficial reuse within the urban area.	Outcomes
	(A3.5.2) Reclaimed or Recycled Material Use Performance	Extent to which the construction process included the use of materials for the permanent works come from reclaimed or recycled sources. This covers those materials from offsite which have been specified and made from repurposed material.	Percentage of reclaimed materials used over the total material consumption for permanent works. [%]	This indicator does not contain bulk fill and sub-base material. Calculation should be consistent by weight or volume.	Outcomes
	(A3.5.3) Fill / Sub-base Material re-use Performance	Extent to which the construction process contemplates the use of reclaimed/recycled materials to be used within the fill/sub-base works. These can proceed from source off-site or be part of the on-site repurposing strategy.	Percentage of reclaimed materials used over the total material consumption for fill/sub-base works. [%]		Outcomes
	(A3.5.4) Material Transport Distance Performance	Measure of the overall project performance in terms of Transport of the required materials for the project. It represents a weighted average of the transport distances required to procure the materials for the project.	Material Transport Weighted Average Distance Deq=Σ(di*(Wi/ΣW)) [km]	Expected transport distance from distribution source multiplied by the weight of the material i over the total weight of materials needed.	Outcomes
	(A3.5.5) Abiotic Resource Depletion Potential	The abiotic resource depletion potential is a measure of the reduction in availability of given abiotic resources (minerals, fossil fuels, etc.) It represents the relation between reserves (natural or in the economy) of resources and the extraction rates of those materials. For these criteria an abiotic resource is relevant if it cannot be regenerated within human lifetimes.	Abiotic Depletion Potential Index (ADP) [-]	Dimensionless index based on the depletion rate of Antimony as a reference element. (Directoraat-General Rijkswaterstaat, 2002)	Outcomes
	(A3.5.6) Responsible Material Sourcing Plan	Define a Material Selection and sourcing plan. The plan must initially set the target values for re-use performance of top-soil, structures and fill/sub-base works. In addition, the plan must prioritize the selection of materials using the available information on global warming, acidification, eutrophication and resource depletion potentials. Finally, the plan contemplates the selection of regional materials for minimizing the transport-related emissions and to integrally boost local economy.	Dichotomic variable: **Yes** - For the existence of the Responsible Material Sourcing Plan, complying with minimum requirements. **No** - Otherwise		Actions
(A4) Conservation of Ecologic value					
Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A4.1) Natural Systems Assessment & Management	(A4.1.1) Environmentally Sensitive Areas Assessment [3]	Perform an assessment of the potentially sensitive areas within the influence zone of the development. The assessment should cover at least	Dichotomic variable: **Yes** - For the existence of the Sensitive Areas Assessment, complying with minimum requirements. **No** - Otherwise		Actions

	(A4.1.2) Wetlands & Water bodies Buffer distance	Measure of the setback distance from the development to existing wetlands or water bodies. This setback is meant as a protection measure for the water bodies, aiming to preserve their functions as habitats and flood buffers.	Buffer distance to wetland/water bodies [m]	The minimum distance from the development boundary to a waterbody.	Outcomes
	(A4.1.3) Forestry and Terrestrial Habitats Buffer Distance	Measure of the setback distance from the development to existing terrestrial habitats. Aligned with the reduction of potential negative impacts from the development over the habitat (noise, light, air, water, and soil pollution), the aim is to preserve their functions as habitats.	Buffer distance to forestry/terrestrial protected habitat areas [m]	The minimum distance from the development boundary to the protected area/forestry zone	Outcomes
	(A4.1.4) Ecology Protection Strategy	The results of ***A4.1.1*** are used to guide the definition of an ecology protection strategy, aimed to protect the existing habitats and minimize the negative impacts of the development on them. This plan needs to cover at least the construction and operation phase, assuring no loos of ecological value in the neighbouring areas to the development.	Dichotomic variable: **Yes** - For the existence of the Ecology Protection Strategy, complying with minimum requirements. **No** - Otherwise		Actions
(A4.2) Biodiversity Conservation	(A4.2.1) Biodiversity Survey	After the assessment of existing habitat areas (***A4.1.1***) a biodiversity survey is conducted to determine animal (including migratory) and plant species on the identified habitat areas. The survey should inquire in the population of the existing species as well as the particular ecosystem services they consume/provide.	Dichotomic variable: **Yes** - For the existence of the Biodiversity Survey, complying with minimum requirements. **No** - Otherwise		Actions
	(A4.2.2) Habitat Creation Performance	An estimate of the Carrying Capacity of any ecosystem is a complex task. However, this capacity is dependent on several factors which act as limits for the ecological functions any ecosystem can provide. Available space constitutes a proxy of this availability of resources (biotic and abiotic), if the conditions of said space comply with forestry reserves, wildlife reserves, river reserves, water bodies and/or habitat linkages.	Biotope area factor: Total biotope area within the development / Total developed area. [m2/m2] - [%]	Biotope makes reference to the areas which provide the conditions for allowing the living functions of interacting organisms (biocoenosis) (del Monte-Luna, Brook, Zetina-Rejón, & Cruz-Escalona, 2004)	Outcomes
	(A4.2.3) Biodiversity Enhancement Plan	Development of a plan for maintaining biodiversity in the identified habitat areas. This plan covers first the control of nocive or injurious species, which might affect the balance of the habitat and second the creation of structures to support local wildlife. These will facilitate safe passage, nesting or feeding of wild species within the urban fabric. These measures include green bridges/tunnels and green roofs/facades, etc. The plan should be developed to the scale of the development and in consultation with qualified ecologist/wildlife specialist	Dichotomic variable: **Yes** - For the existence of the Biodiversity Enhancement Plan, complying with minimum requirements. **No** - Otherwise		Actions
Social Dimension					
(A5) Climate Adaptation & Resilience					

