SPATIAL DECISION SUPPORT SYSTEM FOR INDUSTRIAL PARK PLANNING

Case study: Southern Province, Rwanda

RAPHAEL EDEM FIAVE
JUNE, 2020

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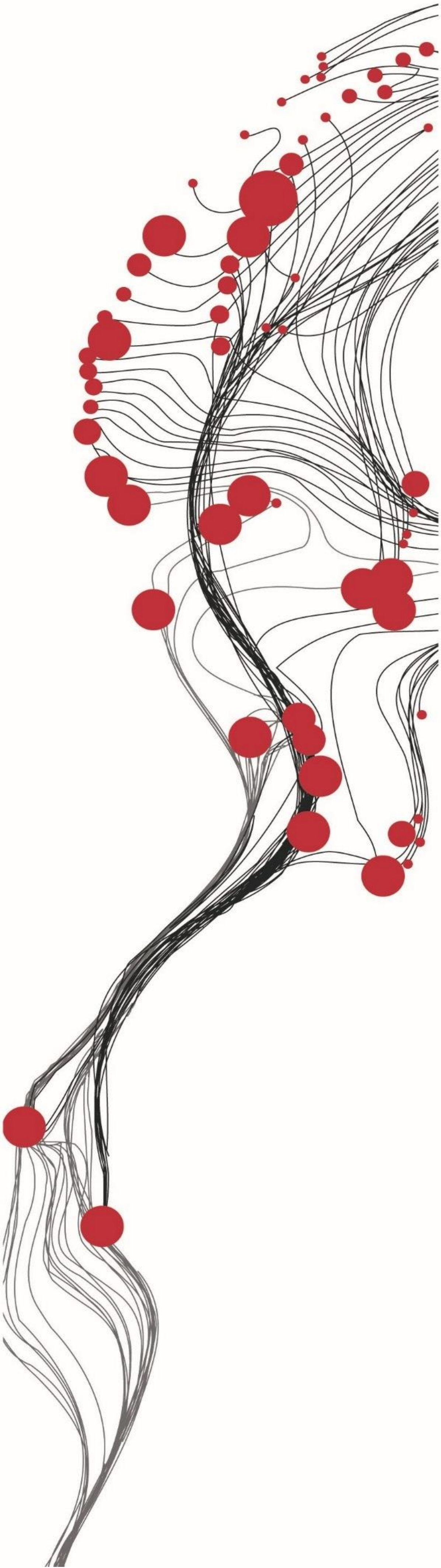

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Case study: Southern Province, Rwanda

RAPHAEL EDEM FIAVE

Enschede, The Netherlands, JUNE, 2020

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Spatial Engineering

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ABSTRACT

Over the last three decades, the development of industrial parks across the globe has received significant attention mainly as a result of an increased desire by most countries to achieve rapid industrialisation and creation of off-farm jobs. For countries in the global South particularly, industrial parks represent strategic means for attracting needed investments into the industrial sector towards a long term goal of increasing domestic production for international markets. The planning and development of these parks is however complicated by the need for pre-feasibility studies that provide the needed technical, environmental and financial basis for assessing the viability of an industrial park project. The main challenge exists during the site selection stage where the need to select suitable locations for industrial parks that meet the needs of optimal labour accessibility and proximity to utility infrastructure in the midst of environmental and economic justifications is paramount. This study developed a dynamic SDSS for deciding on industrial park locations within the Southern Province of Rwanda as a case study. Based on background information, the results show that indeed current processes can benefit from the gains of a SDSS that integrates labour accessibility, connection costs for water and power as well as the validation of environmental and economic growth impact assessment into site selection activities.

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1. INTRODUCTION

1.1 Background and justification

The last three decades has seen a significant increase in the development of Industrial parks mainly as a result of an increased desire by many countries to attract investments and promote competition among firms (UNIDO, 2019a). This has largely been driven by the enactment of industrial policies that see industrial parks as strategic means to promote industrial development and the creation of off-farm jobs (Le et al., 2020). These motivations are particularly relevant for countries in the global South that are striving to move from merely producing raw materials for export to more industrialised economies that are able to produce for both domestic and international markets (Azizov (2014). So far, the potential to increase urbanisation in settlements close to industrial parks have resulted in calls for better integration of these parks into urban societies while growing awareness of the negative implications on the natural environment resulting from industrial wastes for example, continue to shape future planning and development of industrial parks (Alawa, 2013; Abdul-Wahab & Al-Arairni, 2004). Regardless of the geographical context within which industrial parks are situated, they hold the potential to boost not only the economic growth of host countries but also to promote environmentally responsible industrialisation within parks that insulates the rest of the urban scene from negative externalities of large industries (Meylan & Alhilali, 2018; UNIDO, 2019a).

The planning and development of industrial parks is however complicated. From the preparation of a business model that justifies the need for an industrial park through the identification of alternative sites to the final drafting of financial and park management agreements, industrial park planning and development requires strong oversight (Meylan & Alhilali, 2018). Accordingly, the United Nations Industrial Development Organisation (UNIDO) identifies four key steps in the planning of industrial parks namely, Business Case Development and Decisions, Pre-feasibility studies, Feasibility studies and Financial structuring (UNIDO, 2019a). The business case development phase aims to clearly establish the potential economic benefits of a proposed industrial park while the feasibility studies phase exists to justify the decision to begin and finance an industrial park on the basis of environmental, infrastructural and other impact assessments. The financial structuring step relates to the drafting of all financial details relating to the development and management of an industrial park.

The pre-feasibility analysis phase serves to provide the needed technical, environmental and financial basis for assessing the viability of an industrial park project (UNIDO, 2019a). It includes amongst other factors, the consideration of site development costs and access to affordable infrastructure which would require the gathering of appropriate geospatial data that must be analysed and interpreted by both experts and non-technical stakeholders.

Furthermore, to achieve successful integration of industrial parks into urban areas, decision making on the effective integration of land use and transport infrastructure would be key. Meaning, decision makers should be able to integrate the relationship between industrial parks and transport considerations in a collaborative planning process mainly because it is key to promoting economic growth and aids to establish connections between people and the opportunities these parks offer (Skorobogatova & Kuzmina-Merlino, 2017). This integration is also necessary to ensure that people can access preferred activity areas with ease via physical connections such as bus, train transport services (Blanton, 2000)

However, due to the often diverse objectives and goals of stakeholders, involving stakeholders has proven to be a difficult task (Brand and Gaffikin, 2007). The development and integration of industrial parks into urban areas touch not only on the transport sector but also on environmental and social issues and thereby requires the need for collecting and analysing geospatial data to better understand existing phenomenon. These complexities therefore require flexible tools to aid in decision making. This is where Spatial Decision Support Systems (SDSS) are effective. SDSS provide dynamic tools for decision makers to decide on complex spatial problems and includes capabilities for analysing, modelling, displaying and reporting on both spatial and non-spatial data (Sugumaran & DeGroot, 2011). With SDSS, decision makers and stakeholders can together develop evidence-based actions, simulate consequences of these actions as well as prepare strategies to implement them (Chen & Gold 1992). This research therefore adds to the recently growing literature that attempts to effectively integrate the gains of SDSS, infrastructure development and stakeholder collaboration in decision making. This is even more important for developing countries that need to make better decisions on infrastructure development in the midst of other urban governance challenges.

1.2 Research problem

The United Nations Industrial Development Organisation (UNIDO) identifies pre-feasibility studies as one of the most important steps in the planning of industrial parks. Based on available information on demographics and market analysis for example, pre-feasibility studies work to position the potential of a proposed industrial park in both local and national contexts (UNIDO 2019a; Meylan, et. al., 2017). As such, one key activity that pre-feasibility focuses on is 'site selection'. It is described to mean the comparison of alternative sites based on factors such as access to labour, market, transportation, overall site development costs, power, water etc (UNIDO 2019a). Similar to other major physical infrastructural developments, the success or otherwise of site selection activities can have major implications on the future viability of industrial parks.

In most cases, site selection activities consist of three key considerations: transportation time to labour; the availability of infrastructural services including power and water service lines and the avoidance of environmentally sensitive areas (UNIDO, 2019a). The first relates to the availability of a pool of potential workforce distributed within a certain travel range from industrial parks while the second entails the maximisation of access to utility services with regards to power and water services. The third covers an analysis of existing environmental conditions to ensure that industrial parks avoid areas with environmental vulnerabilities. Analysing these considerations in an efficient manner can be cumbersome and therefore is seen as a challenging task mainly because of the often multi-sectorial nature of data required for analysis (Xiong, 2015).

Current decision making processes however lack capabilities for decision makers to effectively analyse geospatial data for deciding amongst alternative sites. UNIDO's 'Toolbox for Eco-Industrial Parks' (UNIDO, 2019b) although provides a set of tools that includes tools for scoping and selection of industrial parks, works best for already existing industrial parks that require strategic re-development and also does not include geospatial analytical capabilities. Therefore, a computer-based tool such as SDSS, that allows for quick analysis of geospatial data on alternative sites as well as the consequences of these alternatives on labour, utility and the environment should be desirable.

To fill this gap, this research aims to ascertain how SDSS can support site selection processes for industrial park development. When applied to urban and regional industrial development, SDSS can provide the opportunity to enhance collaborative planning by providing a platform where decision makers could generate useful insights for decision making.

1.3 Research objectives

The SDSS that is proposed in this study is meant to provide an interactive interface whereby stakeholders can collaboratively decide on possible locations for industrial parks based on three main criteria 1) accessibility to labour 2) connection costs for water and power and 3) environmental and economic growth impact analysis.

1.3.1 Main objective

The main objective of this research is to develop a prototype SDSS for industrial park planning towards the integration of labour accessibility, connection costs for water and power into decision making as well as for validating environmental and economic growth impact assessments.

1.3.2 Sub-objectives

To be able to develop a SDSS that is appropriate to the needs of site selection for industrial parks, it would be necessary to first understand current processes in terms of decision making and what kind of relations exist between stakeholders. Further, the component that deals with accessibility to labour would rely on an understanding of current situation in terms of travel times to existing industrial parks. Finally, the knowledge from the above would coincide to provide needed background for the development of the SDSS.

1. To analyse the current decision making process on industrial park allocation and development.
2. To evaluate the current accessibility of labour to existing industrial parks.

3. To develop a SDSS that integrates labour accessibility, connection costs for water and power as well as environmental and economic growth impact assessments into decision making on industrial parks.

1.3.3 Research questions

1. **To analyse the current decision making process on industrial park allocation and development.**
   a. What is the current decision making process for industrial park location allocation and development within the case study area?
   b. Which stakeholders are involved in the decision making process for industrial parks?
2. **To evaluate the current accessibility of labour to existing industrial parks.**
   a. What is the main mode of transport for commuters within the case study area?
   b. How can travel time to existing industrial parks be quantified and visualised?
1. **To develop a SDSS that integrates labour accessibility, connection costs for water and power as well as environmental and economic growth impact assessments into decision making on industrial parks.**
   a. What is the design for the SDSS tool for decision making?
   b. At what stage of the decision making process shall the SDSS tool contribute?

1.4 Conceptual framework

The conceptual framework is partly based on existing literature on the planning of industrial parks as promoted by UNIDO and on the works of Cheng & Bertolini (2013) who reflect on accessibility as the interaction between people and land uses via transportation networks such as roads. As people travel between locations to access opportunities, they must overcome the impedance of time created by the incidental spatial separation of these locations. Further, and to make the research more relevant for decision making on industrial parks, the concept of accessibility is merged with analysis on potential costs for utility connections such as power and water. The framework also includes site assessments done to ensure that proposed parks are guided by both environmental and economic growth considerations.

The parameters that are covered under connection costs for utilities include power and water as the two most critical utilities needed for the development of industrial parks. An analysis on environmental and economic growth considerations is based on two components: (1) an assessed performance of economic growth as an output from the Spatial Development Framework for Rwanda and (2) a Strategic Environmental Assessment for flood risk mitigation. This would serve as a dynamic layer to guide stakeholders and decision makers in selecting appropriate locations for industrial parks. Hence, the research aims to combine the gains of (1) accessibility analysis (2) connection costs for utilities (3) environmental and economic growth, to develop a prototype SDSS to guide decision making during the site selection stage in the planning of industrial parks (Figure 1).

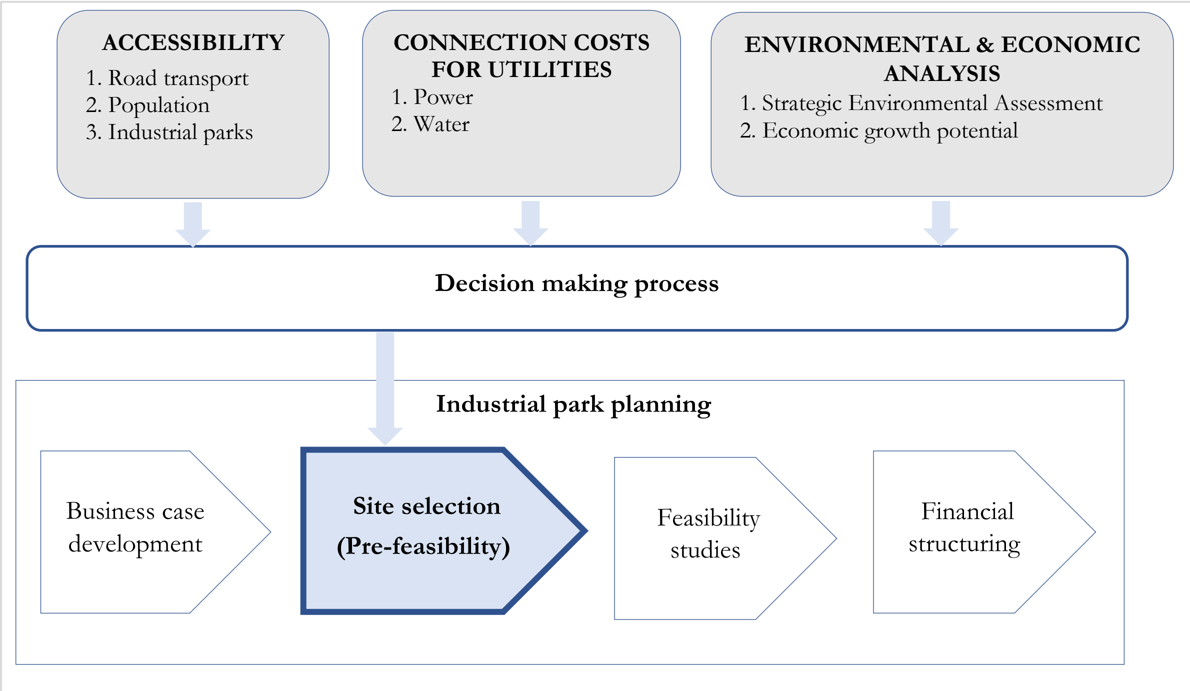

Figure 1: Conceptual framework adapted from UNIDO (2019) & Cheng & Bertolini, 2013

1.5 Thesis structure

This thesis is composed of seven chapters:

Chapter 1 presents introduction to the entire study including the background on industrial park planning in general in the form of a justification for the study. The chapter also includes a definition of the research problem, objectives and questions.

Chapter 2 is focused on a discussion of existing literature on key concepts that are relevant to the study including details on industrial parks, spatial decision support systems, decision making and accessibility methods.

Chapter 3 is a description of the entire research methodology including the approach and data collection techniques.

Chapter 4 presents details on issues relating to industrial park planning processes in the case study area. Issues about the decision making processes and accessibility issues are discussed here.

Chapter 5 is dedicated to the design and development of the SDSS prototype focusing on the main components of the tool.

Chapter 6 reflects on the results of the study based on three main objectives of the study and discussed in context of the existing literature.

Chapter 7 presents some concluding remarks about the study and includes a description of the research limitations and recommendations for future studies.

2. LITERATURE REVIEW

This chapter presents an analysis of existing literature relevant to the study organised in four sub-sections. It provides the needed scientific background to the study and explains the context within which key concepts are applied in the ensuing chapters. The first part explains the concept of industrial parks focusing on major steps in the planning of industrial parks including their general locational and infrastructural needs. The second part examines the concept of spatial decision support systems and characteristics while the third focuses on the spatial decision making process. The final part discuss the concept of accessibility as a major component of land use and transport systems integration.

2.1 The concept of industrial parks

Generally, industrial parks are seen as an effective developmental initiative towards boosting local economic growth within a specific region of a country (Le et al., 2020). This motivation also resonates well with other countries that consider it as a means to facilitating off-farm job creation, establishment of service industries as well as the promotion of environmentally responsible industrial development (Le et al., 2020). Nevertheless, the principal purpose behind the establishment of industrial parks as recognised by UNIDO is to enable "industry to settle and develop at a specific location that is planned and improved to that effect" (UNIDO, 2019a). This broad rationale is also intended to cover the often wide range of terms resulting from differences in the functions and objectives of industrial parks. Consequently, different types of industrial parks such as enterprise zones, free trade zones, high-tech zones etc. have emerged over the years depending on the defined key objectives behind the development of the industrial park. UNIDO in its guidelines for industrial parks differentiates between eight different types of industrial parks namely Eco-Industrial Parks, Special Economic Zones, Border Economic Zones, Export Processing Zones, Free Trade Zones, Bonded Areas, High-Tech Zones and Agro-Industrial Parks (Table 1).

2.1.1 Industrial park planning

Regardless of the type of functionality assigned to an industrial park, four distinct stages in the planning of industrial planning can be identified: Business case formulation, pre-feasibility studies, detailed feasibility studies and financial structuring and agreement (Figure 2).

The first step requires that any decision to initiate an industrial park project is preceded by a strong business case that validate the project risks and opportunities in a detailed manner. Meylan et al., (2017) further asserts that one of the major reasons for the failure of many industrial parks in developing countries is due to the often limited attention that is given to the development of a strong business case. UNIDO further observed that this situation often leads to 'gaps' during the operationalisation of industrial parks where park amenities do not meet the priorities of firms. A proper business case development must cover the following assessments: potential investor priorities; investment and trade patterns; comparative advantage (UNIDO, 2019a).

The second step in the planning of industrial parks involves a cursory pre-feasibility studies to establish the overall potential of an industrial park based on site analysis. This step covers the assessment of critical factors that might influence the location of an industrial park such as access to labour, existing master plans, geophysical conditions and the availability of such infrastructural services as transportation and utilities. The third step covers similar analysis as the pre-feasibility stage but does so in much more detail and serves to justify the decision to initiate and finance any industrial park. As such, it involves a detailed technical assessment of market trends including future projections, cost and benefit analysis, environmental assessments, infrastructure requirements etc. (UNIDO, 2019a). The final step in the process takes care of the financial details required to ensure that the development of the park runs smoothly. During this stage, agreements are made between investors, and institutions who are committed to backing the project.

Table 1: Types of industrial parks

Type	Definition
Eco-Industrial Parks (EIPs)	Also called, sustainable, low-carbon, green, or circular zones, EIPs are industrial parks designed to improve the social, economic and environmental performance of their resident firms, including through the promotion of industrial symbiosis and green technologies delivering resource efficiency and resulting in competitive advantage, promoting climate-resilient industries and green value chains, as well as inclusive and sustainable business practices and socially responsible relations with surrounding communities.
Special Economic Zones (SEZs)	Delineated areas of a country, subject to unique economic regulations that differ from other areas in the same country and generally provide for extra-territorial treatment with respect to customs tariffs.
Export Processing Zones (EPZs)	Duty-free zones focused on manufacturing for export, generally providing export subsidies in the form of tax holidays and having no or minimum export quotas.
Border Economic Zones	Economic zones located along an international border to facilitate cross-border trade and investment.
Free Trade Zones (FTZs) / Free Zones(FZs)	Delineated areas with suspended import taxes and where regulatory compliance obligations are reduced, in order to attract new business and foreign investments.
Bonded Areas / Bonded Zones	Areas where dutiable goods may be stored, manipulated, or undergo light processing (such as assembly) without payment of duty, subject to customs bonds.
High-Tech Parks (HTPs)	Special areas designated to facilitate and promote the creation and growth of innovation-based companies through incubation and other policy interventions.
Agro-Industrial Parks (AIPs)	Specially-designated areas designed to attract and promote industries in downstream agricultural processing.