Theme	*Criteria*	*Description*	*Indicator*	*Comments*	*Focus*
(A5.1) Heat Island Effect Management & Outdoor thermal comfort	(A5.1.1) Perceived Outdoor Temperature	Measure of the expected perceived temperature in the outdoor areas of the development. This value can come as a result of detailed modelling and temperature maps for the development with specific sampling points throughout the development.	Average Perceived Temperature [°C]		Outcomes
	(A5.1.2) Wind Comfort	Measure of the presence and strength of wind gusts in outdoor areas. Gusts represent a sudden increase in air velocity over a short period of time. These can generate discomfort and increase the risk of accidents for cyclist and other public space users. The calculation of this value can be done through computerised models which include buildings and wind flow landscape information	Average Gust velocity as a percentage of baseline wind speed [%]	Wind velocity increase / Baseline wind velocity	Outcomes
	(A5.1.3) Heat Island Reduction Area Coverage	Measure of the degree of coverage of the Heat island reduction measures within the development area. Through GIS based model, determine a 200m buffer area around all heat island control measures, namely tree canopy, green roof/wall, cool/white roofs and open flow water canals. The resulting area is considered as the area of influence of the projected measures	Share of Heat Control Influence Area over the total development area [%]	Ratio of the calculated buffer (area of influence) from the total area of the development.	Outcomes
	(A5.1.4) Outdoor Low Heat-Absorption Area Performance	Measure of the degree of heat absorption of hardscape within the development. This measure is directly related with the capacity of the surfaces to reflect light, thus high albedo materials/colours are recommended. This calculation can be done through a computerised model of the development	Solar Reflection Index (SRI) [-]	An average value of the representative hardscape areas, normalized over the GFA of the hardscape of the development	Outcomes
	(A5.1.4) Urban Microclimate Enhancement Plan	Creation of a Microclimate enhancement plan for the development. This should include at the least, considerations for reducing solar exposure of walking and cycling areas, orientation of infrastructure/buildings to reduce sun exposure and allow wind flow and seasonal tailoring (i.e. Use of deciduous tree cover: In summer time generates shading area and in winter (loose of foliage) allows better natural lighting)	Dichotomic variable: **Yes** - For the existence of the Microclimate enhancement Plan, complying with minimum requirements. **No** - Otherwise		Actions
(A5.2) Sustainable stormwater and flood management	(A5.2.1) Flood Risk Assessment [3]	Evaluation of the probability of flooding events and the linked exposure levels of the planned assets in the development area. In addition, identify possible impacts over neighbouring areas due to the new development.	Dichotomic variable: **Yes** - For the existence of the Flood Risk Assessment, complying with minimum requirements. **No** - Otherwise		Actions
	(A5.2.2) Soil Sealing Factor	Measure of the imperviousness of the outdoor surfaces within the development area. Represents the weighted infiltration capability average of the development.	Infiltration volume Flux Average [mm/h]	Calculation of Volume flux: Σ(Volume Flux*A(i))/ΣA, for all horizontal surfaces within the development	Outcomes

	(A5.2.3) Surface Water Run-off Reduction Performance	Measure of the share of post-development expected water run-off resulting from hydrologic models. This is a measure of the capacity of the development to act as a water run-off buffer and further manage precipitation through infiltration, thus avoiding water run-off. Run-off reductions mechanisms include source management (Water harvesting at source, green roofs) and site management (Filtration and retention wetlands and buffers).	Water run-off reduction ratio: [%]	Expected run-off controlled at source + site over the total expected water run-off on the development area [mmh/mmh]	Outcomes
	(A5.2.4) Green Stormwater Infrastructure coverage	Measure of the degree of coverage that green stormwater infrastructure provides for the development area. Green infrastructure is defined as that which provides bioretention and infiltration services.	Green Infrastructure Coverage Percentage [%]	From hydrologic models identify basin areas served by green infrastructure and determine an area coverage percentage	Outcomes
	(A5.2.5) Sustainable Urban Drainage Systems Plan	Based on the results from A5.2.1 determine design measures focused on controlling flood risk through Sustainable Urban Drainage Systems (SUDS). These include the implementation of green roofs, decks and retention and filtration basins. The plan needs to address the potential use of these measures, as well as the monitoring, control and maintenance required to avoid water pollution from fault connections (mixing wastewater with drainage water).	Dichotomic variable: **Yes** - For the existence of the Sustainable Urban Drainage Systems Plan, complying with minimum requirements. **No** - Otherwise	The bottom line of SUDS is the accommodation of further services apart from flood control, like provision of amenities, and multi-use storm control structures (fountains, parks, etc.)	Actions
(A5.3) Flexibility & Adaptability to Future needs	(A5.3.1) Climate Change Adaptation Plan	From the results in ***A5.2.1*** implement a plan for assuring that future expected sea levels and storm frequency/intensity are covered by the implemented flood risk measures. (Capacity Building). Furthermore, in connection with ***A3.2.4*** determine future water supply conditions and design measures aimed to preserve and refill aquifers and other water sources.	Dichotomic variable: **Yes** - For the existence of the Sustainable Urban Drainage Systems Plan, complying with minimum requirements. **No** - Otherwise		Actions
	(A5.3.2) Service Infrastructure Resilience Performance	Degree of coverage of the existing and planned service infrastructure, with external damage control measures and system hardening. These measures aim to assure the provision of essential services in case of external risk materialization. For wastewater systems, clean water systems (including treatment and distribution), power grids and communication infrastructures, provide design considerations to harden these systems against extreme events (i.e. flooding, storms, fire). Some strategies include retention, backflow prevention and monitoring systems	Share of Hardened Service Infrastructure [%]	Percentage of the existing and planned infrastructure which have hardening provisions against extreme events, from the total infrastructure providing services to the area	Outcomes
	(A5.3.3) Innovative Urban Agriculture Plan	In alignment with ***A1.2.2*** develop a plan to incorporate the provision of areas that can accommodate innovative urban agricultural uses. This goes in alignment with rain water reuse	Dichotomic variable: **Yes** - For the existence of the Innovative Urban Agriculture Plan, complying with	A multi-objective focus allows the targeting of water harvesting, community	Actions

		strategies, where self-sustaining urban farming, managed by the community, can develop aquaponics, roof gardens and other self-production initiatives.	minimum requirements. **No** - Otherwise	management and self-food production	
	(A5.3.4) Infrastructure Adaptability	Measure of the degree of reusability and adaptability of planned district infrastructure (street furniture, bus tops, small buildings, etc.). These criteria reflects on the extent of use of modular building which allows the disassemble and reassemble with maximum reuse rate for accommodating future geometric configurations and relocations.	Share of Modular District Infrastructure [%]	This item contributes not only to adaptability, but also to reusability of building parts and sections.	Outcomes
	(A5.3.5) Urban Adaptability Plan	Plan which encompasses all design considerations aiming to guarantee the provision of services for future needs. The plan must cover at least the increase in capacity following population shifts, by age group, adaptability of spaces and district infrastructure as well as the provision of support for emerging technologies (i.e. electric vehicles charging spots, e-bike/e-scooter docking facilities as part as public transport parking facilities)	Dichotomic variable: **Yes** - For the existence of the Urban Adaptability Plan, complying with minimum requirements. **No** - Otherwise	Facilities need to consider future needs based in projection of population growth and age group shifts. As well as allow to accommodate emerging technologic improvements	Actions