Source: UNIDO (2019a)

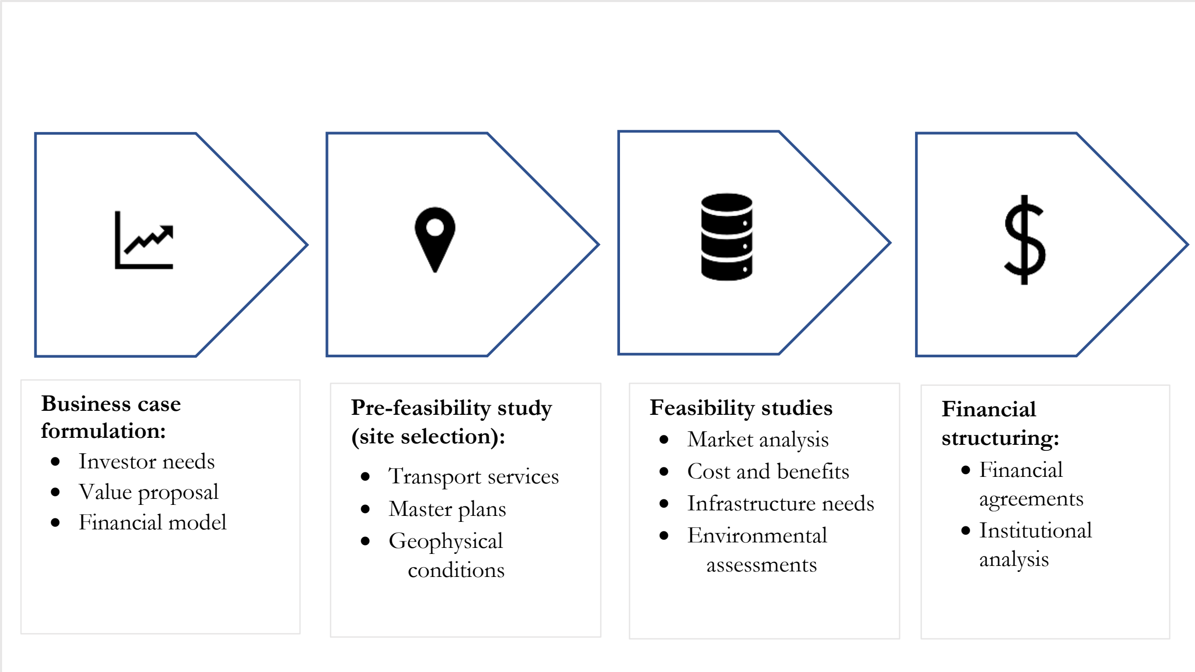

Figure 2: Steps in industrial planning (source: UNIDO, 2019a)

2.1.2 General location requirements and infrastructural needs for industrial parks

Depending on the type of industrial park being planned, locational requirements can range from general geo-political conditions and master plan approvals to more detailed considerations such as projections for market viability, access to labour, strategic environmental assessments, energy and water supplies (Leeuwen, Vermeulen & Glasbergen, 2003; Massard, Leuenberger & Dong, 2018; UNIDO, 2019a). The following outlines some of the key locational and infrastructural needs for industrial parks.

2.1.2.1 Environmental safeguards

Despite the potential of industrial parks to boost the economic growth of host countries, such parks may also pose serious environmental risks (UNIDO, World Bank & GIZ 2017). Indeed, there is an example from Ulsan in South Korea where a report by the Global Green Growth Initiative in 2017 pointed out that industrial wastes had polluted water and air rendering most of the city unliveable (Avis, 2018). Such situations have largely been blamed on the disregard for stricter environmental assessments during the planning and development of industrial parks in favour of fiscal and economic factors (Meylan et al., 2017; Avis, 2018).

But while ensuring that environmental safeguards are incorporated throughout the planning phase, it is most critical during the site selection stage where alternative sites are evaluated. This can ensure that industrial parks deliver the needed social and economic benefits without negative consequences for the environment (UNIDO, World Bank & GIZ, 2017). Avis (2018) also argues that ensuring this at the site selection stage may also lead to savings on environmental compliance costs in the long term. To guide this, a number of international protocols have been put in place. One of such is the Ramsar Convention of

Wetlands which was signed in 1971 to ensure the protection and wise use of wetlands (Gardner & Connolly, 2008). Similarly the Asian Development Bank has prepared a comprehensive sourcebook based on its years of experience in environmental assessment and collaborative management practices with other international development banks (ADB, 2012).

2.1.2.2 Labour force

One of the principal effects of the development of industrial parks is the potential to pull labour from nearby settlements in response to the incidental creation of both skilled and non-skilled employment opportunities (Steiner & Butler, 2007; OECD/PSI, 2020 pp.94). Vidova (2010) for example concluded in his paper that industrial park development in Slovakia should be further encouraged mainly because it acts as a platform for employment creation. Similarly, The World Bank noted that the expansion of Ethiopia's industrial parks was having a positive impact on job creation (World Bank, 2019). While the main factor that affects the attraction of labour force is the type of industrial park being proposed, other issues must be considered during the planning and development of industrial parks. These include the following as outlined by Steiner and Butler (2007);

- Location of labour force
- Characteristic of labour force
- Available transport systems to connect labour force to industrial park
- Relative cost of labour

The first relates to an assessment of places where labour force live and must transport from while the second indicates the specific socio-economic classification of the labour force such as type of skilled labour or educational background available. The third is very critical and relies on the first to assess connectivity of labour force to industrial parks via roads, rail etc. The final consideration covers the relative cost of engaging labour force in the parks.

2.1.2.3 Utilities

Industrial parks require sustainable access to utility services such as power, water and sanitation facilities (UNIDO, 2019a). These must be in adequate supply to match the needs of industrial processes including firefighting purposes in the case of water supply (Steiner & Butler, 2007). To be able to assess these, consideration must be given to locations that are in close proximity to existing utility lines in order to minimise connection as well as general developmental costs. It is also worthwhile to rely on existing watershed features to develop regional stormwater management structures to support industrial parks (Steiner & Butler, 2007).

2.2 The concept of Spatial Decision Support Systems (SDSS)

According to Malczewski (1999), SDSS is "an interactive computer based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem.". SDSS are distinct from GIS in that they are characterised by much more analytical functionalities. In general, SDSS extend beyond the analytical and modelling capabilities of GIS to include flexible and interactive user interfaces to aid in scenario generation and are specifically designed to solve semi-structured spatial problems (Goel, 1999). Given that the problems that are addressed by SDSS are multidimensional and touches on the preferences of different stakeholders, SDSS must allow stakeholders to be able to intervene in the process of decision making through an iterative process of improving solutions that work for all stakeholders. To achieve this, the user interface for SDSS must be less complex and be user friendly (Figure 3).

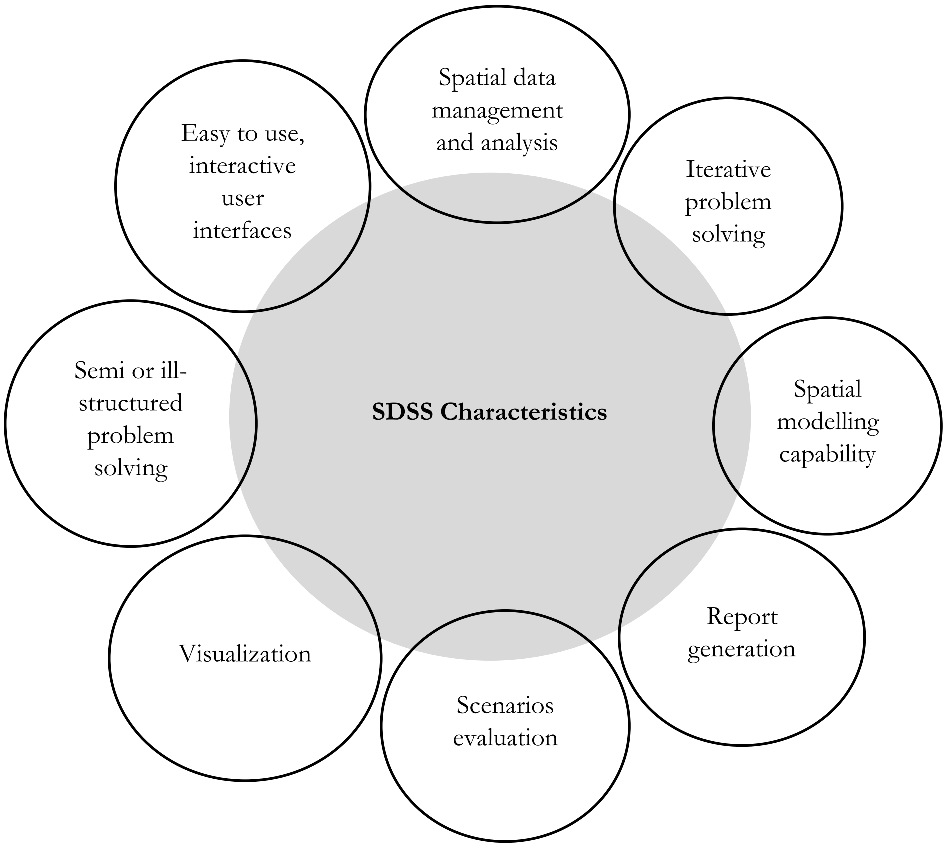

Figure 3: SDSS Characteristics (Sugumaran and DeGroote, 2011)

2.3 Spatial decision making

Decision making refers to the act of making choices between alternatives that are predefined by set objectives and goals (Sugumaran & DeGroote, 2011). These decisions can range from choices such as deciding on where to go on a holiday based on cost of living calculations to more complex decisions that are made by firms on where to build a new retail outlet for example. The latter is an example of spatial decision making that require more complex and decision aids and tools that provides capabilities to analyse spatial characteristics. Kemp (2008) distinguishes between four types of spatial decisions: site selection, location allocation, land use selection and land use allocation.

- *Site selection* decisions are very popular amongst government agencies and businesses that need to consider many spatial factors in deciding on new locations for activities (Sugumaran & DeGroote, 2011).
- *Location allocation* decisions aim for optimal allocation based on set goals and objectives. An example is the consideration of minimising travel time when planning to develop health facilities (Sugumaran & DeGroote, 2011).
- *Land use selection* decisions covers the need to decide on the best use for a given parcel of land. It could be based on 'the parcel, potential surrounding customer base for a business, or physical parameters and limitations of the land for certain kinds of development' (Sugumaran & DeGroote, 2011).
- *Land use allocation* decisions relate to typical spatial planning decisions with regards to assigning various uses to land such as residential, industrial or commercial (Sugumaran & DeGroote, 2011).

Generally spatial decision making is often complicated by the need to include various information that also need to be interpreted by stakeholders with diverse background. It falls into a category of decisions described by Simon (1960) as semi-structured as they are often multidimensional with undefined goals and objectives (Gao et al., 2004). These complexities therefore call for computer based systems that are able to process large amounts of data efficiently and also help to decide amongst alternative solutions (Sugumaran & DeGroote, 2011).

2.4 The concept of accessibility

Over the years, accessibility has been defined and operationalised in various ways. As a consequence the concept has taken on different interpretations. Some of these include the ease of access to a particular land use activity from a location via a transport system (Dalvi and Martin, 1976), 'the extent to which transport systems allow groups of individual reach activities by means of a transport mode' (Guers and Van Wee, 2004) and the "potential space of action firms and households located in certain place have to engage in spatially and temporally dispersed activities" (Straatemeier, 2004). The common features of these definitions are the relations between transport and land use as a consequence of people's need to access opportunities. Guers and Van Wee (2004) relies on this to identify four components of accessibility: land use, transportation, temporal and individual. The *land use component* consists of three sub-components namely (1) the distribution of opportunities in space (2) the demand for these opportunities at trip origins and (3) the interplay of supply and demand which leads to competition for these opportunities. The *transportation component* of accessibility relates to the type of transport system which allows an individual to cover the distance between an origin and destination taking into account travel time and costs. The *temporal component* refers to the availability of opportunities at different times of the day while the *individual component* reflects the needs, abilities and opportunities of individuals.

Litmann (2019) however notes that, although research on accessibility is growing, most current practices in transport system analysis focus on indicators that relate to mobility. This often leads to policy decisions that increases physical movement between locations but reduces accessibility. For example, mobility assessments could result in policy decisions to improve travel speeds within an urban area so that workers could access jobs early. However this could also stimulate urban sprawl and reduce travel options leading to limited interactions between opportunities (Litmann, 2019). Similarly, Levinson and Istrate (2011) in a Brookings institution report also confirm the limitations of mobility assessments by comparing two cities in the United States: Manhattan in New York City and Manhattan in Kansas. The results reveal that although travel speeds were about 37% faster in Manhattan (Kansas) than in New York, city dwellers could reach more job locations in New York than in Kansas mainly due to the relative higher density of jobs in New York. He therefore recommends more comprehensive accessibility analysis to enhance optimal decision making with regards to urban land use decision making.

2.4.1 Accessibility methods

There are different methods for measuring accessibility ranging from very simple to more complex methods. To find answers to the research questions under Sub-objective 2, it would be necessary to understand the advantages and disadvantages of the different methods that exist. Accordingly, Guers & van Wee (2004) identifies four distinct perspectives on measuring accessibility: Infrastructure-based, Location-based, Person-based and Utility-based measures.

- *Infrastructure-based* measures only focus on the transportation component of accessibility to evaluate the performance of the system. A critique of this measure is that it is one-sided and does not consider the land use component of accessibility and thus not adequate for comprehensive analysis (Brussel, Zuidgeest, Pfeffer and van Maarseveen, 2019).
- *Location-based* measures considers both transport and land use components to analyse accessibility between an origin and destination for example the number of jobs within 30 minutes from a specific location (Guers & van Wee (2004). Location-based measure range from simple contour measures to more complex analysis that include the effect of distance and spatial separations on accessibility.
- *Person-based* measures analyse accessibility at the individual level and thus require detailed disaggregated data. It mainly considers travel time between spatially distributed activities (Guers & van Wee (2004)
- *Utility-based* measures considers the travel costs between locations to assess the utility commuters derive from access to distributed activities

Contour measures are however popular among urban and transport planners mainly due to its easy interpretability (Bruinsma and Rietveld, 1998). Compared to other accessibility measures, contour requires less data and assumptions thereby making it easy for researchers and planners to explain to non-technical audiences (Guers & van Wee, 2004).

3. METHODOLOGY

Chapter 3 explains the methodology employed to answer the research questions feeding on key concepts from chapter 2 as well as existing literature on design research. After a short description of the research approach, the section begins with a brief description of the study area to put the rest of the chapter in context. The second part describes the data collection methods and instruments for both primary and secondary data. A detailed description of the methodology for accessibility assessments is included in the third part to provide background for the fourth part that describes the main approach adopted for the SDSS development. This also includes a detailed description of the SDSS design framework and how data is analysed and processed to achieve the ultimate goal of SDSS development. The last section talks about the key ethical considerations employed in this study.

3.1 Research approach

The principal research method employed in this study is a case study research as a component of design research (Teegavarapu & Summers, 2008). Simon (1969) defined design as "a series of steps taken by designers to transform a given situation into a preferable one" and is often applied and framed as an empirical study focusing on both scientific and tacit human knowledge of existing phenomenon to develop tools and models that are of general value (Teegavarapu & Summers, 2008). In this context, case study method helps to "investigate a contemporary phenomenon, focusing on the dynamics of the case" and is particularly useful for design research that attempts to find answers to how kind of research questions (Teegavarapu & Summers, 2008) by combining different data collection techniques.

According to Yin (2009) a case study research method typically follows a six-stage process that comprise of Plan, Design, Prepare, Collect, Analyse and Share (Figure 4). The plan phase entails the identification of appropriate rationale and research questions for a doing a particular study. As such a detailed assessment of relevant literature vis-a-viz the research questions is a major requirement for case study research (Ravitch & Riggan, 2011). The design stage defines the unit of analysis focusing on some of the underlying issues that could affect data collection and analysis (Baskarada, 2014). In the context of this paper therefore, this entails defining all issues relating to industrial park planning in Rwanda including infrastructure, utilities, stakeholders etc. The prepare stage aims to adequately equip the research with all needed skills prior to undertaking data collection (Yin, 2009). Consequently, issues such as testing of data collection instruments, techniques and overall methodology are considered in this stage. The collect phase focuses on the actual data collection on the unit of analysis. With case study, data collection focusses more on collecting direct evidence about events and happenings rather than the perceptions and character of participants (Yin, 2009). The analyse phase finds basis on theory to present data as an output from the collect stage (Baskarada, 2014). The final stage of case study focuses on determining an appropriate way to communicate text and display material to target audience (Yin, 2009). This is to allow for easy interpretation by readers.

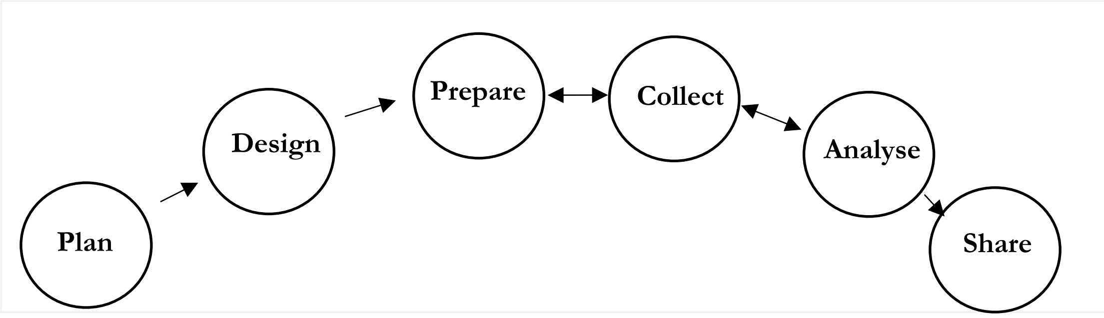

Figure 4: The case study process adapted from Yin, (2009)

3.2 Study area

With a population of 2,589,975 the Southern Province is the second most inhabited province in Rwanda. It is part of five provinces created in 2006 after the government reorganised the previous 12 préfectures to the current 5 provinces namely: Kigali City, Southern Province, Northern Province and Eastern Province. The Southern province is however amongst the least urbanised (9 per cent) in the country with Huye, Muhanga, Ruhango and Nyanza being the only urbanised districts (Figure 5). Huye and Muhanga also coincide as the locations for the only two industrial parks in the province.

The economic mainstay of the province is dominated by agriculture with districts such as Gisagara, Kamonyi and Ruhango leading in agricultural productivity. There are also good educational and health facilities located in Huye and Gisagara. The first national university in Rwanda is situated in Huye and thus hosts many students from across the country in the midst of growing influx by tourists who visit the national museum that is strategically situated along the main highway from Kigali to Burundi (The Republic of Rwanda, ITC & UN-Habitat, 2016).

In terms of socio-economic development the SDF[1] report for 2016 classified the three districts of Muhanga, Ruhango and Nyanza as constituting an Economic Development Area (Figure 6) mainly due to the concentration of urban population (about 6 percent) situated in close proximity to each other and functional interdependencies (The Republic of Rwanda, ITC & UN-Habitat, 2016) and thus able to support investments in industrial infrastructure that create off-farm job opportunities.

3.3 Data collection methods

The following sections describe the processes and strategies employed to gather data from respondents via interviews and a simulated workshop. Interview sessions were semi-structured to allow for flexibility and to ensure a comfortable environment for respondents. The workshop session served to gain inputs from target stakeholders on the usability of the first version of the SDSS prototype.