(A6) Quality of Life & Provision of Amenities and Services

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A6.1) Diverse Housing Provision	(A6.1.1) Demographic Needs and Priorities Assessment	Taking as a base the results from ***A1.1.1*** and through the participation mechanisms stablished in ***A1.2.2***, determine aspects about the needs of the community. As a minimum the specific housing requirement (housing types and tenure modes), and needs for public areas, interaction spaces and other services. Furthermore, identify potential displaced population as a result of the development.	Dichotomic variable: **Yes** - For the existence of the Demographic Needs and Priorities Assessment, complying with minimum requirements. **No** - Otherwise		Actions
	(A6.1.2) Housing Diversity Performance	A measure of the types of dwellings developed within the area of intervention. The possible considered housing types are Detached houses, semidetached houses, terraced houses, townhouses, clusterhouses, low-rise apartments/condominiums (<4 floors) and high-rise apartments/condominiums (>4 floors).	Housing Diversity Index [-]	Based on the Simpson Diversity Index. Is calculated as $1-\Sigma(n/N)^2$. Where n is the number of dwellings of each type and N the total amount of dwellings.	Outcomes
(A6.2) Healthy, safe & Appealing Urban spaces	(A6.2.1) Shared Street Space Density	According to the results from ***A6.1.1*** regarding the provision of social interaction spaces, this indicator acts as a measure of the availability of such areas resulting from the development. Shared Street space is aimed to allow social interactions and amusement opportunities for the community (Social fabric). These areas are characterized by pedestrianized zones, attractive landscaping, urban mobiliary and other amenities.	Shared Street Space Density [%]	Ratio of planned shared areas over the total development area which corresponds to public space.	Outcomes

		(A6.2.2) Defensible Space Provision	The concept of Defensible space refers to the possibility of inhabitants of a neighbourhood to overlook the public areas neighbouring their private ones. The design features cover the provision of direct sightlines from private developments, setbacks allowing front yards over the pedestrian public areas and suitable public illumination schemes.	Share of Defensible Public Areas [%]	Ratio of the public areas featured as defensible from the total provision of public areas within the development. (Newman, 1996)	Outcomes
		(A6.2.3) Parkland and Open Green Space Provision	Provision of public parkland and other public recreational facilities like playgrounds, and recreational green spaces/lakes. These areas can provide multiple benefits as described in ***A5.2.4*** when flood buffer areas can be provided with additional recreational value	Area Provision Density [m2/1000 inhab]	Area of public parkland / recreational facilities for each 1000 inhabitants of the developed area.	Outcomes
		(A6.2.4) Accessibility to Physical activity Areas	Through GIS-assisted models, determine the degree of coverage of public space facilities that encourage healthy lifestyles, like adult fitness parks, sport fields areas, athletic field, trail network, etc.). The coverage is based on walking accessibility	Percentage of population served by healthy lifestyle areas according to distance-based accessibility [%]	Benchmarked walking distance oscillates between 350-800m.	Outcomes
		(A6.2.5) Urban Open space Integration Plan	Integrating the urban open space refers to the alignment of the newly developed space with the identity and visual features of the city. This includes unifying the urban mobiliary, landscaping and other open space structures (bus stops, bike parking, etc.) to suit a urban identity. Accordingly, the plan needs to cover at least consideration of materials, colours, morphology and layout design considerations to assure the integration with the existing identity, landmarks and ease of navigation for inhabitants and visitors.	Dichotomic variable: **Yes** - For the existence of the Urban Open space Integration Plan, complying with minimum requirements. **No** - Otherwise		Actions
	(A6.3) Mixed land use for Provision of services & amenities	(A6.3.1) Higher-level Integration Assessment	The concept, zoning and provision of services within the development needs to be aligned with high-level goals from a Regional Planning perspective. As a result, the assessment will cover the considerations and areas of interest to integrate the development with the regional planning while providing the services for the community discovered in ***A6.1.1***	Dichotomic variable: **Yes** - For the existence of the Higher-level Integration Assessment, complying with minimum requirements. **No** - Otherwise	Zoning reduces negative impacts from the existence of incompatible uses within the development area	Actions
		(A6.3.2) Land Use Mix	Land-use mix has been identified as a proxy of a healthy urban design. Namely, it reduces the need to travel and promotes both the provision of services and the boost in local economy. The land-use mix should comprise at least the following uses: Residential, Offices, Education and research, Healthcare, Commerce, Production and industry.	Land-use Diversity Index [-]	Based on the Simpson Diversity Index. Is calculated as $1-\Sigma(P)^2$. Where P is the area-based probability of finding a given land-use within the development. (van Eck & Koomen, 2008)	Outcomes
		(A6.3.3) Accessibility to Community Services	From GIS-based models, identify the accessibility performance of the development from all residential areas to projected services like Childcare and Primary School, Higher education, Leisure	Travelling time accessibility functions.	The model can be a part of a city-scale model. And the accessibility can be assessed for	Outcomes