[1] The Spatial Development Framework (SDF) for Rwanda is a document that serves as a guide for national urbanisation based on an understanding of territorial dynamics and structure as well as the specific roles of settlements in the country's strive for a 35% urbanisation by 2030 (SDF, 2016)

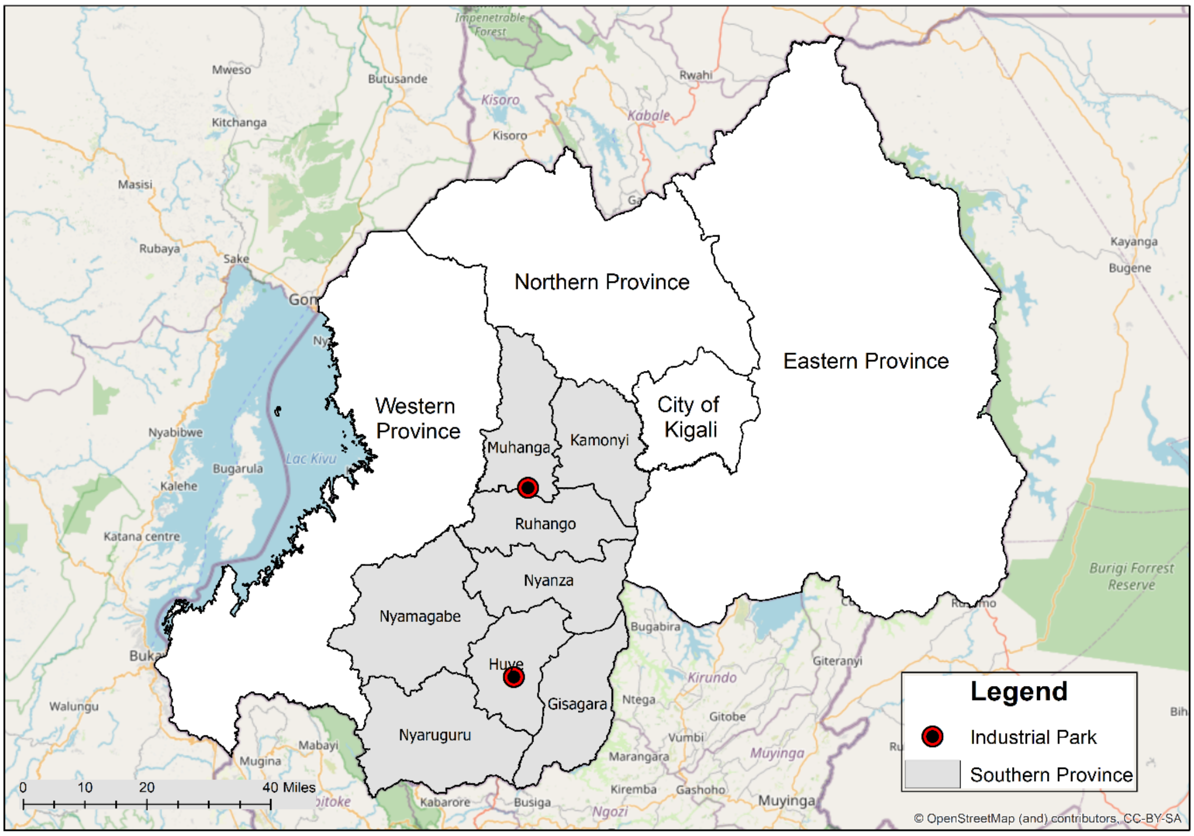

Figure 5: The Southern Province of Rwanda

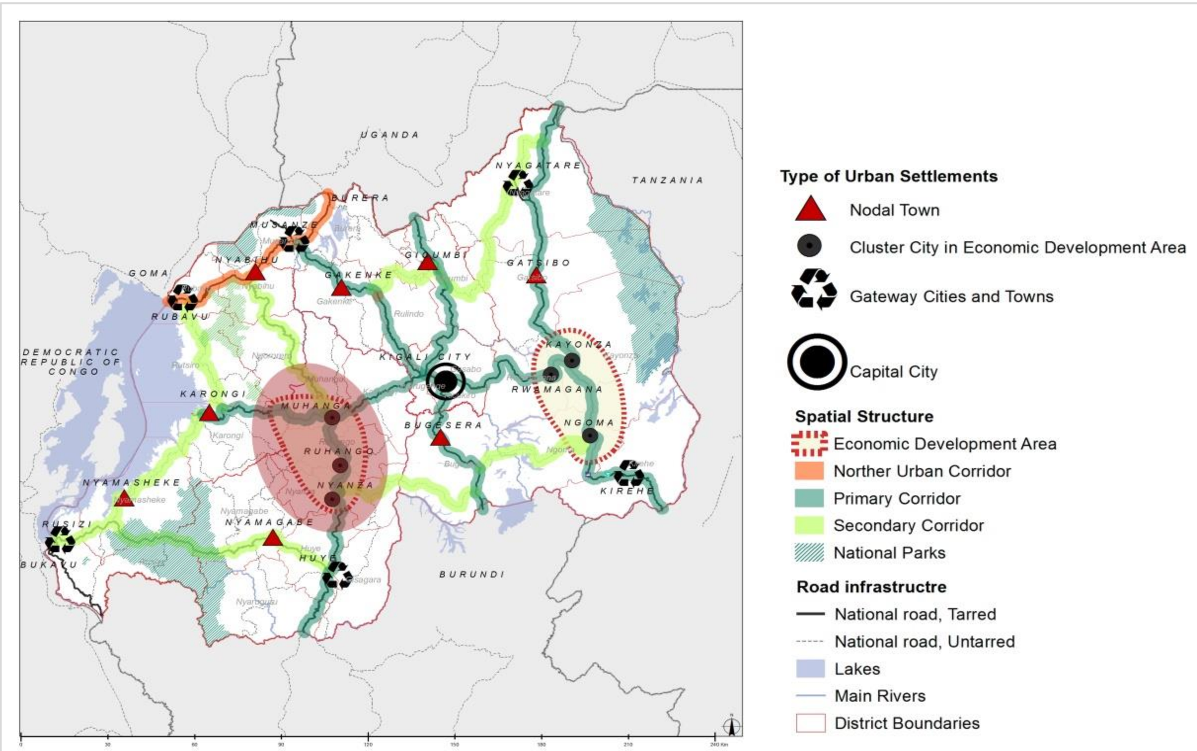

Figure 6: Economic Development Area for the Southern Province in national context (source: The Republic of Rwanda, ITC & UN-Habitat, 2016)

3.3.1 Key informant interviews

This study adopted the semi-structured interview strategy as explained by Abdulai (2010) and Naoum (2013). This type of key informant interview is preferred over the other two types (i.e. structured and unstructured) mainly to gain a broader view of the decision making process and also to allow for follow up questions while keeping the dialogue formal.

Based on an exploratory interview with representatives from the Ministry of Infrastructure (MININFRA), a number of key stakeholders were selected including representatives from, Ministry of Trade and Industry (MINICOM), Huye One Stop Centre, International Growth Centre (IGC), Private researchers, Rwanda Land Management and Use Authority (RLMUA) and the National Institute of Statistics Rwanda (Table 2). The choice for these institutions were based primarily on the diverse roles they play in the industrial park planning processes. MININFRA in particular is the institution responsible for implementing all infrastructural needs for industrial parks and as such coordinates with the other stakeholders mentioned above in the development of industrial parks.

Table 2: List of key informants per institution

Institution	Person(s)	Code
Ministry of Infrastructure (MININFRA)		
• Transport Unit	2	Informant 1 & 2
• Water & Sanitation Unit	1	Informant 3
• Urbanisation Unit	1	Informant 4
• Energy	1	Informant 5
Ministry of Trade and Industry (MINICOM)	1	Informant 6
Huye One Stop Centre	1	Informant 7
International Growth Centre	2	Informant 8 & 9
Researcher	1	Informant 10
National Institute of Statistics Rwanda	1	Informant 11
Rwanda Land Management & Use Authority	2	Informant 12 & 13

The questions contained in the interview guide covered five main themes; (1) How is the decision making process in terms of industrial development (2) How is collaborative planning ensured in the process (3) Which stakeholders are involved in the process (4) What are the current plans for industrial development (5) How could the SDSS improve the decision making process.

3.3.2 Workshop

The main goal of the workshop is to test the usability of the first version of SDSS prototype, it also served to achieve the objectives of *prototyping approach* to SDSS development whereby developers and end users iteratively work towards an acceptable final version of the system (Veronica, 2007). Observations and comments generated from the workshop served as input for improving the prototype SDSS further. In this regard, a stakeholder workshop was planned and executed on the 25th of February, 2020.

The choice for participants was based on four main criteria including spatial planning, GIS expertise, and those with experience in working in the power and water utility sectors. Consequently, participants were drawn from the Planning, GIS, Energy and Water and Sanitation divisions of MININFRA (Table 3). Participants from the Planning division also had experience with industrial park planning through continues collaboration with MINICOM in the development of relevant infrastructure. This was to ensure that inputs gathered from the workshop would cover a wider range of technical and procedural issues necessary for improving the model.

Workshop views and comments for further improvement of the SDSS prototype were gathered by way of a 30 minutes recorded session whereby participants discussed amongst themselves the key issues that needed to be addressed in the model.

Table 3: Professional background of workshop participants

Division	Person(s)
Planning	6
GIS	2
Water & Sanitation	1
Energy	1
Total	10

3.4 Method for measuring labour accessibility to existing industrial parks

To measure current labour accessibility to existing industrial parks, the study adopted a contour measure as a type of location based accessibility methods (explained in 2.4.1). This requires data on both the land use and transport components to measure travel time between locations. Consequently, spatial data on the locations of the two existing industrial parks together with the locations of unemployed people per Sector within the Southern province was used for the analysis. These served as the land use components of the accessibility assessment. The transport components is represented by the road data that is made up of National and District Roads Class 1 within the province. Based on this, and calculating from the industrial park locations, travel time is visualised by polygons that merge places of equal travel time at a discretional time breaks of 30, 60 and 120 minutes. The methodological steps for this process is shown in Figure 7.

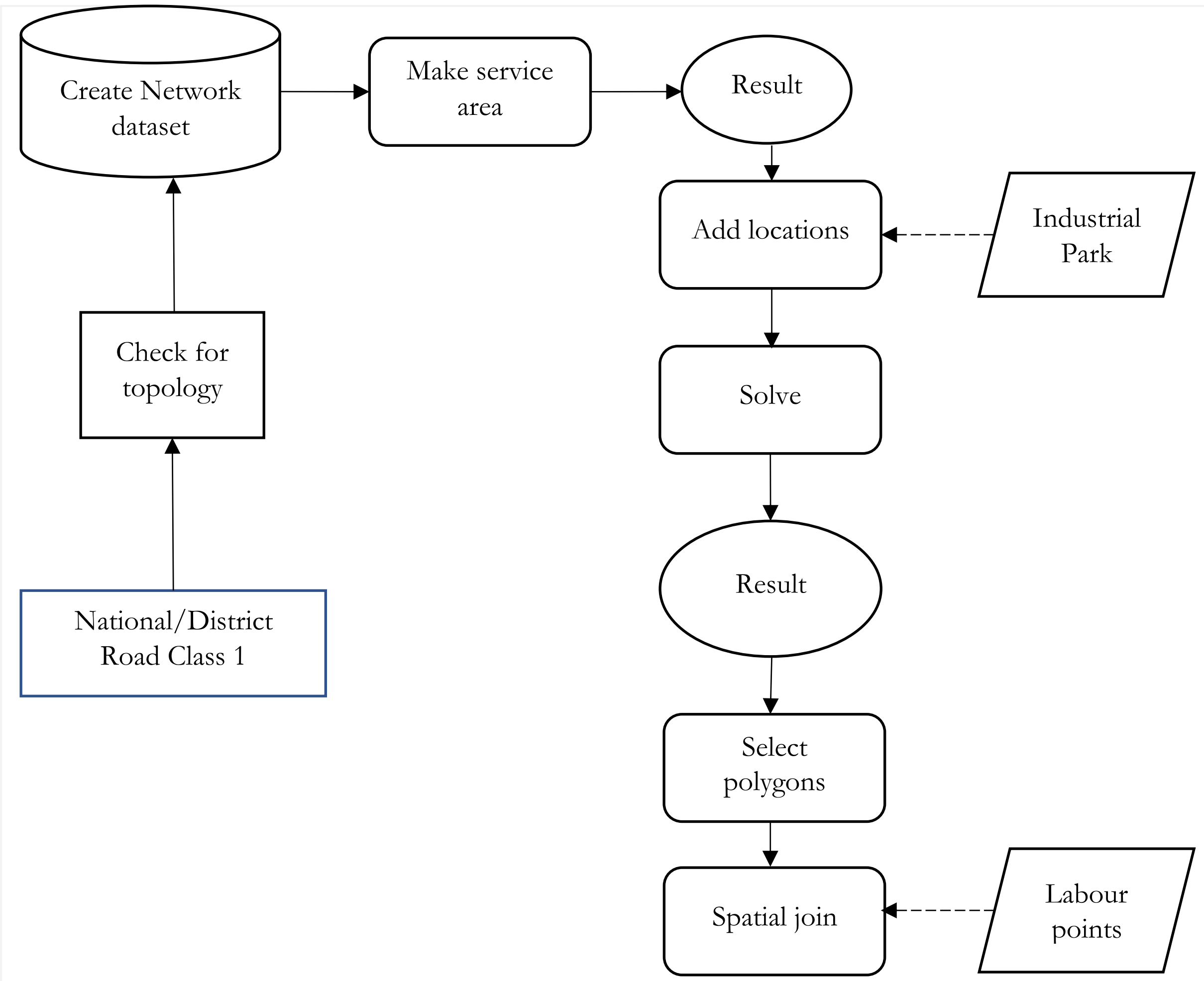

Figure 7: Method for labour accessibility measurement

3.5 Method for SDSS development

The method adopted for the SDSS development process is the Prototyping Approach as explained by Veronica (2007) amongst 3 other approaches: Phased, Evolutionary and End User. According to her, the prototyping approach is convenient for the development of complex decision support systems and provides an iterative and feedback functionality (Figure 8) whereby developers and end users can work together towards an acceptable final version of the SDSS through prototype development and testing cycles (Sugumaran & DeGroote, 2011). The phased approach is based on a linear process of problem definition, analysis of systems requirements, system design and implementation while the evolutionary approach follow a similar iterative procedure as the prototyping whereby both the developer and the end user continually improve the system that is developed at the end (Sugumaran & DeGroote, 2011). The end user approach works well for relatively smaller spatial problems where the end user is also the system developer.

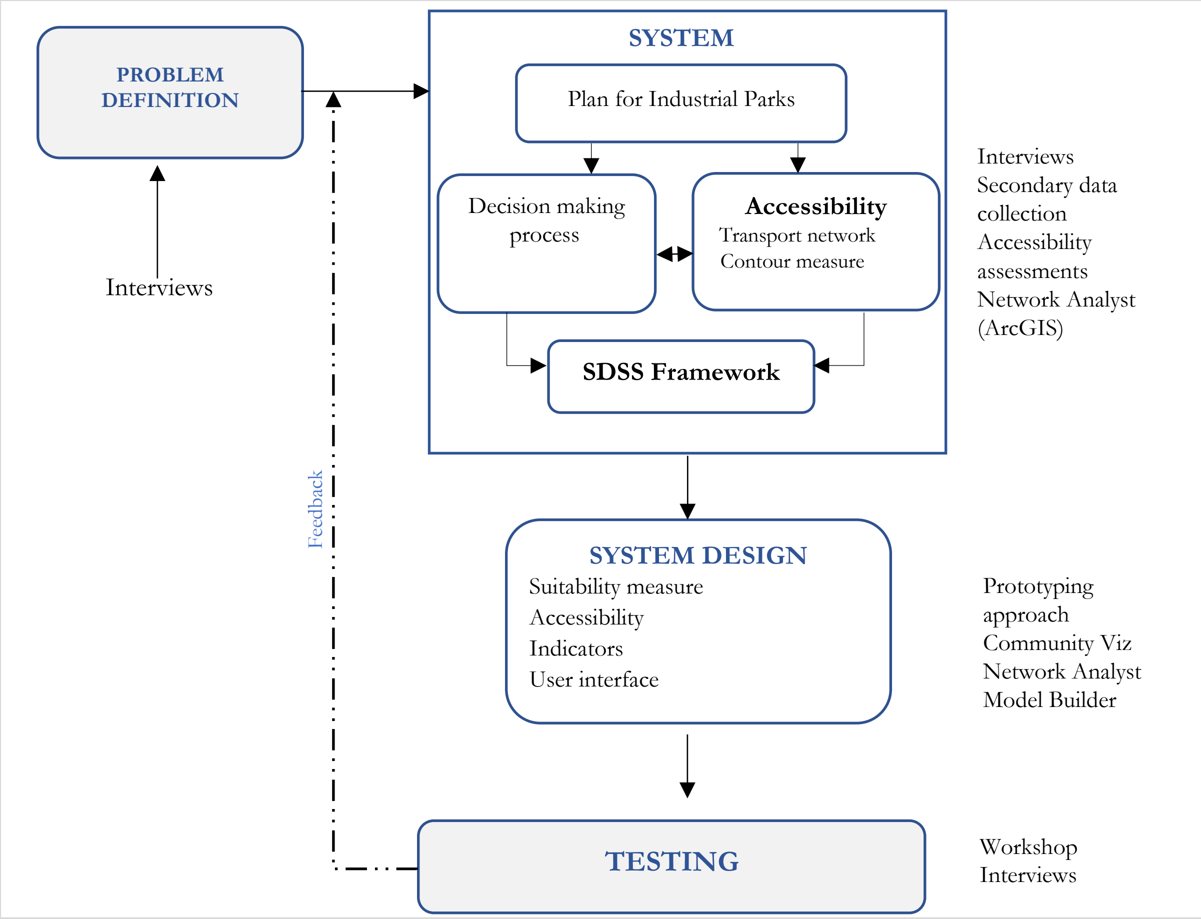

Figure 8: SDSS development process (adapted from Hartati, 2018)

3.5.1 SDSS Design components

Sugumaran & Degroote (2010) identified four key elements of any SDSS framework namely Database management, Dialogue management, Model management and a Stakeholder functions (Figure 9). The Database management functionality holds all necessary input data that are included in the design while the dialogue management functionalities provide an interface whereby users can make inputs and interact with the system. Model management is the key component that links together all processes that are activated when users interact with the system while stakeholder element explains how users must interact with the system.

3.5.1.1 Database management

The Database management component is where all spatial and non-spatial data including the network dataset needed for accessibility analysis. The process for setting up the network dataset is described in the following section.

Building network dataset

The first step in accessibility analysis required the preparation of a network dataset using ArcGIS' Network Analyst extension (Figure 10). First the road infrastructure data was checked for connectivity using the 'topology' tool in ArcGIS. As a requirement, this was performed for both national and district roads class

1 roads after which both were combined into a single shapefile called 'Road' and stored in a geodatabase. The length of each road segment and travelling speeds of 40 and 30 kilometres per hour was calculated and stored as an attribute for National and District Road Class 1 respectively. This is used by the Network Analyst to calculate travel times as the main impedance for each trip.

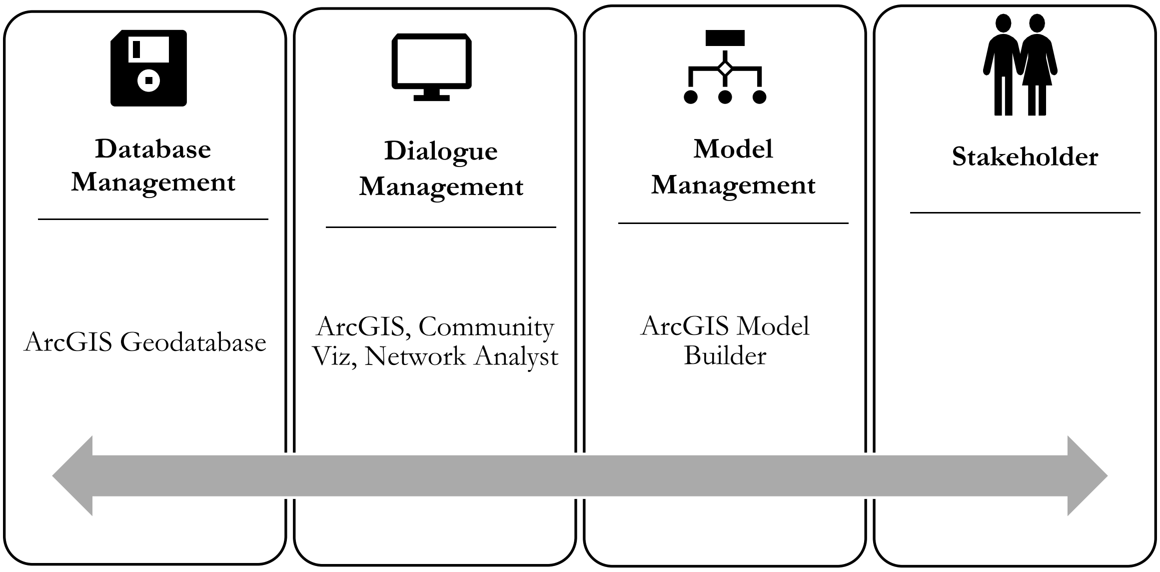

Figure 9: SDSS design framework

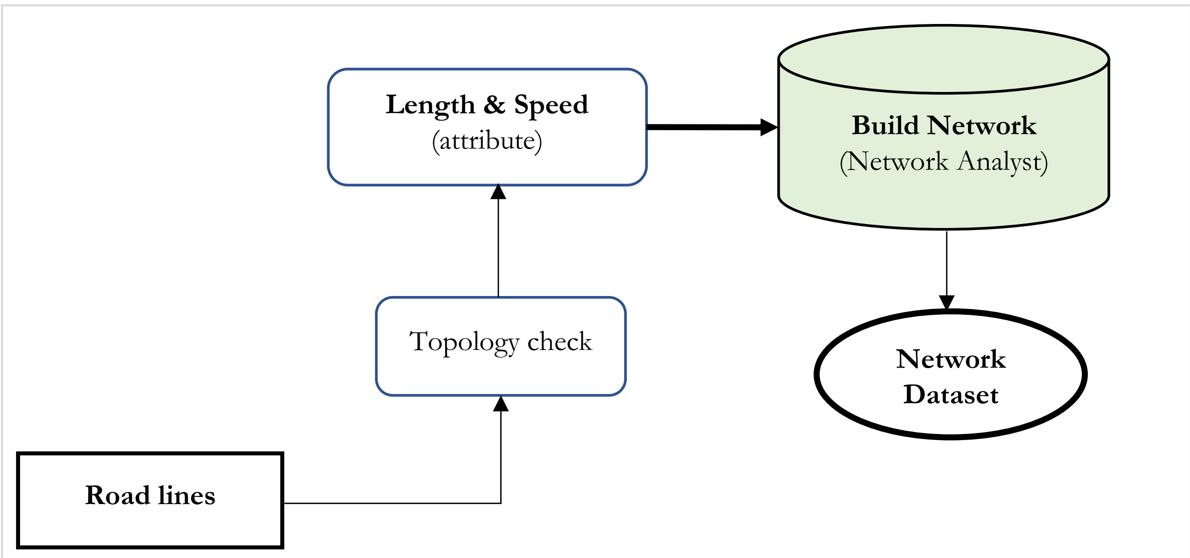

Figure 10: Building the network dataset

3.5.1.2 Dialogue management

The dialogue management component uses basic functions of ArcGIS, Community Viz and Network Analyst to visualise data, indicators and accessibility outputs which serve as the user interface. There are five panels that make up the user interface (Appendix 2). *The Indicator* and *Table of Content* panels display charts and input data respectively. The *Map View* panel displays both input data and results of analysis done via the use of the *Custom Toolbar* as users interact with the model. The *Editing* panel allows users to edit and create new features on the map view.

3.5.1.3 Model management

ArcGIS' ModelBuilder is the main tool used in model management to connect the necessary workflows that are activated by users' inputs (Figure 11). It is made up of two main components. The first component contains a workflow for accessibility measurement using service area analysis tool of Network Analyst while the second component contains a set of tools that work with Community Viz to trigger updates on the indicator panel.

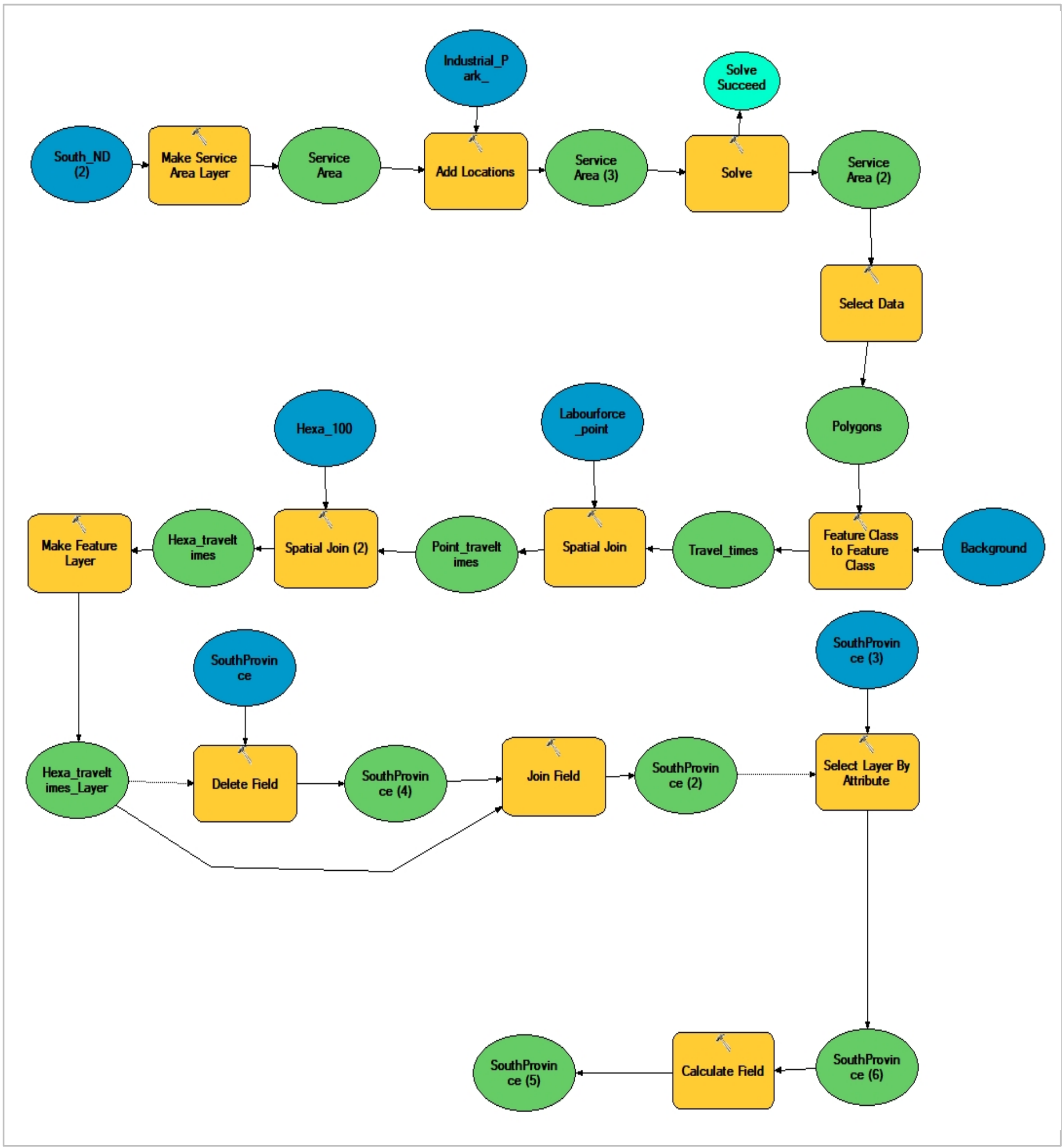

Figure 11: Model management component of SDSS

Accessibility measurement

The accessibility measurement was achieved using the service area tool of Network Analyst toolbox and forms the first part of connected tools as shown in Figure 11. Figure 12 shows in detail the key processes that connect to achieve the accessibility measure. The tool generates isochrones that merges areas with equal travel time. To achieve this, the centroid of industrial parks served as points of origin and depend on the speed information built into the Network dataset discussed in 3.4.1.1 to generate polygons that merge areas at the defined travel time breaks of 30, 60 and 120 minutes.

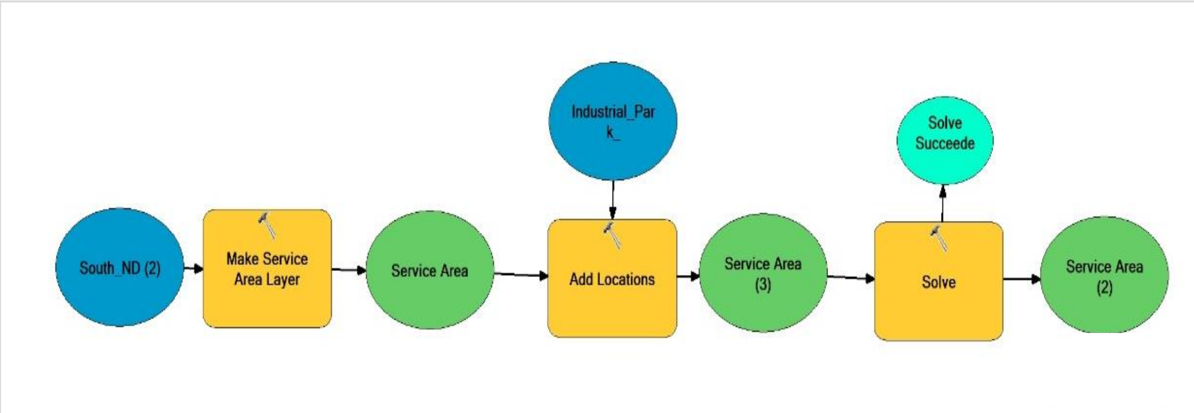

Figure 12: Model for accessibility measurement

Dynamic updates

Whenever the accessibility measurement is activated, it prompts the dynamic updating of the three charts that are displayed on the indicator panel namely: labour force, power connection costs and distance to water pipeline. To quantify the number of labour force, the model performs a 'spatial join' analysis in combination with Community Viz and the result shown in a bar chart for each travel time. The second dynamic indicator calculates the connection costs for power for each industrial park location using Equation (1). This update relies on Community Viz to measure the minimum distance from an industrial park to the closest existing power Medium Voltage line and then multiplies it by the unit cost given as 45 million Rwandan Francs (personal communication, informant 5, interview 24-Feb-2020).

Connection cost = minimum length (km) x 45,000,000 RWF ------------------------------------ (1)

The third dynamic update relates to the distance of industrial parks from the nearest water pipeline to give an indication for further calculation of water connection costs. Similar to the second indicator, it also relies on the capabilities of Community Viz to derive the minimum distance to existing water pipelines.

3.6 Ethical considerations

This study applied the principle of Kantian ethics throughout the research to ensure that all rules of conduct are adhered to. Kantian ethics is based on the ideology of always doing the right thing and for the right reasons mainly in recognition of the fact that human dignity must be respected at all time (Westacott, 2019). This study therefore applied ethical considerations in two phases: seeking consent and protection of personal data. To achieve the first, the ITC's consent form were administered to interviewees to seek their consent prior to answering questions. This was to ensure that they understood all the necessary information provided them prior to participating in the research. Also, given that some responses touched on personal preferences, utmost care was taken to ensure confidentiality during the analysis phase. All responses are therefore analysed anonymously with no possibility to identify respondents from the outputs of the research. Additionally, the following principles guided the implementation of the research: honesty, scrupulousness, transparency, independence and responsibility in line with the Netherlands Code of Conduct for Research Integrity (ITC Ethics committee, n.d.).

4. INDUSTRIAL PARK DEVELOPMENT IN RWANDA

This chapter provides more details on issues relating to industrial park planning processes in three sections. It is based on secondary data collected (Table 4) through informant interviews as described in the previous chapter and would serve as the basis on which the SDSS is developed. The first part provides further infrastructural, demographic and environmental details on the Southern Province as the case study area. The second part analyses the decision making processes for industrial park planning including a description of stakeholder roles in the process. The final part focuses on the current accessibility to industrial parks focusing on travel time for labour force.

Table 4: Data formats, year and description

No	Data	Format	Year	Owner
1	Population data	Shapefile	2012	NISR
2	Location of existing industrial parks	Shapefile	2016	RLMUA
3	Location of proposed industries	Shapefile	2016	MINICOM
4	Road Network	Shapefile	2015	MININFRA
5	Traffic surveys	.pdf	2016	MININFRA
6	Average travel speeds	.pdf	2019	MININFRA
7	Neighbourhood boundaries for Southern Province	Shapefile	2019	MININFRA
8	Power distribution lines	Shapefile	-	MININFRA
9	Water distribution line	Shapefile	-	MININFRA
10	Strategic Environmental Assessment for Huye	Raster	2020	Mossink (2020)

4.1 Industrial park development

Data on industrial parks were gathered from MINICOM including the spatial locations of all existing and proposed industrial parks. There are currently 2 industrial parks located within the Southern province at Huye and Muhanga respectively and are at different stages of development (Figure 5). The location of these two industrial parks in Huye and Muhanga also align with the new designation of these settlements as secondary cities and as such are targeted to be developed as growth poles to contribute towards the country's push for a 35 per cent urbanisation by 2030 (MININFRA, 2013a). Already some 65 acres and 50 acres of land have been allocated for the industrial parks in Muhanga and Huye respectively. But while the land at Huye has been fully acquired and expropriated, that of Muhanga is yet to be fully acquired in the midst of limited funds which has halted further land allocation processes (MINICOM, 2020). The main reason for this situation is that current expropriation arrangement depend heavily on government subventions which are often unreliable (personal communication with informant 7, interview 22-Jan-2020).

So even though some Five Billion Rwandan Francs has been budgeted for Muhanga, the disbursement of funds has not been forthcoming as expected (MINICOM, 2020).

4.2 Road infrastructure and travel speeds

Rwanda adopts a hierarchical classification of its road network which are further designated according to the functionality it serves in the entire network of roads in the country. Accordingly, four main classes of roads are identified: National Roads, District Road Class 1, District Road Class 2, Other Roads. However only two classes National and District Class 1 roads are included in the model mainly because current bus operations do no cover the other road classes. Further the comparatively bad surface conditions of the other classes of roads as a result of years of neglect in investments (MINICOM, 2011) make it practically unfit for assessing travel times for accessibility modelling especially to industrial parks, a situation already described by MINICOM as one of the main constraints faced by industries in Rwanda.

Speed information was obtained from a report by Esri Rwanda Ltd. in 2019 working on behalf of MININFRA as part of an assignment to study Road and Public Transport Accessibility for the entire country. Consequently, the practicable travel speeds assigned to National Roads and District Road Class 1 is 40 km/hr and 30km/hr respectively and is based on analysis on the topography and the legal travel speeds within urban areas (Figure 13).

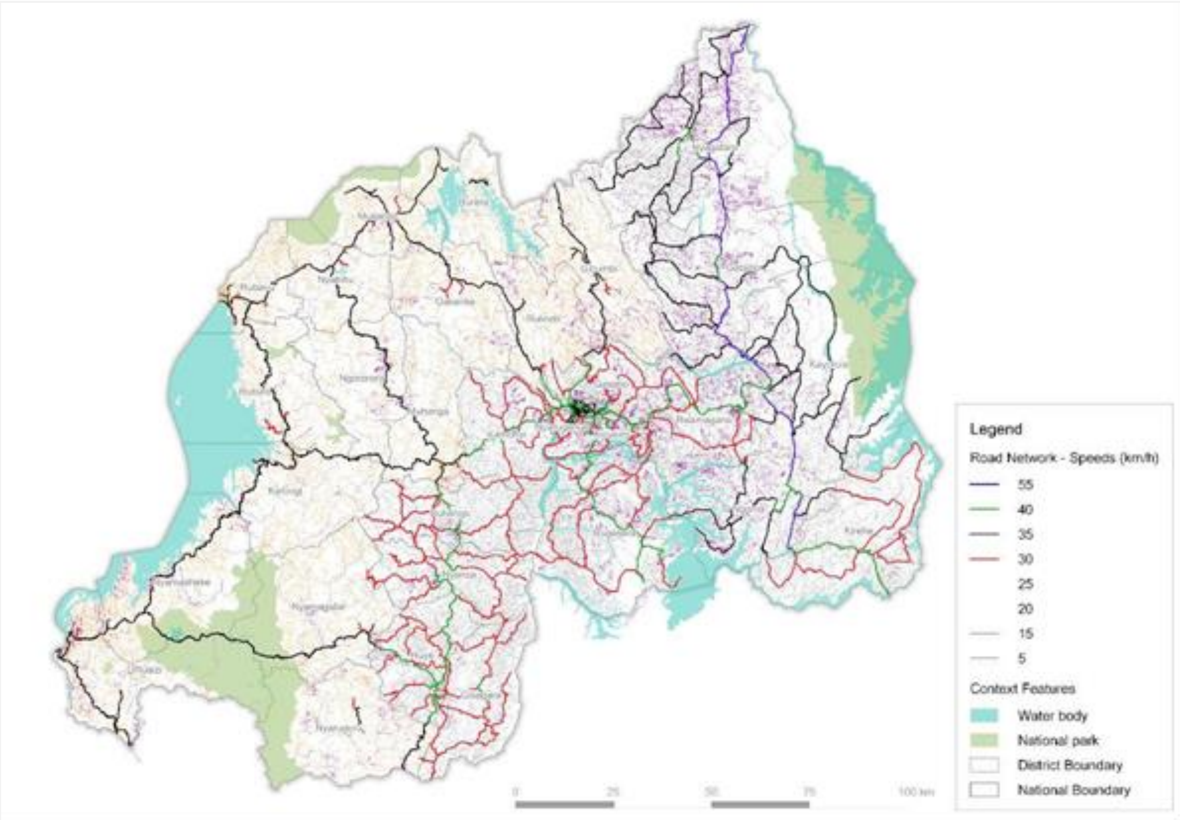

Figure 13: Road classification by travel speed. Source: Esri Rwanda Ltd. (2019)

4.3 Power and water distribution lines

MININFRA provided spatial data on two utility distribution lines: power, and water (Figures 14 and 15). These two are defined by MINICOM as the two most critical utility needs that influence decision making on industrial park location allocations. This would be included in the model to assess the estimated costs of connecting proposed industrial park sites to existing utility infrastructure. The data on power include three classifications of Low, Medium and High Voltage lines while that of water include locations of all water pipelines with varying diameter ranging from 25 inches to 950 inches.

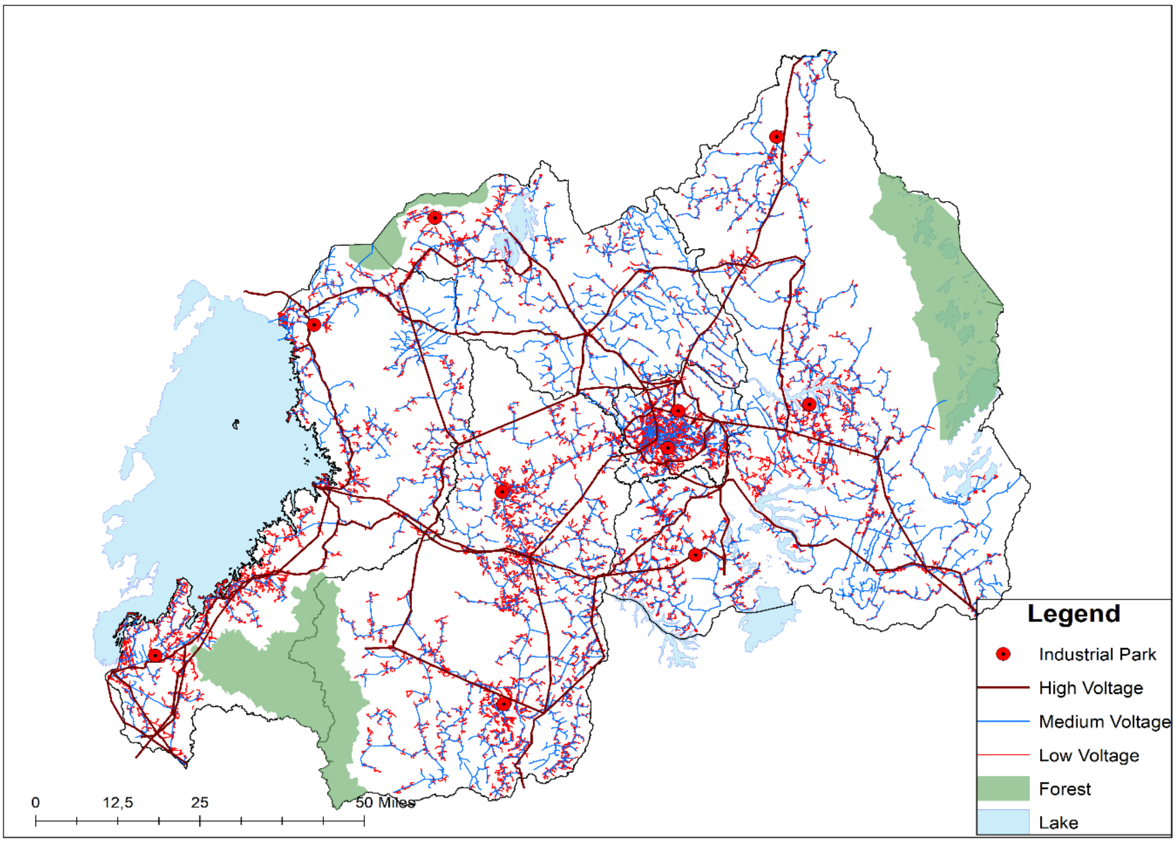

Figure 14: Power distribution lines in Rwanda. Source: MININFRA (2020)

4.4 Population

Population data was derived from the National Institute of Statistics Rwanda (NISR) up to the Sector level. Due to the lack of a more recent disaggregated data on population dynamics up to the lowest administrative unit available, the 2012 Population and Housing Census is used for this study. Figure 16 represents the population distribution of residents aged 16 years and above per sector who are classified as unemployed (NISR, 2014). Given that the legal age for working in Rwanda is 16 years, unemployed population is therefore defined by NISR as number of persons who are available for work but are without work (NISR, 2014). This classification of people however, do not constitute people who were unemployed but actively seeking work as at 2012.