		activities (cinema, galleries), civic services (police, fire station, post office, assembly hall) and sport facilities.		Walking, Biking or Public Transport.	
	(A6.3.4) Open Space Multi-Purposing Plan	The plan for the provision of open spaces is done from a multipurpose perspective. This means that the plan should consider the multiple functionalities of the provided open spaces and assure that considerations of habitat provision (***A4.2.2***), flood management (***A5.2.4***), microclimate management (***A5.1.3***) and market provision are covered within the design concept of the recreational open spaces, including green areas, public parkland, public squares, etc.	Dichotomic variable: **Yes** - For the existence of the Open Space Multi-Purposing Plan, complying with minimum requirements. **No** - Otherwise	The plan will increase the efficiency of open space usage, in terms of the provision of multiple functionalities for the community.	Actions
	(A6.3.5) Land-use Synergy Plan	In coordination with ***A6.3.1***, the projected land uses within the development area based on two principles. First the reduction of potential disturbances from incompatible land uses (Sensitive areas) (i.e. noise, vibrations and other polluting effects). Second the promotion of synergies within the district allowing stronger commercial relationships, knowledge sharing and innovation	Dichotomic variable: **Yes** - For the existence of the Land-use Synergy Plan, complying with minimum requirements. **No** - Otherwise	Synergies can be achieved within commercial complexes and technology/innovation/scientific parks	Actions
(A6.4) Cultural & Historic Heritage	(A6.4.1) Historic Heritage Assessment and Integration	Develop an inventory of registered and unregistered historic environmental assets, like built heritage, landscape or townscape, archaeological remains, among others. Additionally, integrate the available assets into the layout and design concept, so that the identified assets can be retained, restored and re-used as part of the development. This can be achieved through on-site protection measures and educational and campaigns with on-site or on-line information boards.	Dichotomic variable: **Yes** - For the existence of the Historic Heritage Assessment and Integration, complying with minimum requirements. **No** - Otherwise		Actions
	(A6.4.2) Share of Conserved Historic Heritage Assets	From the identified assets in ***A6.4.1***, this criterion measures the percentage of those which where conserved within the development, and for which restoration and quality enhancement measures were undertaken.	Percentage of conserved assets [%]	Ratio of Conserved Assets over the total amount of assets in the inventory.	Outcomes
	(A6.4.3) Cultural identity conservation Plan	Through consultation methods established within ***A1.2.1***, determine the specific design features of social spaces which make them enhance the local identity of the community. Accordingly, include identity-promoting landscape and open space elements into the design concept of the development. This is done to increase the sense of belonging and promote frequent use of the public space.	Dichotomic variable: **Yes** - For the existence of the Cultural identity conservation Plan, complying with minimum requirements. **No** - Otherwise		Actions