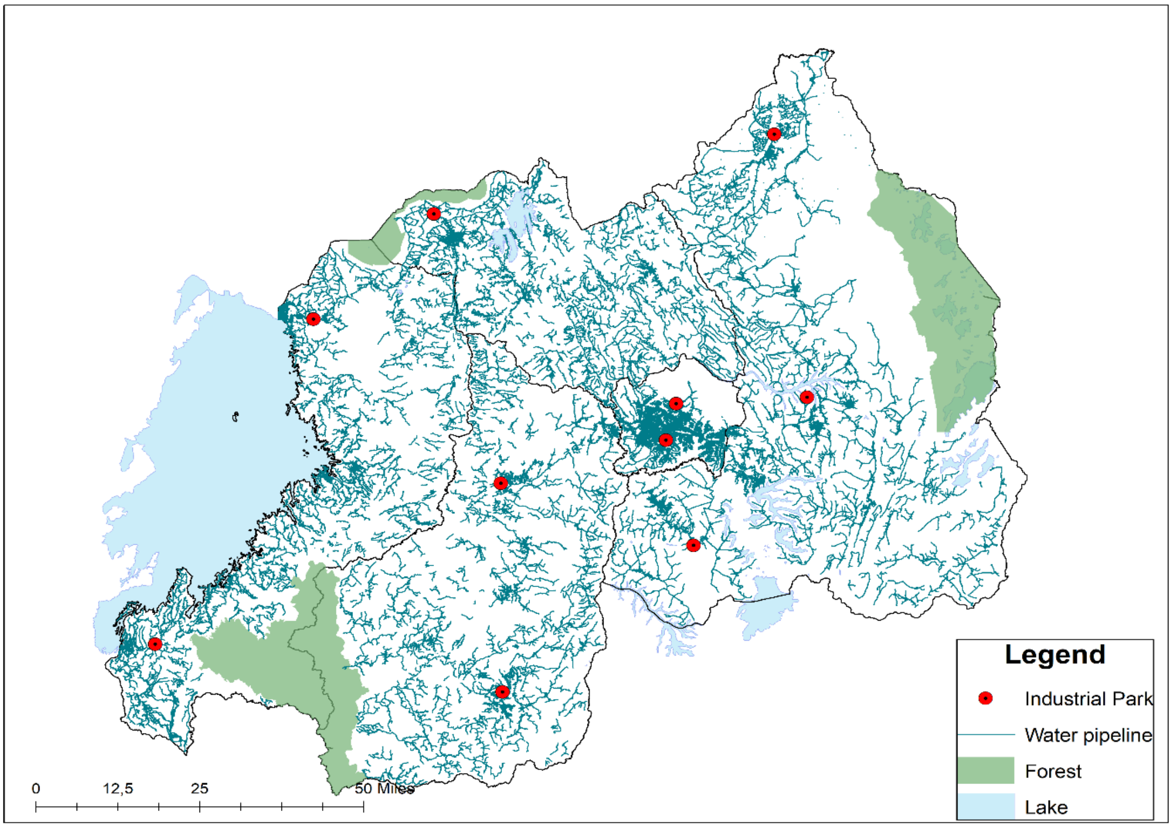

Figure 15: Water distribution network for Rwanda. Source: MININFRA (2020)

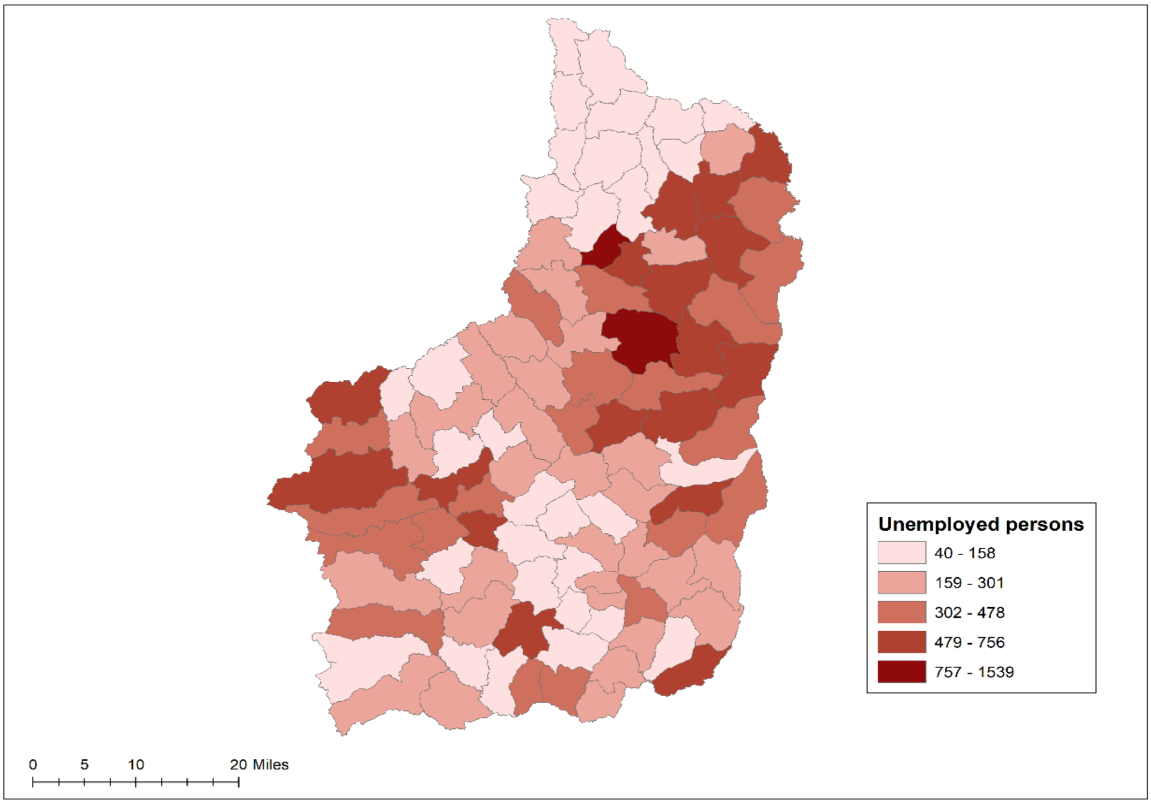

Figure 16: Number of people classified as unemployed per Sector. Source: NISR, 2014

4.5 Economic growth performance

Figure 17 is a performance evaluation of settlements in terms of achieving economic growth and off-farm job creation as one of the major pillars of the National Urbanisation Policy (NUP). The result is achieved during the Spatial Multi-Criteria Evaluation phase of the SDF preparation by an identification of human settlements in which better progress is made towards the goal of achieving economic growth. The specific objective is to "*facilitate employment and off-farm productivity*" which is also in line with the motivations behind the development of industrial parks in Rwanda (The Republic of Rwanda, ITC & UN-Habitat, 2016).

The unique advantage of such data is its potential to guide investment targeting in urban centres for the purpose of stimulating rapid off-farm employment creation such as those offered by the development of industrial parks. Thus stakeholders would be able to make informed choices the allocation of industrial parks during the planning process.

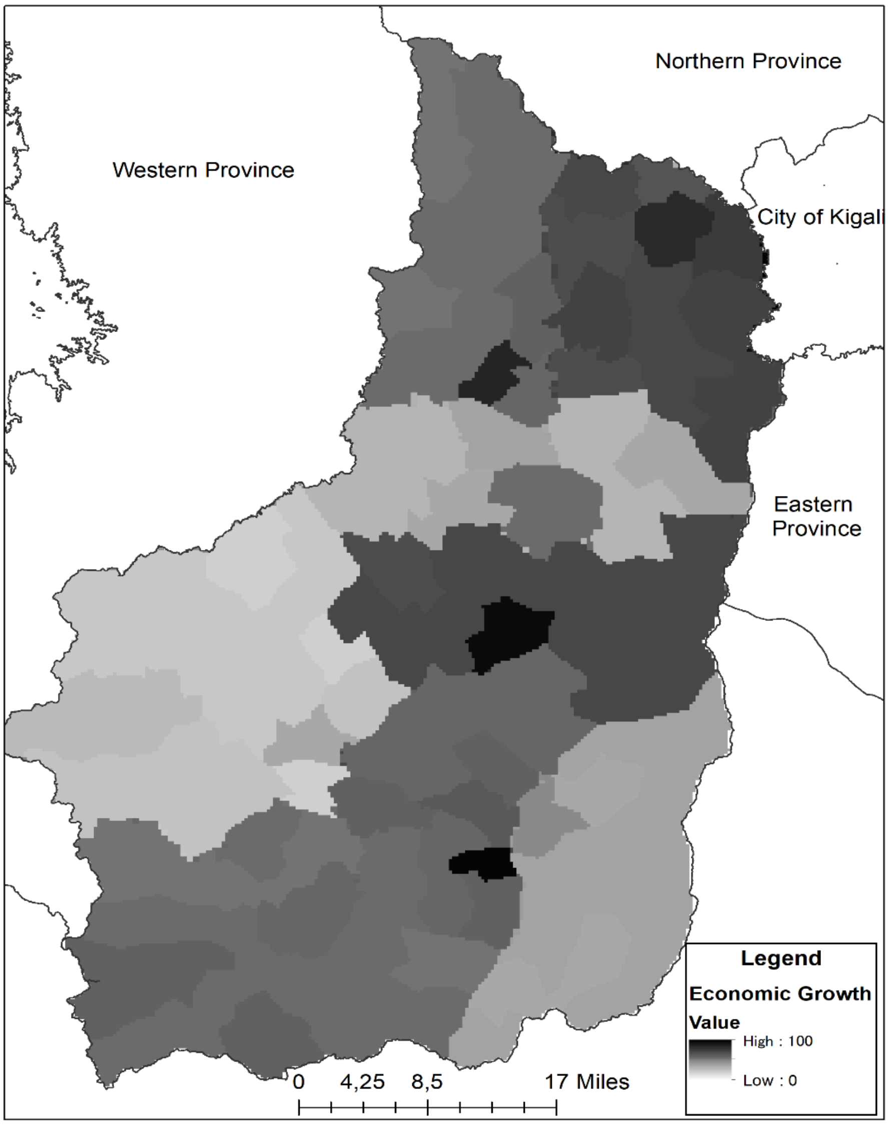

Figure 17: Economic growth performance of settlements in the Southern Province (source: The Republic of Rwanda, ITC & UN-Habitat, 2016)

4.6 Strategic Environmental Assessment for flood risk mitigation in Huye

Figure 19 represents the output of a Strategic Environmental Assessment (SEA) assessment that has been prepared for the district of Huye by Mossink (2020). The overall objective of the SEA is to position the development of industries within an environmental context focusing on the mitigation of floods risks and is built on 5 sub-objectives (Figure 18).

The first sub-objective is built on 2 key indicators; (1) to minimise surface run-off resulting from increases in impervious surfaces and (2) to minimise surface run-off that results from an increase in construction activities on steep slopes. The second sub-objective is aimed at protecting wetlands by discouraging construction activities near water bodies such as rivers, lakes and wetlands. The main indicator under the third sub-objective aims at further securing 'protected' wetlands from degradation resulting from upstream developments. The fourth sub-objective is premised on assisting industries to minimise costs relating to flood adaptation in two areas; avoiding areas with high rainfall patterns as well as those with steep slopes. The final sub-objective focuses on encouraging the development of industries in relatively safer areas based on four key indicators; (1) areas with low water discharge due to high infiltration rates, (2) areas with high reservoir storage capacities, (3) areas with relatively larger wetlands to store and retain water and (4) areas with larger marshes to store and retain water.

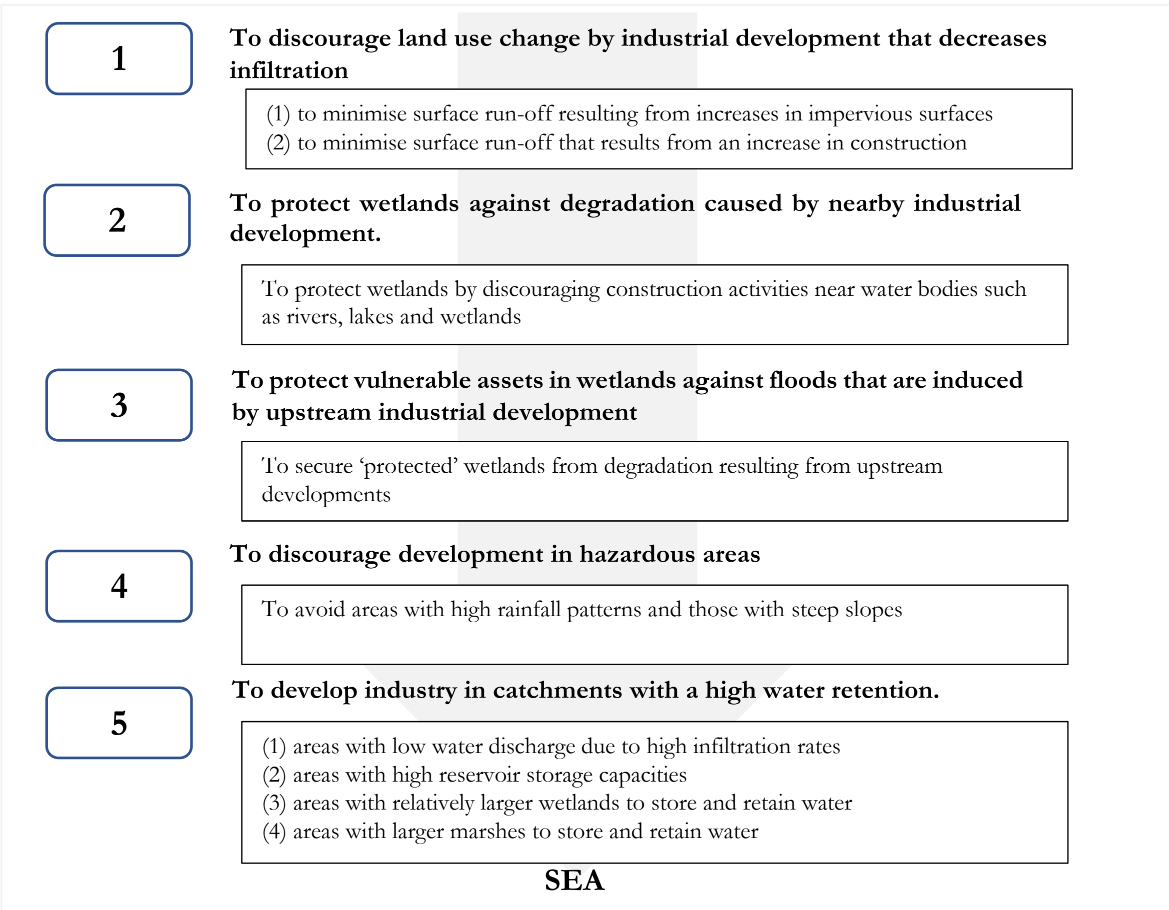

Figure 18: Objectives of SEA for flood risk mitigation

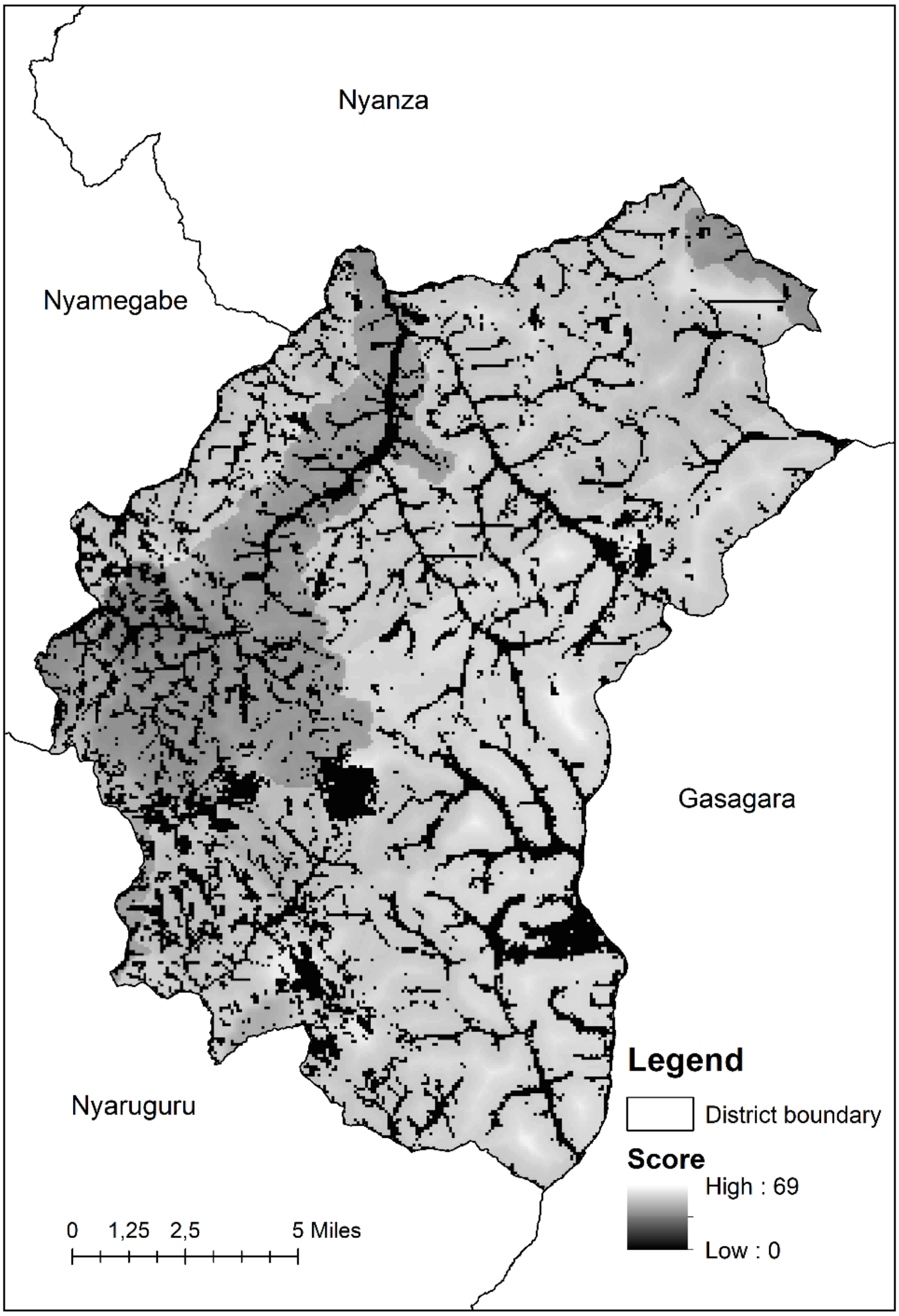

Figure 19: Strategic Environmental Assessment for flood mitigation in Huye (Mossink, 2020)

4.7 Current decision making process on industrial park allocations in Rwanda

The development of industrial parks in Rwanda is a relatively recent activity which began with the establishment of the Kigali Free Trade Zone and Kigali Industrial Park in Kigali even though both have since been merged to form the Kigali Special Economic Zone (KSEZ) in 2009. Since then, many other industrial parks across the country have been earmarked to be developed mainly in response to an Industrial Policy document which seeks to promote "growth, value addition and expanding new areas of comparative advantage" while also tackling key challenges to the country's industrialisation drive (MINICOM, 2011).

The first major step towards boosting industrialisation resulted in the allocation of four provincial industrial parks in Bugesera, Huye, Rubavu and Rusizi (Figure 20). By 2013 however, six more industrial park locations were added and are at various stages of development amidst financial challenges (MINICOM, 2020). The aim is to improve the industrial sector's contribution to Gross Domestic Product (GDP) from 15 percent to 26 percent by 2020 at an annual growth rate of 12 percent. However, allocation decisions as well as the subsequent development of allocated industrial parks have proven problematic partly due to lack of appropriate feasibility studies (MINICOM, 2020; UNIDO, 2016) that could serve as basis for vetting proposals from investors with varying priorities. Consequently, there exists no system for positioning investor interests in the context of government priorities or for ensuring that site specific issues feature in the decision making process for industrial parks.

To understand the decision making process for industrial park development however, it is important to differentiate between two levels of decision making and oversight: national and district (MINICOM, 2020). While the latter is largely concerned with the preparation of city level master plans that incorporate preliminary locations for industrial zones based on land demand projections, the former takes responsibility for the preparation of roadmaps to guide investments in general infrastructure needs including water, electricity and roads as well as issues relating to land expropriation. This also confirms Rwanda's current institutional arrangement which designates districts as the main authority for planning and governance and yet demonstrates robust upward accountability across the levels of administration at Villages, Cells, Sectors, Districts and National levels (Goodfellow & Smith, 2013).

4.7.1 District level decision making

At the district level, decision making on industrial park allocations is merged with the general spatial planning processes that include the preparation of master and local plans (Figure 21) to guide the development of residential, commercial, industrial and other land uses (personal communication with informant 7, interview 22-Jan-2020). The planning process begins at the village level where stakeholders make inputs based on local developmental priorities such as water, schools, clinics etc., which are then forwarded through elected representatives at the Cell and Sector levels to the District Administrative officials.

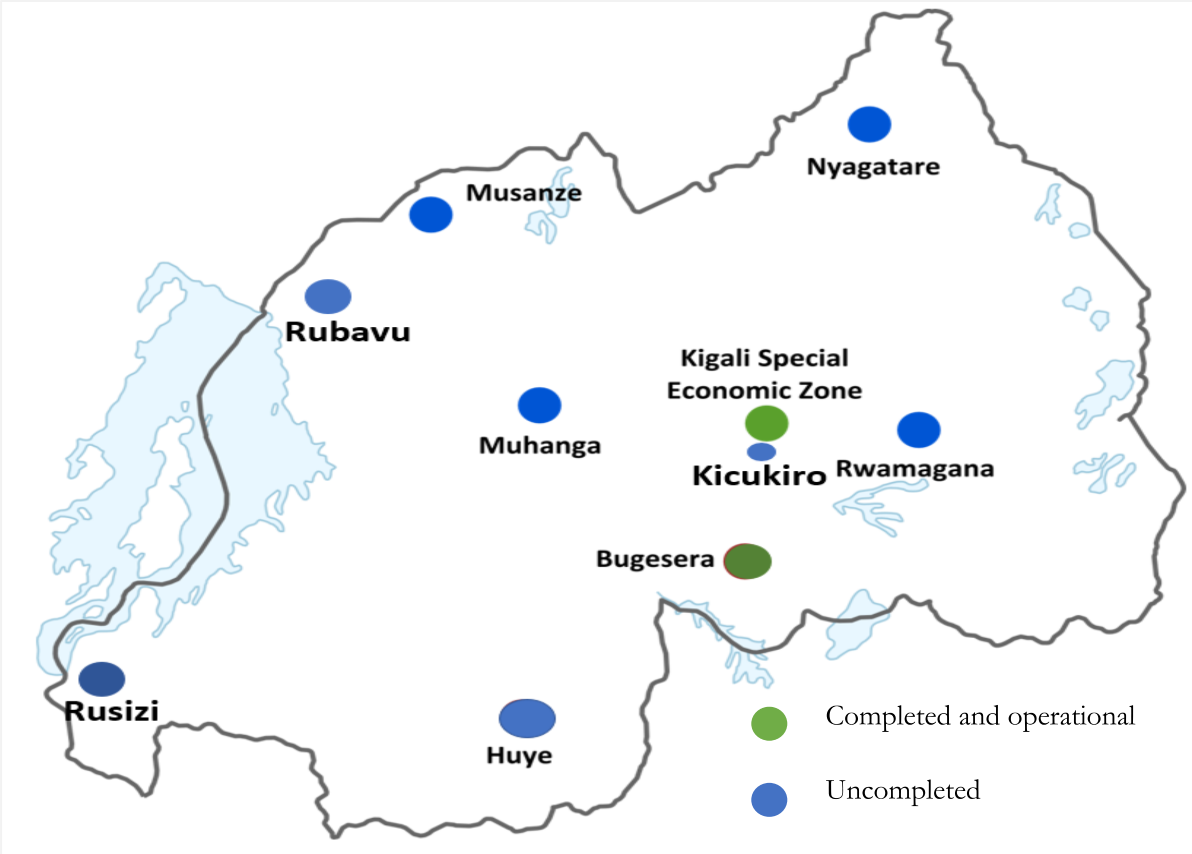

Figure 20: Current status of industrial parks (source: MINICOM, 2020)

These inputs and priorities subsequently inform district and city authorities on the allocation of industrial zones among other land uses in the preparation of city master plans that guides the spatial growth and expansion of the district (personal communication with informant 7, interview 22-Jan-2020).

Proposals for industrial zones in particular are made based on projections for employment needs since industries are seen as major employers (MINICOM, 2020). MINICOM acknowledges that this sole motivation without other considerations such as market analysis or infrastructure needs assessments is inadequate and has resulted in the duplication and over-prescription of industrial zones across most districts (MINICOM, 2020).

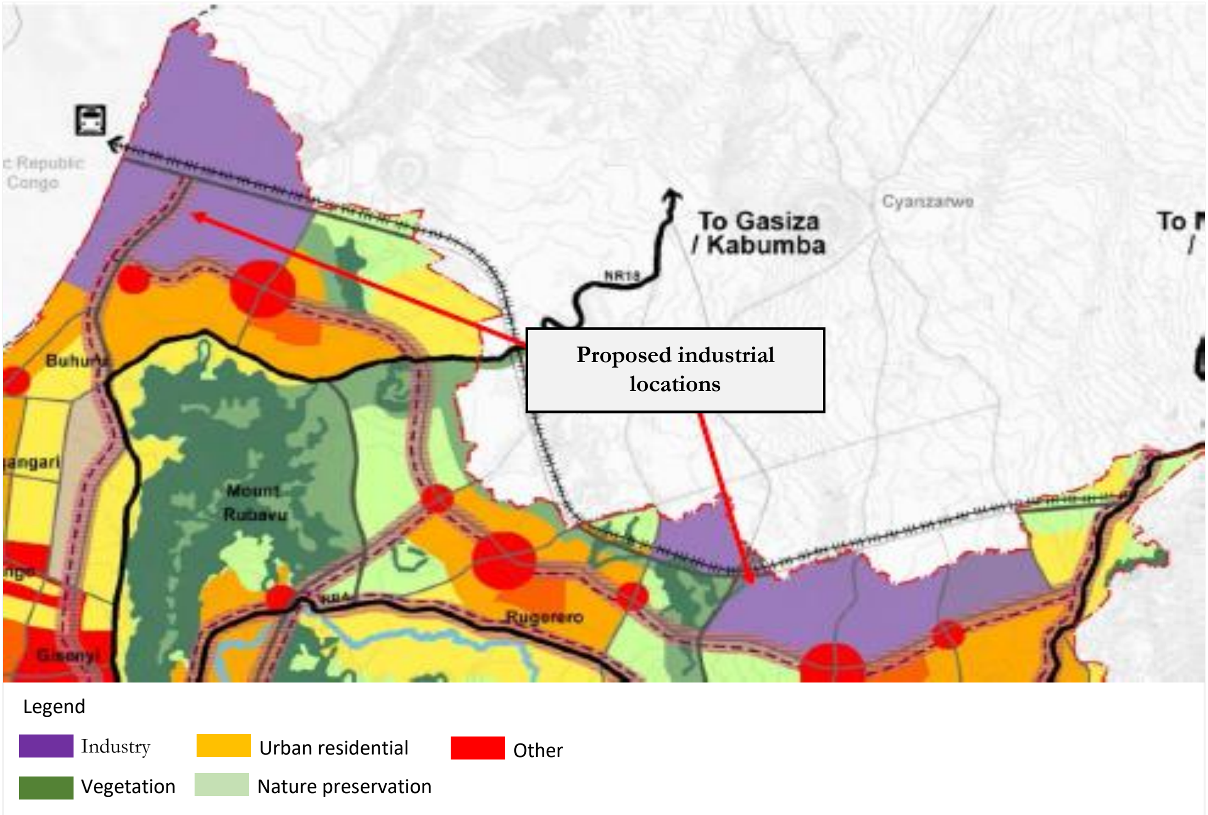

Figure 21: Snippet from the Rubavu master plan showing zoning for industrial locations (source: MINICOM, 2020)

4.7.2 National level decision making

On the other hand, industrial park allocation decisions at the national level are steered by a Committee that is led by MINICOM and consists of officials from key institutions such as MININFRA, Rwanda Development Board (RDB), Green Growth Institute (GGI) and District Officials. The role of the steering committee among others include drafting modalities for evaluating alternative sites for industrial parks, development of infrastructure, preparation of feasibilities studies and management structure. Among these tasks however, MINICOM acknowledges that the process for evaluating and selecting suitable sites as part of feasibility studies is lacking and often results in difficulties in the development of chosen sites (personal communication with informant 6, interview 18-Feb-2020). Meaning the lack of a system to evaluate proposed sites as contained in the district master plans results in a situation whereby proposals from investors are only vetted based on their own merit with no means to assess whether they meet the needs of the ministry or not. Currently, MINICOM acts as the custodian of lands that are proposed for industrial parks prior to their development and subsequent allocation to investors and has consequently resolved to dedicate more efforts into conducting more stringent feasibility studies which could then be used to validate proposals from potential investors. This study is therefore timely and can provide useful tools to assist in the evaluating of sites as part of feasibility studies.

4.7.3 Stakeholder analysis

As explained in 4.7, decision making on industrial parks is achieved at the national and district levels. The institutions that take up such responsibilities at the two levels operate and relate to each other in a collaborative manner that needs to be highlighted especially because the operationalisation of the SDSS must be able to situate effectively within these existing relations and processes. Figure 22 is a presentation of key relations that exist at the levels of decision making highlighting only direct relations between stakeholders.

Rwanda's governance structure implies that there is strong oversight from the national level over district level planning and decision making processes including the allocation of industrial parks (Goodfellow & Smith, 2013). Meaning the activities of local level institutions are often subjected to review by key national level institutions that are directly involved in the planning of industrial parks. Institutions that are directly involved in the planning and development of industrial parks are therefore organised often at the national level in all deliberations. The institutions that are directly involved in such deliberations include the newly established Special Economic Zone Authority of Rwanda (SEZAR) as an independent regulator, MININFRA as the institution responsible for infrastructure provision and management, RDB as a management body in charge of selected industrial parks, MINICOM as the custodian of all lands and in charge of all expropriation and investments and District Councils that work in close collaboration with the One-Stop Centres to allocate, secure and manage infrastructure provision as well as offer key services to investors (Table 5).

In the midst of these activities by the above institutions, other institutions and organisations play significant roles that influence the planning process for industrial parks. These bodies often act as advisory bodies working in close collaboration with national level institutions to offer appropriate expertise on specific topics (personal communication with informant 8, interview 22-Feb-2020). Such institutions whose activities also border on industrial park planning processes include GGI, UN-Habitat and International Growth Centre. The UN-Habitat for example, continues to work with MININFRA towards the successful integration of the SDF into national and local level planning instruments. This activity is significant in the discussion about industrial parks because SDF implementation is a major tool towards achieving the objectives of the National Urbanisation Policy which sees the establishment of key industries as necessary to achieve a 35 percent urbanisation by 2030 (MININFRA, 2013a).

Table 5: Role of key institutions in industrial park planning and development in Rwanda

	Institution	Role in industrial park planning
1	Special Economic Zone Authority of Rwanda (SEZAR) as a unit under Rwanda Development Board	Enforcing policy recommendations Advice government on establishment, development, maintenance and operation of industrial parks.
2	Ministry of Trade and Industry (MINICOM)	Prepare project documents for developments of industrial parks Expropriation of land in industrial parks General oversight responsibility for eight industrial parks
3	Ministry of Infrastructure	Develop connectivity to industrial parks in terms of road, power and water lines.
4	Rwanda Development Board (RDB)	Public-Private Partnership agreement negotiations for the development and management of industrial parks
5	District Councils and OSCs	Manage infrastructure provision Facilitate necessary permit and license acquisition Utility connection and payments including water and power

Source: UNIDO (2016)

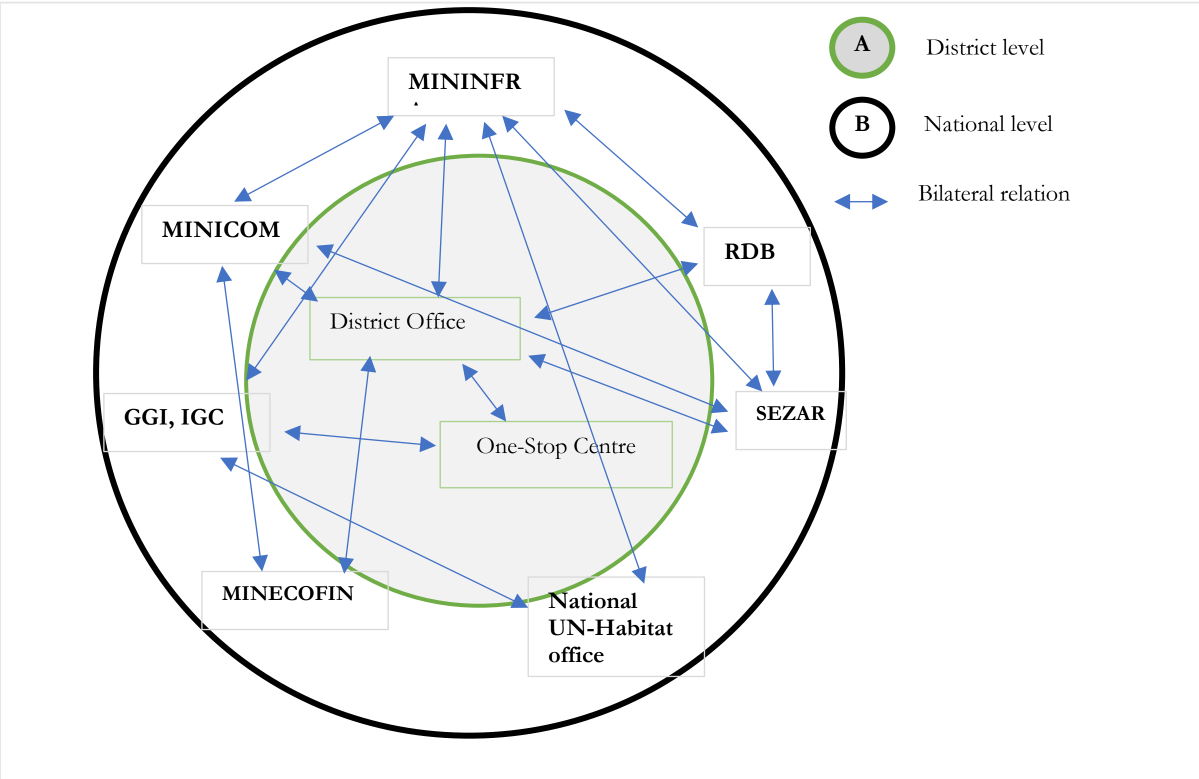

Figure 22: Stakeholder relations at the national and district levels

4.8 Current accessibility of labour to existing Industrial Parks

To quantify travel time to existing industrial parks, a contour measure accessibility method is used. As a type of location-based accessibility method however, it requires data on both land use characteristics and transport systems. The land use requirement is catered for by the locations of labour as *origin* and the industrial parks as the *destination*. The transport system analysis is discussed below.

4.8.1 Mode of transport

According to the Transport Sector Strategic Plan for EDPRS2, the main mode of transport for both passengers and goods across Rwanda is via road infrastructure (MININFRA, 2013b). Accordingly, a total of 13,049 vehicles provide public transport services for passengers across the country which comprised of: Bus (o.8%), Medium Bus (4.5%), Minibus (16.6%), Taxi (4.4%) and Motorbike (73.6%) (MININFRA, 2013b). The dominance of motorbikes however does not correspond with highest passenger carrying capacity which is rather topped by minibuses with 54% (Table 6). Consequently, mini and medium buses play important roles in the delivery of public road transport services to the largest number of people.

Table 6: Types of public transport vehicles and their carrying capacity

Type of Vehicle/Operator	Number of Vehicle	Percentage of Vehicle	Passenger Capacity/Vehicle	Total Passenger Carrying Capacity	Percentage of Passenger Carrying Capacity
Bus	110	0.8%	51 to 80	5,162	7.1%
Medium Bus	588	4.5%	25 to 33	16,271	22.5%
Minibus	2,163	16.6%	18	38,934	53.9%
Taxi Cab	579	4.4%	4	2,316	3.2%
Motorbike	9,609	73.6%	1	9,609	13.3%
Total for all vehicles	13,049	100.0%		72,292	100.0

Source: Transport Sector Strategic Plan (MININFRA, 2013b)

The accessibility analysis contained in this study is therefore based on the use of mini and medium buses as the main mode of road transport within the Southern Province. To facilitate road transport by bus, a number of private individual operators including 41 companies (MININFRA, 2013b) operate bus services across 10 corridors including the city of Kigali (Figure 23). For the Southern Province however, these bus lines also correspond with the National Road and District Road Class 1 mainly because of the relatively better road conditions of these two classes of road.

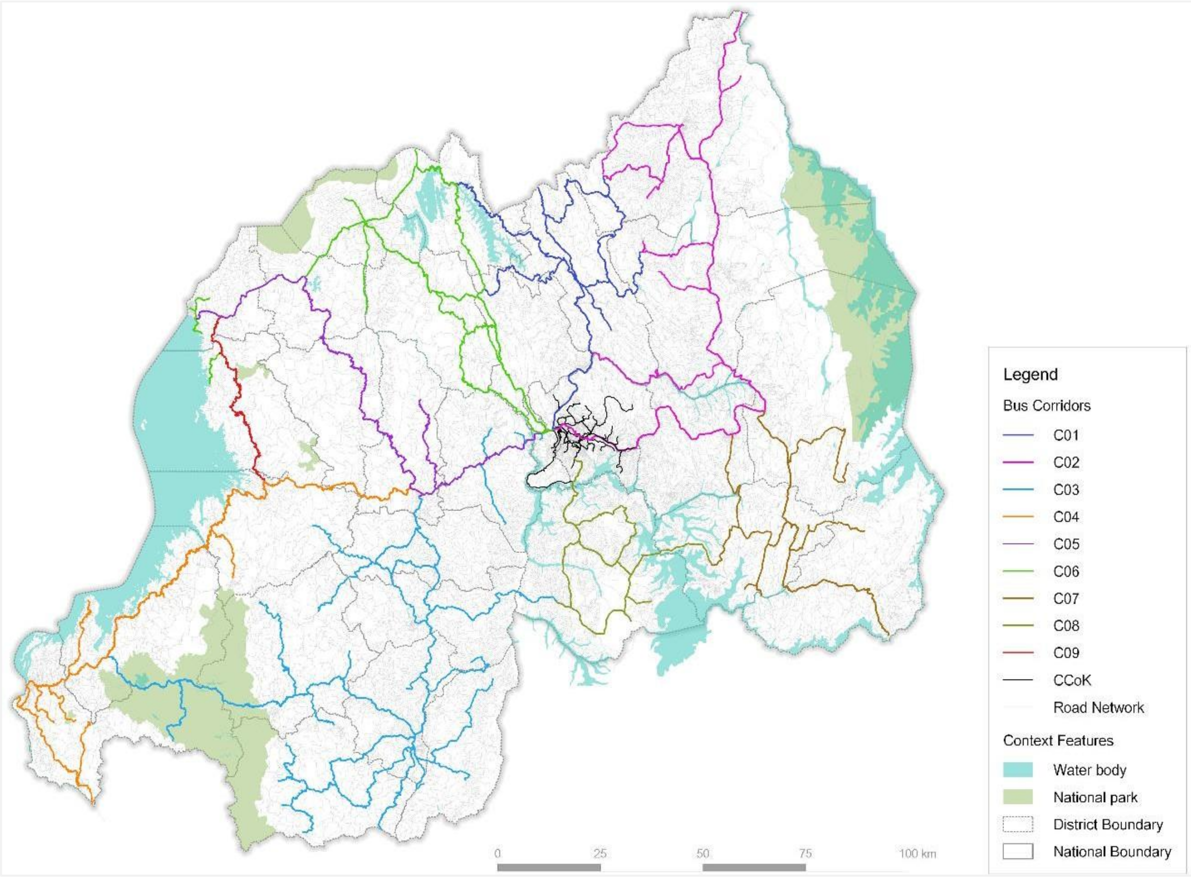

Figure 23: Bus corridors in Rwanda (Source: Esri Rwanda Ltd., 2019)

4.8.2 Modelling accessibility by labour force to existing industrial parks

The modelling of labour accessibility to existing industrial parks was achieved using the Network Analyst extension of ArcGIS. Figure 24 represents a simple contour measure of travel time assessed to industrial parks. The result show that while 15 percent are within 30 minutes travel time from the industrial parks, a good majority of 51 percent are between 30 minutes and 1 hour travel time from any industrial park. 24 percent are within 1 hour and 2 hours travel time while only a few 10 percent would travel beyond 2 hour travel time from any industrial park (Figure 25).