(A7) Inclusiveness & Social Equity

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A7.1) Housing & Transport Affordability	(A7.1.1) Household Income	Measure of the percentage of projected occupancy groups (from ***A.1.1.1***), whose household income is at least the Area Median Income (AMI)	Percentage of Population whose household income is equal or higher than the AMI [%]		Outcomes
	(A7.1.2) Housing Expenditure	This criterion measures the potential degree of expenditure of households in housing costs as a percentage of a reference income. The indicator makes use of the Area Median Income measure as a reference for the developed area, compared against the expected housing prices within the development.	Average Housing Expenditure as a Percentage from the AMI [%]	A lower average indicates a lower expenditure from household income in this factor, thus reflecting on higher affordability.	Outcomes
	(A7.1.3) Transport Expenditure	This criterion measures the potential degree of expenditure of households in transport costs as a percentage of a reference income. The indicator makes use of the Area Median Income measure as a reference for the developed area, compared against the expected transport prices within the development.	Average Transport Expenditure as a Percentage from the AMI [%]	A lower average indicates a lower expenditure from household income in this factor, thus reflecting on higher affordability.	Outcomes
	(A7.1.4) Equitable Housing Plan	Review and develop land policies to allow a mix of economic groups to inhabit the developed area, providing suitable housing options matching the expected demographic needs.	Dichotomic variable: **Yes** - For the existence of the Equitable Housing Plan, complying with minimum requirements. **No** - Otherwise		Actions
(A7.2) Accessibility & Connectivity	(A7.2.1) Accessibility to Transit Services	Measure of the walking distance from origin points (households, offices, etc.) to local or regional transit hubs. The measure is path-based, so a Transport model is desirable for achieving this measure. The indicator will reflect on the percentage of origins and destinations within the development that are within acceptable walking distance to transit stations.	Percentage of developed assets within acceptable walking distance from the total assets in the development area [%]	Acceptable walking distance ranges from 300m-800m. A detailed study of real walking desirability is recommended to set the maximum acceptable walking distance.	Outcomes
	(A7.2.2) Intermodal Connectivity	This criterion measures the level of services of existing and planned transit services (rail, bus, etc.) over the area of the development. A transport model should be in place for the total urban area, so that accessibility measures could be extracted to reflect on the selected area of the development. In general terms Distance decay functions are widely used to assess this, using Public Transit and Bike and Ride schemes.	Distance Decay Accessibility for the chosen site of the development. [-]	A distance Decay function is usually unitless, but it reflects the reachable destinations as a function of the traveling times required to reach them.	Outcomes
	(A7.2.3) Quality of Transit Facilities	To promote the use of public transport, the development of transit facilities should consider safety, ease of use and comfortability aspects. As a minimum, the stations will be provided with appropriate protection from climatic conditions (rain, wind, snow, sun, etc.) and be well lit. In addition, stations should include	Share of Transit Facilities complying with minimal requirements [%]	This criterion applies for projects aimed to develop public transport infrastructure.	Outcomes

		passenger information system covering schedules and routes information and electronic toll collection systems (whether in the stations or in the vehicles). Finally, the location of the stations should minimize interference with pedestrian/biker flows.			
	(A7.2.4) Transport Integration Assessment	A transport assessment is to be developed (In case of not having one already in place), to determine the wider effects of the development, in terms of job accessibility for the region. The aim is to increase job availability for the wider urban region, and not just for the developed area as a result of internal relocation. The transport assessment will also cover the transport capacity updates resulting from the development to assure a good service quality (frequency vs. expected users). Furthermore, include considerations of renewable energy usage for the transport infrastructure (vehicles and stations) as part of a wider urban initiative	Dichotomic variable: **Yes** - For the existence of the Transport Integration Assessment, complying with minimum requirements. **No** - Otherwise		Actions
	(A7.2.5) Intra and inter Connectivity Performance	The design of the layout of the new development covers the provision of continued connectivity through and across neighbouring areas. This reflects not only on the access routes that are continuation of incoming routes into the development, but also the ease of movement within the developed area, as a result of design considerations in the layout.	Density of closed roads within the development [#/m2]	The count of closed roads (cul-de-sac) include those which are closed to all modes. Pedestrian Paths with bikeable area are not counted in this indicator.	Outcomes
(A7.3) Walkability & Bikeability	(A7.3.1) Quality Walking Infrastructure Provision	Measure of the provision of suitable walking facilities within the development. This includes paths to access transit infrastructure and green spaces. Quality considerations are aligned with safety and security (***A6.2.2***), thermal comfort (***A5.1.3***) and ease of access (***A7.5.2***). Additionally, align with local regulations for minimum dimensions.	Density of Quality Walking Network Provision [m/m2]	Measure of the amount of metres of provided walking infrastructure normalized over the area of the development.	Outcomes
	(A7.3.2) Density of Pedestrian crossings	Urban form research has shown that a measure of human scale development is reliant on the availability of pedestrian crossings as a function of the area. This is a proxy of the length of the blocks, thus reflecting on the capacity of being walked. Additionally, it acts as a measure of walking connectivity, as a measure of connectivity density between pedestrian paths.	Density of Pedestrian Crossings [#/m2]	Amount of 3-way and 4-way pedestrian crossings included in the layout design of the development as a function of the area	Outcomes
	(A7.3.3) Quality Cycling Infrastructure Provision	Measure of the provision of suitable cycling facilities within the development. This includes cycle lanes continuing from neighbouring areas and within the development. Agreement with local regulations is required for minimum dimensions and safety considerations. Motorized Traffic speed determines the geometric	Density of Quality Cycling Network Provision [m/m2]	Measure of the amount of metres of provided cycling network complying with the quality requirements	Outcomes