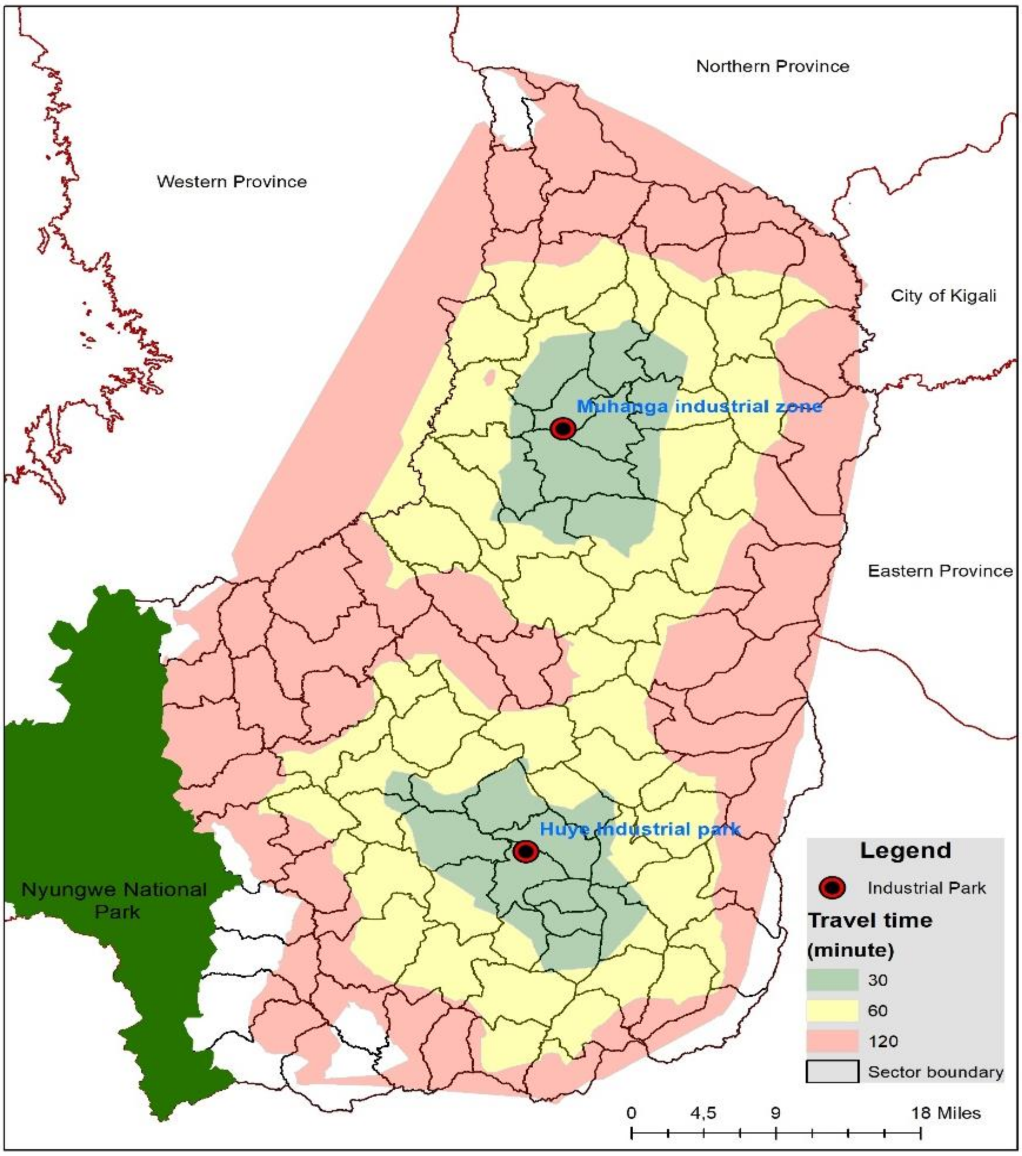

Figure 24: Contour measure accessibility

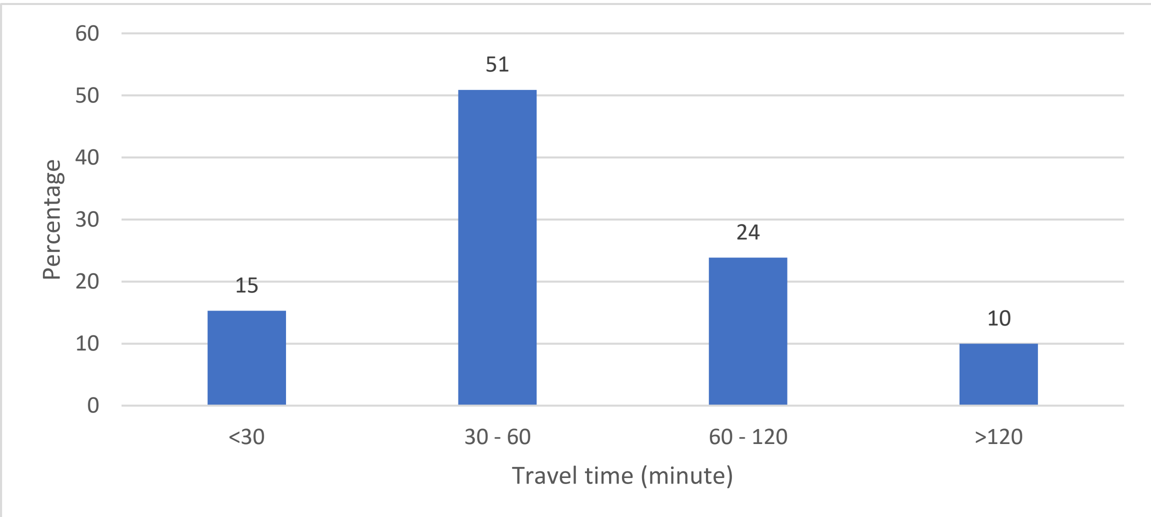

Figure 25: Percentage of labour force living at different travel time from industrial parks

5. DESIGN OF SPATIAL DECISION SUPPORT SYSTEM

Chapter 5 answers the third sub-objective by presenting the design components of the SDSS that is developed to assist industrial park planning. The first part of the chapter briefly describes the purpose of the SDSS while the second part outlines the key components of the SDSS. The final part explains the process to test the first version of the SDSS in line with the prototyping approach to SDSS development.

5.1 Purpose of SDSS

The planning and development of industrial parks in Rwanda is achieved at the national and district levels where the task of evaluating alternative sites as part of prefeasibility studies has so far proven challenging. Adding to this challenge is the need to analyse and interpret data from different sectors for collaborative decision making. Consequently, current decision making rely heavily on investor information and preferences which might not necessarily meet the needs of Rwanda. Without adequate accessibility assessments for example, greater majority of the labour might not be able to access industry jobs within shorter travel times or at cheaper costs. Also, the current decision making processes should be able to position the development of industrial parks within environmental and economic growth considerations. It should also be able to estimate costs of utility connections for water and power prior to more detailed feasibility studies. This would ensure that chosen sites for industrial parks can be developed at relatively minimal costs.

The SDSS prototype that is developed in this study therefore proposes a tool that assists stakeholders to assess the suitability of alternative sites based on three critical factors that include accessibility to labour force, water and power connection costs that are guided by environmental and economic growth considerations.

Setup

Generally, stakeholders can interact with the prototype in three sequential steps.

- First stakeholders must decide on suitable locations for proposed industrial parks via an assumptions window (Figure 27) and editing tools (Figure 28) that is based on environmental and economic analysis (discussed in 5.2.1). This is to ensure that chosen sites are less vulnerable to flood impacts and also ensuring that they strengthen the economic growth performance of areas.
- Secondly, stakeholders run the model by selecting the 'Run' button on the SDSS prototype toolbar. The process takes approximately 10 seconds to complete after which users click on "update analysis' button to update the indicators panel (Appendix 2).
- The third step involves reading the impacts on labour accessibility, cost of power and distance to water pipelines which is calculated for each industrial park location

5.2 SDSS components

The SDSS provides a framework for national and district level institutions to be able to measure the relationship between industrial parks, labour force accessibility and site developmental costs relating to power and water connectivity. These considerations make up the dynamic layers of the SDSS. Together with non-dynamic layers, these are discussed under three broad headings in the succeeding paragraphs.

5.2.1 Environmental and economic growth analysis

The SDSS prototype includes a suitability measure that is composed of two factors: Strategic Environmental Assessment for flood risk mitigation in Huye (Mossink, 2020) and the Economic Growth pillar as an output from the National Spatial Development Framework (The Republic of Rwanda, ITC & UN-Habitat, 2016). These two factors are combined into a dynamic measure using the 'Suitability Wizard' tool in Community Viz to serve as a guide for stakeholders in deciding on preliminary locations for industrial parks (Figure 26). As a dynamic component, the suitability measure can be varied depending on collective preferences via a pop-up called the 'assumptions window' (Figure 27). The result is seen in the form of a map showing areas with high or low suitability scores. Currently, and because the extent of the SEA is restricted to the Huye district there are relatively higher suitability scores for locations in Huye. It is therefore important for stakeholders to note this effect and understand that the scores for areas outside Huye are only affected by the Economic growth pillar only.

5.2.2 Labour accessibility to industrial parks

The accessibility component of the SDSS is based on a contour measure using the Network Analyst extension of ArcGIS. The primary function is to allow stakeholders to be able to assess the total number of labour within a given travel time away from proposed industrial park locations. The locations of industrial parks and where people live correspond with the origin and destination respectively. Further, and in the absence of more recent census data up to the village level, the available 2012 Population and Housing Census data up to the Sector level is used. Results are shown both on a map (Figure 29) and in a chart (Figure 30) for easy verification.

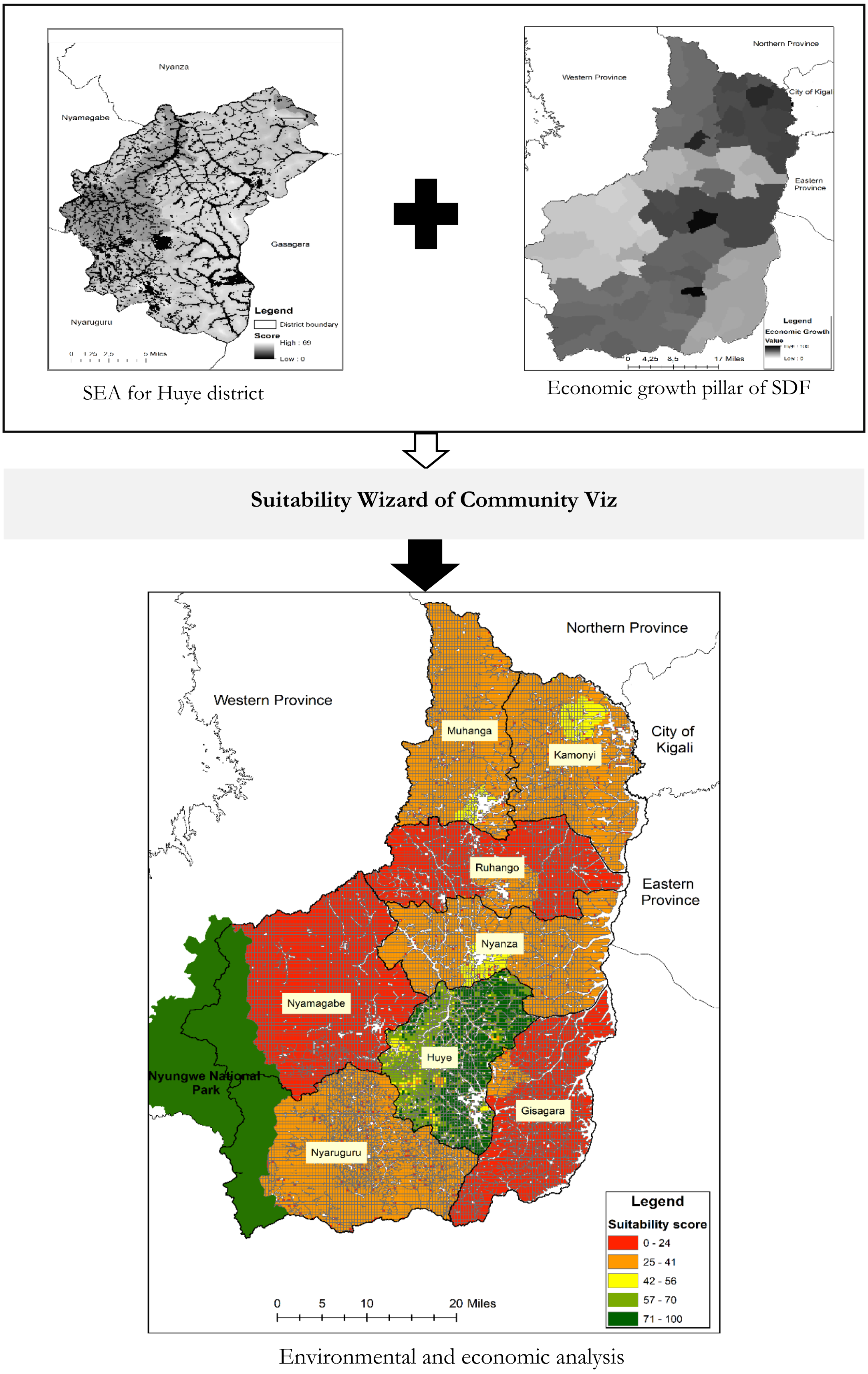

Figure 26: Environmental and economic growth analysis component of SDSS

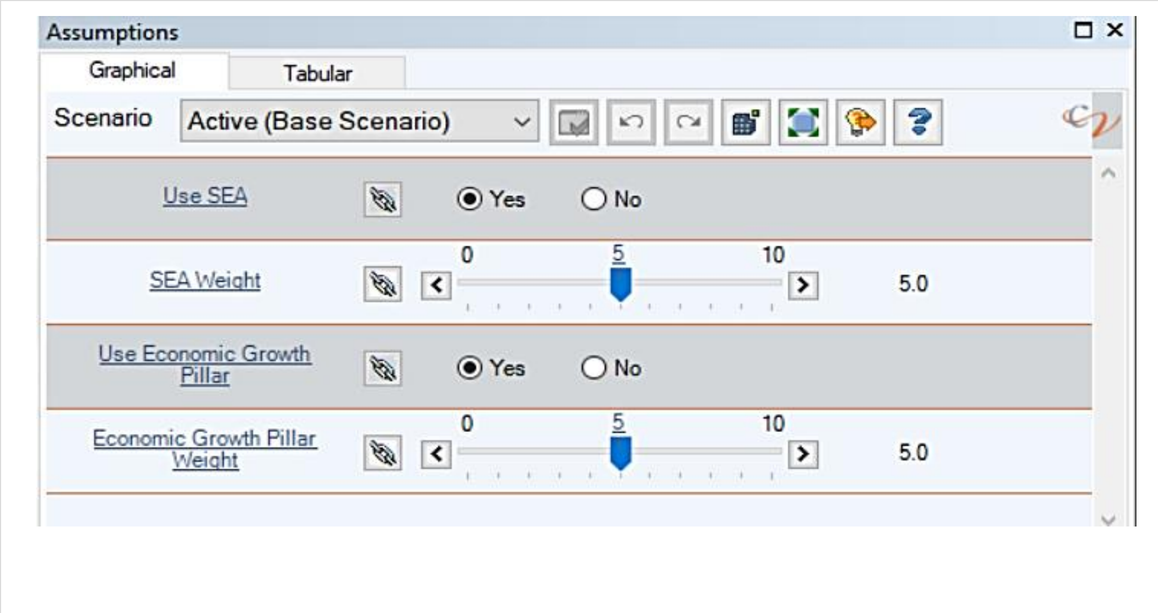

Figure 27 Assumptions window

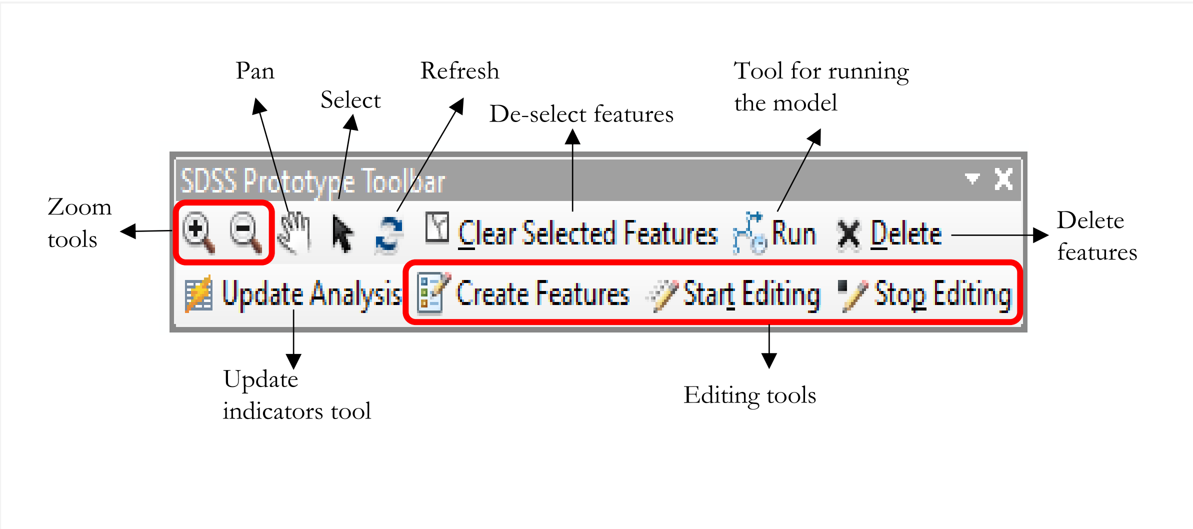

Figure 28: SDSS prototype toolbar

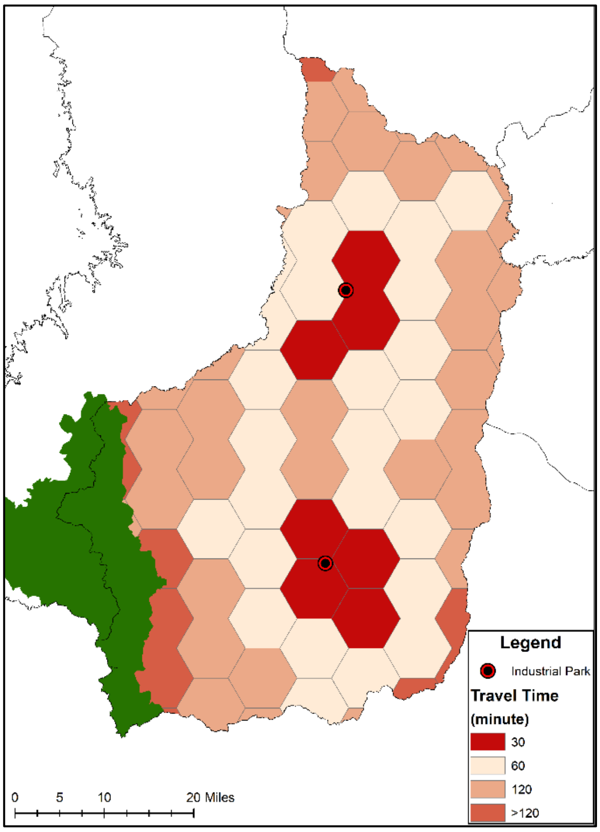

Figure 29: Accessibility component of SDSS

5.2.3 Indicators

The indicators panel represents an important feature of the SDSS. It functions to display three key measurement parameters based on which stakeholders can make informed decisions (Figure 30). The three indicators are represented by bar chats that show (1) Labour force accessibility (2) Power costs and (3) Distance to water pipeline as key measure of cost for water connection. These indicators are updated automatically every time the 'run' button is clicked.

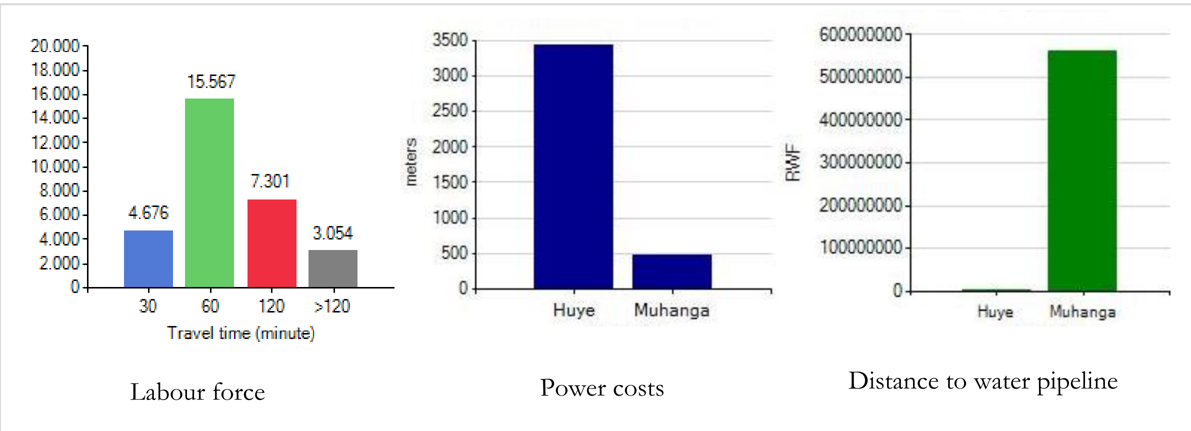

Figure 30: Three key indicators as a component of SDSS

5.3 Testing of first version of SDSS

The prototyping approach to SDSS development emphasises the importance of an iterative process whereby developers and end users work together towards an acceptable final version of SDSS (Figure 31). In keeping with this requirement therefore, one workshop was planned and executed in Rwanda to test the usability of the first version of SDSS. The workshop was hosted at the newly established Collaborative Spatial Design and Decision room at MININFRA (Figure 32).

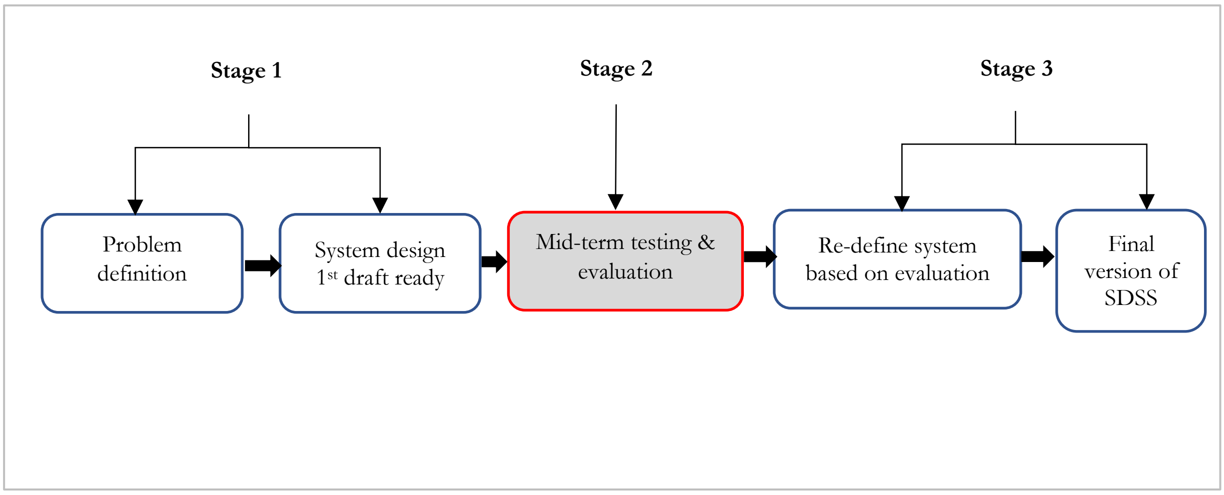

Figure 31: Positioning the testing phase within SDSS development process

A total of 10 participants attended the workshop including officials from three key departments of MININFRA namely: Planning Division, Water and Sanitation Division, Energy Division. The workshop lasted for an hour and half starting with a short introduction to highlight the purpose, key features of the SDSS as well as an explanation of assumptions made. Participants were then allowed to test the model based on a specific task to use the SDSS user interface to allocate and determine new suitable locations for industrial parks, which lasted for approximately 25 minutes. After, participants discussed amongst themselves on ways to improve the model and provided verbal feedback accordingly.

Stakeholder experiences

Stakeholders expressed diverse opinions on the first version which ranged from the ease of use of the SDSS to its more technical capabilities. A summary of key recommendations from the stakeholders who participated are highlighted below:

- There is the need to provide more data to guide stakeholder inputs for new industrial park locations such as wetland information.
- The model needs to be dynamic and flexible enough for future improvements beyond this study.
- A suitability analysis included that aggregates layers to guide decision making on industrial park locations.

- The user interface for the SDSS should have less windows and tools to encourage more interaction from non-technical stakeholders.

The above recommendations formed the basis for further improvements towards the final version of SDSS (Appendix 2) in a number of ways. For example, the inclusion of slope and wetlands data layers in the final version was based on point 1 while the second point guided how various ArcGIS tools were connected via ModelBuilder to ensure that it is flexible enough for future enhancements. The third point also was the basis for the use of the 'suitability wizard' of Community to enable stakeholders interact with the factors that they need for deciding on suitable locations for industrial parks. Generally, the final user interface has been simplified to encourage easy interaction by stakeholders.

Figure 32: Stakeholder workshop to test SDSS usability

6. DISCUSSION

Chapter 6 gives a discussion on the results from this study in the context of existing literature on key concepts outlined in chapter 2. It is presented in three sections in order of the research objectives. The first section relates the current situation on industrial park planning to existing scientific literature on same while the second discusses the implications for the integration of accessibility considerations into the decision making processes. The final part focuses on the overall goal of integrating the SDSS prototype into decision making processes for industrial park planning in Rwanda.

6.1 Current decision making processes for industrial parks

In an attempt to understand Rwanda's decision making processes for industrial parks, this study analysed decision making at two levels: national and district, which also revealed key strategic relations between stakeholders at both levels which go a long way to influence the discourse on industrial park planning. Stakeholders at the district level decide on locations for industrial parks as part of a larger planning process to guide the spatial development of towns and villages. These proposed locations for industrial parks must however also meet the objectives and needs of national level stakeholders such as MININFRA that is responsible for the development of needed infrastructure such as water and power.

The current arrangement in terms of industrial park planning depicts two different types of spatial decision making described by Kemp (2008); land use allocation and location allocation. Kemp (2008) defines land use allocation decisions as typical spatial planning decisions for assigning various uses such as residential or commercial uses to land while location allocation decisions are usually based on a set of goals and objectives to find optimal locations for activities such as minimising travel time to health facilities (Sugumaran & DeGroote, 2011). District level decision making for industrial parks in Rwanda are therefore based on the former while national level are more aligned towards the latter. This often results in situations whereby the development of some industrial parks have proven difficult mainly because the motivations for such locations do not meet set goals and objectives of all stakeholders. The current approach therefore will remain unsustainable if the setting of goals and objectives behind industrial parks translate from the nation through to the district level prior to deciding on locations for industrial parks. In this regard, it may be worthwhile to expand the master planning process at the district level to incorporate national level stakeholders such as MINICOM, MININFRA and SEZAR during discussions on the allocation of industrial parks. Furthermore the use of the SDSS could help in such deliberations to ensure that chosen locations meet the objectives of all stakeholders.

The literature on industrial park planning (Le et al., 2020; UNIDO, 2019a) recommend a systematic process from the development of strong business models through site selection to detailed feasibility studies and finally financial and management structuring. This also include the need to establish consensus among key stakeholders during the selection of potential sites to limit challenges that result from high cost of infrastructure development for road, water and sanitation and power for example. In practice however, this is challenging and as is the case of Rwanda, stakeholder objectives are not always aligned and in the midst of unreliable financial commitments, the process from project initiation to completion is sometimes delayed. UNIDO studied the planning and implementation of industrial parks across 7 countries including Morocco, Vietnam, China, India, South Africa, Columbia and Peru, and concluded that the process works best when there is adequate awareness-raising across all levels of decision making that is guided by an independent entity such as a university or consultant. And since, the process typically spans different thematic areas, it is important to ensure a closer inter-agency collaboration that also includes the business community (UNIDO, 2019b).

6.2 Current labour accessibility to industrial parks

This study employed a contour measure as a component of location-based accessibility methods. The purpose is to reveal the implications on travel time to the existing industrial parks by labour within the Southern province based on two factors that influence such accessibility analysis namely *location of labour force* and *available transport systems* (Steiner & Butler, 2007). Given that the existing industrial parks are still under development, the output would be useful for further strategies towards ensuring optimal accessibility to industrial jobs.

Current accessibility to industrial parks is highest within the urban centres of Huye and Muhanga and reduces towards the urban fringes and further towards adjoining rural districts. This is consistent with the general principle of gravity-based accessibility analysis whereby distance to the point of attraction is taken into account (Guers and Van Wee, 2004). Therefore we see with the current situation in the Southern province that the further one moves away from the industrial parks travel time increases for labour. This increase in travel time is also influenced by the relative concentration of both national and district roads class 1 in in the urban centres when compared with other areas in the province. Consequently, areas that are less connected with both national and district roads such as at the fringes of the province have higher travel time to any industrial park. The labour force living in these areas would therefore have to travel about 2 hours to access industrial jobs. In terms of numbers, this translates to about 10 percent (3,054) of the labour force population.

It is worth noting that bus transport with an average travel speed of 40 and 30 kilometres per hour for national and district roads respectively, that was used for the accessibility analysis is adequate mainly because it remains the main mode of transport for inter-district travels. However, major improvements in terms of road conditions is needed to ensure that buses can ply more routes beyond the current ones. This would enhance access for people and consequently reduce travel times to existing industrial while enhancing accessibility analysis for future industrial park planning processes. This would also go a long way towards creating an enabling environment for rapid industrial growth through the development of appropriate infrastructure (MINICOM, 2011).

6.3 Design and development of SDSS for decision making on Industrial Parks

The SDSS developed in this study is a strategic attempt to achieve Malczewski's (1999) definition of same as "an interactive computer based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem." The definition highlights four main elements: *computer based system, iteration, users* and *semi-structured spatial decision making*. These elements form the basis for the SDSS developed in this study and is designed to offer analytical and modelling capabilities on a user-friendly interface to allow stakeholders develop scenarios for decision making.

The environmental analysis for flood risk mitigation component of the SDSS is grounded on the findings by Avis (2018) who found out that poor planning of industrial parks in Ulsan, South Korea has led to the pollution of air and water resources. The measure therefore is intended to limit the potential negative impacts of industrial parks on the environment while also ensuring that some considerations in terms of off-farm job creation is incorporated in the process. However, the environmental analysis incorporated in the design of the model is partial in its coverage as it covers the Huye district only. It is an output from a comprehensive SEA methodology for industrial development with major considerations for flood impact mitigation (Mossink, 2020). Future improvements in the SDSS prototype could however consider other environmental impacts such as air and water pollution using similar methodological outputs as prescribed by Mossink (2020). This must however be guided by the goals and objectives of key stakeholders to ensure relevance. In that regard, the use of the 'suitability wizard' in Community Viz for the environmental analysis is specifically to allow for possible inclusion of other environmental factors in future.

Generally, the SDSS is designed for the stakeholders mentioned in Section 4.7.3 of this report as being directly involved in the decision making process for industrial park allocation at the national and district levels. Stakeholders such as MININFRA, MINICOM, SEZAR and RDB working closely with the One-Stop Centre and local government officials could work together using this SDSS to find locations for industrial parks that meet both local and national level policies and strategies. This could work to eliminate decision problems that arise because individual objectives are not aligned. What is needed for that to be achieved is for district level master planning processes to be expanded to include collaborations with the above named national stakeholders. This is necessary because the mandates of these institutions have implications for the successful development of these industrial parks and must therefore be incorporated even at the earliest stages for site selection activities.

The capabilities of the SDSS therefore fits well with location allocation types of decision making because it allows stakeholders to visualize and quantify specific impacts in order to find optimal locations for industrial parks which is central to these types of spatial decision making processes (Sugumaran & DeGroote, 2011).

7. CONCLUSION

This study developed a prototype SDSS to support site selection processes as part of industrial park planning for onwards integration into collaborative decision making processes. It used the Southern Province of Rwanda as a case study to highlight real decision making processes in order to test how SDSS could improve current situations. The results show that indeed current processes could benefit from the gains of a SDSS that integrates labour accessibility, connection costs for water and power as well as the validation of environmental and economic growth impact assessment into site selection activities. This chapter therefore summarises the conclusions derived from the study reflecting on the main objectives and research limitations. The chapter concludes with a section on recommendations for future studies.

7.1 Conclusion

Though the planning phase of industrial parks presents challenges and hence requires strong oversight from all relevant stakeholders, agencies and governments, the development of dynamic computer based tools such as that proposed in this study offer great opportunities. The main challenge exists during the site selection stage where the need to select suitable locations for industrial parks that meet the needs of optimal labour accessibility and proximity to utility infrastructure, in the midst of environmental and economic justifications is paramount. And since not one solution fits all jurisdictions, enough attention must be paid to contextualising and adapting strategies including the design and development of decision support tools that aid site selection activities. This is where the development of SDSS can be useful.

This study modelled the applicability of SDSS for deciding on industrial park locations within the Southern Province of Rwanda as a case study. Based on background information on the decision making processes, interactions between key stakeholder institutions and transport systems, the study revealed that considerations for locations are currently not backed by sound justifications for labour accessibility and connectivity to available utility infrastructure such as power and water. Even though some relations do exist between institutions, these interactions do not allow for the alignment of individual institutional preferences to ensure that chosen sites meet the objectives of all. Consequently, district councils which remain the planning authority at the local level make recommendations for industrial park locations independent of national level institutions such as MINICOM, SEZAR and MININFRA. This is problematic given that MINICOM especially is the custodian of lands zoned for industrial park purposes and as such coordinates with MININFRA for the development of appropriate utility infrastructure for water and power.

Currently UNIDO recommends a collaborative stakeholder approach to industrial park planning as a means to maximise the benefits that industrial parks present to communities, regions and countries. To enhance this process, this study integrates analysis on three distinct parameters in the design of a SDSS which hitherto would have remained an activity by individual institutions. Instead, the integration of transport, environment, economic growth and utility analysis into a single system would allow institutions such as

MINICOM, MININFRA and the Ministry of Environment to collaborate more effectively. In this regard, the national steering committee for industrial parks in Rwanda for example, would benefit from such a SDSS that touches on key stakeholder mandates and allows for more collaboration at that level. And since the committee also includes membership from the district councils, the allocation of zones for industrial parks at the local level could be enhanced.

The development of a SDSS must however be guided by the same collaborative principle. This study applied the prototyping approach for the design and development of the SDSS prototype. The underlying principle of this approach as explained by Veronica (2007) is the need for both the developer and end users to iteratively work together towards a final acceptable version of the prototype. This study tested the first version of the prototype at a stakeholder workshop in order to gain inputs for further improvements. The idea was also to simulate a decision making process for industrial park allocation thereby placing the prototype in context. At the end, participants at the workshop made valuable inputs ranging from technical to procedural recommendations that served to improve the development of the final version. However, further developments of similar SDSS prototype can benefit from a series of such workshops that systematically build on inputs towards a final version rather than a single mid-term testing and evaluation session. This is necessary if prototypes are to deliver the purposes for which they are designed including taking advantage of tacit knowledge to improve draft versions.

With proper planning, the development of industrial parks could indeed serve as the platform for achieving Rwanda's targeted 26 percent contribution of industrial sector to GDP growth and the ripple effects on off-farm job creation. However, the siting of industrial parks can contribute immensely towards the achievement of such national and local economic objectives.

7.2 Limitations

This study was achieved in the midst of some limitations. These are:

- The testing and evaluation phase of the development was hindered by imposed restrictions on the gathering of people as a result of the outbreak of the novel Covid-19 across the world. As such only one testing session was held instead of the two that was initially scheduled.
- Difficulties in gaining access to up to date disaggregated unemployment data up to the Village level resulted in the use of Sector level data for 2012.
- Without appropriate data on unit cost for water connections, the prototype indicators component of the SDSS does not estimate cost but rather distance of proposed locations to nearest water pipelines.

7.3 Future studies

The planning phase for industrial park planning present opportunities for expanding the discourse and usability of SDSS. The following are some recommendations to guide future research into SDSS development for industrial park planning:

- Future studies could incorporate the effect of distance decay on job accessibility modelled for a combination of transport modes such as motorbikes and bus transport. This makes for a more accurate and realistic model.
- Given that connectivity to market centres serves as a major deciding factor for investors, future studies could look into expanding SDSS to cover analysis on market and other economic considerations as part of pre-feasibility studies.

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APPENDICES

Appendix 1: Interview guide

1. **DECISION MAKING ON INDUSTRIAL DEVELOPMENT**
    a. Role in the decision making process for industrial development
    b. Stages of the decision making process
    c. Views on the entire process for deciding on industrial development
    d. Spatial and non-spatial considerations made during the process apart from finance e.g. land, accessibility, jobs? etc.
    e. Stakeholder participation in the entire process or level of consultations done
    f. Current tools applied during decision making process if any?
    g. Challenges, opportunities and suggestions for improvements

2. **PLAN FOR INDUSTRIAL DEVELOPMENT**
    a. Current plans for industrial developments at the regional and local levels of governance
    b. Major document(s) guiding development of industries at the local and regional level
    c. Stages of implementation of these industries e.g. completed vs ongoing projects
    d. Preliminary conditions for locating industries e.g. topography? Nearness to major roads?

3. **IMPACT OF SPATIAL DECISION SUPPORT TOOLS**
    a. Knowledge of SDSS tools.
    b. Past experiences with PSS tools in the domain of spatial development
    c. Opportunities and/or challenges with SDSS tools
    d. Suggestions and recommendations for future SDSS tool development

4. **STAKEHOLDER ENGAGEMENT WITH DECISION MAKERS/CITY AUTHORITIES**
    a. Role in urban developmental initiatives at the local level
    b. Relationship with city authorities/decision makers
    c. Frequency of engagements with city authorities e.g. monthly, quarterly, annually?
    d. Nature of engagements with city authorities e.g. formal or informal, centralised or decentralised?
    e. What platforms exist for enhancing stakeholder engagements

5. **INVOLVEMENT IN DECISION MAKING ON INDUSTRIAL DEVELOPMENTS**
    a. Knowledge on existing industries in local and regional contexts
    b. Knowledge on proposed industrial developments
    c. General expectations of these industrial developments e.g. jobs, opportunities
    d. Level of involvement in consultations done prior to development of industries
    e. Challenges and suggestions for improvements

6. DEVELOPMENT OF SDSS

a. Views on current PSS' ability to adequately incorporate views of key stakeholders in infrastructure planning
b. How does current SDSS integrate with existing decision making process
c. Challenges so far?
d. Recommendations for future SDSS developments

Appendix 2: SDSS user interface