		configurations when required (i.e. separate flow, physical barriers, etc,). Other quality considerations are aligned with safety and security (***A6.2.2***), thermal comfort (***A5.1.3***) and ease of access (***A7.5.2***).		normalized over the area of the development.	
	(A7.3.4) Bicycle Parking Facilities Supply in Transit Infrastructure	For the existing and planned transit stations, an assessment of potential users guides the provision of Bicycle parking infrastructure (within the same area or using additional building). As a minimum, Hub stations should provide bike racks, covered, and with the possibility of securing the bikes. CCTV security systems are highly recommended where deemed necessary. In addition, other stations, should include parking facilities with securing possibilities as a minimum.	Share of stations with sufficient bicycle parking infrastructure [%]		Outcomes
	(A7.3.5) Accessibility and Serviceability Plan	A plan is defined to extend accessibility considerations to private developments within the area. As a minimum, this includes considerations for inclusive design, linkage of residential areas with relevant amenities and services, connection with the public space and provision of bicycle parking facilities as part of the private interventions.	Dichotomic variable: **Yes** - For the existence of the Accessibility and Serviceability Plan, complying with minimum requirements. **No** - Otherwise		Actions
(A7.4) Promotion of alternative modes of transport	(A7.4.1) Power Supply in Parking Infrastructure	The share of parking facilities for different types of vehicles, which include (electric cars, scooters, and e-bikes) acts as a measure of the adaptiveness of the development to emergent modes of transport and increasing transport technologies.	Share of Power supplied parking facilities [%]	From the total amount of parking spots for each type of vehicle.	Outcomes
	(A7.4.3) Multimodal Integration Plan	Develop a plan for allowing Park and ride schemes, Bike + Ride, passenger drop-off and feeder services to increase the use of alternative modes of transport and reduce the total length of driven kilometres by private car, thus reducing its dependence. Additionally, seek for private collaboration to implement carpooling initiatives within the development area.	Dichotomic variable: **Yes** - For the existence of the Multimodal Integration Plan, complying with minimum requirements. **No** - Otherwise		Actions
(A7.5) Inclusive Design	(A7.5.1) Ease of access to Transit Infrastructure)	Measure of the degree of inclusiveness in the design considerations for the development of transit infrastructure like stations and vehicles. Ease of access should be provided to users of different ages and physical conditions (reduced mobility, visually impaired, etc.). Additionally, to the ease of access, the dimensioning should allow normal use of the facilities once they are accessed for every type of user.	Share of Transit Infrastructure complying with inclusive ease of access requirements [%]	Universal Design	Outcomes
	(A7.5.2) Public Space Inclusive Design Provision	Criteria measuring the degree of accessibility of reduced mobility and visually impaired users to public space zones. These zones cover, sidewalks, bike lanes, crosswalks and parkland. As a	Share of Inclusive Design complying Infrastructure [%]	This indicator can be reported separately for each type of infrastructure.	Outcomes

		minimum, unobstructed access should be provided, and means of access for wheelchair/mobility scooters should be provided, as well as tactile signalling for the visually impaired. Align with local regulations on Inclusive Accessibility.			
	(A7.5.3) Universal Design Service Infrastructure Plan	In agreement with private parties and developers, include provision of parking facilities and appropriate signage for all type of users, including the ones with reduced mobility and the visually impaired. Furthermore, include an assessment of the potential requirement updates resulting from the demographic shift over a future timespan (Aligned with ***A5.3.5***)	Dichotomic variable: **Yes** - For the existence of the Universal Design Service Infrastructure Plan, complying with minimum requirements. **No** - Otherwise		Actions

Economic Dimension

(A8) Project Feasibility

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A8.1) Financial Viability Assessment	(A8.1.1) Life Cycle Costing	The methodology of Life Cycle Costing is suitable to account for the projected costs/earnings structure of the project. The life cycle of an asset should cover as a minimum, the construction phase and the use-phase (operation and maintenance). The discount rate needs to be set according to sector-specific price increase rates to reflect on the decline in acquisitive power of money over time.	NPV of Project Cash Flows, normalized by developed area: [€/m²]	Net Present Value is calculated for a given discount rate and an estimated service life for the asset. Benchmarks consider a period ranging from 20-50 years. Considered area is GFA	Outcomes

(A9) Local economic Impacts

Theme	***Criteria***	***Description***	***Indicator***	***Comments***	***Focus***
(A9.1) Impacts on local economy development	(A9.1.1) Job Generation Potential	This criterion indicates the degree of expected job creation resulting from the development. Within the indicator, settlement of new companies that were not within the municipality or expansion of existing businesses/companies are counted as contribution to the rise of employment.	Projected Job Placements [#/m²]	Normalization using GFA aids in comparability between projects of varying sizes.	Outcomes
	(A9.1.2) Municipal Revenue Increase Potential	Municipal revenue potential is estimated through the calculation of cash flows (net present value) derived from the development. These flows account for increased income tax due to additional residents, trade tax due to additional businesses, property tax due to additional buildings and increase in property value and costs are derived from additional supply of infrastructure and services and their respective operation/maintenance cost structure. In addition, eventual profit/loss from municipal property transactions is included in this criterion	NPV of Project Cash Flows, normalized by developed area: [€/m2]	Net Present Value is calculated for a given discount rate and should be aligned with the service life for the asset used in A8.1.1. Considered area is GFA	Outcomes
	(A9.1.3) Value Stability Plan	A plan is devised for information and promotion purposes. This as a method to attain long-term value stability of the developed area. The plan will make use of marketing strategies and public relations	Dichotomic variable: **Yes** - For the existence of the Value Stability	The plan will generate a good image for the development increasing the planning security	Actions

		events to reach out for potential investors and private parties. The final objective is to develop the potential of the area of the development and assure the provision of required services and businesses.	Plan, complying with minimum requirements. **No** - Otherwise	on long-time investment and value retention.	
(A9.2) Promotion OF Circular Economy Models	(A9.2.1) Compostable Waste Recycling Performance	Under the modality of composting, organic waste can be recycled to produce soil enriching products (fertilizers), while at the same time, reducing the reliance on land filling as waste management strategy. This indicator measures the projected capacity of composting infrastructure, to recycle and repurpose the organic waste from the development	Percentage of organic waste produced within the community, projected to be composted [%]	Calculation: by Volume [m3] or by Weight [T]. Consistent along the process.	Outcomes
	(A9.2.2) Circular Oriented Procurement	Establish strategies and alliances with external parties and contractors to allow circular procurement models for the development. For instance, the use of On-demand procurement, and Product as a Service (PaaS) strategies, leasing or buy-back schemes. These should reflect a reduction in expenditure for the construction phase.	Dichotomic variable: **Yes** - For the implementation of Circular Oriented Procurement, complying with minimum requirements. **No** - Otherwise	(European Commission, 2017)	Actions
	(A9.2.3) Use-phase Circular Strategies Performance	For the occupancy phase of the development, stablish possibilities and alliances with third parties for allowing the recovery of secondary materials from specific businesses to be procured as inputs for other industries, thus generating synergies. Furthermore, allow dematerialisation of the occupancy phase, through digitalization and optimization of material consumption	Circular Procurement Savings [€/m2]	Net Present Value is calculated for a given discount rate and should be aligned with the service life for the asset used in A8.1.1. Considered area is GFA. (REBus, 2018)	Outcomes
	(A9.2.4) Regenerative Design Principles	Implement agreements with contractors for inclusion of regenerative design principles. These include the extension of products lifetime, first by materials selection, second by modular design, which eases reuse, refurbishment of specific parts of the products and third, at the end of its service life allows disassembly for adequate recycling processes. These processes can be supported through information systems (Like BIM) for material register and maintenance monitoring and planning.	Dichotomic variable: **Yes** - For the inclusion of Regenerative Design Principles, complying with minimum requirements. **No** - Otherwise	In general terms, this reduces the consumption of raw materials and the costs at maintenance and end of life management	Actions
	(A9.2.5) Smart Waste Management Infrastructure Plan	The inclusion of smart infrastructure for the development, making use of automatic waste tracking enables the monitoring of waste in collection points. This allows for accurate waste collection scheduling. In addition, the use of web-based systems allow consolidation and sharing of performance indicators for audit an improvement	Dichotomic variable: **Yes** - For the existence of a Smart Waste Management Infrastructure Plan, complying with minimum requirements. **No** - Otherwise		Actions

NOTES

[1]	The Demographic Assessment is a prerequisite for additional criteria within the framework. It is mentioned for clarity purposes, though, it is possible to use existing demographic studies according to their suitability.
[2]	Life Cycle Assessments can be time/resource intense procedures. Market oriented Inventories and Materials Classification systems can be used to guide the material selection. (i.e. The Green Guide to specification - BRE)
[3]	Dutch legislation requires the implementation of Environmental Impact Assessments (EIA) for Infrastructural and development projects. This item can be developed alongside the performed EIA.

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