INTEGRATION OF SPATIAL DEVELOPMENT FRAMEWORK (SDF) METHODS FOR PARTICIPATORY BUDGETING (PB)

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July, 2020

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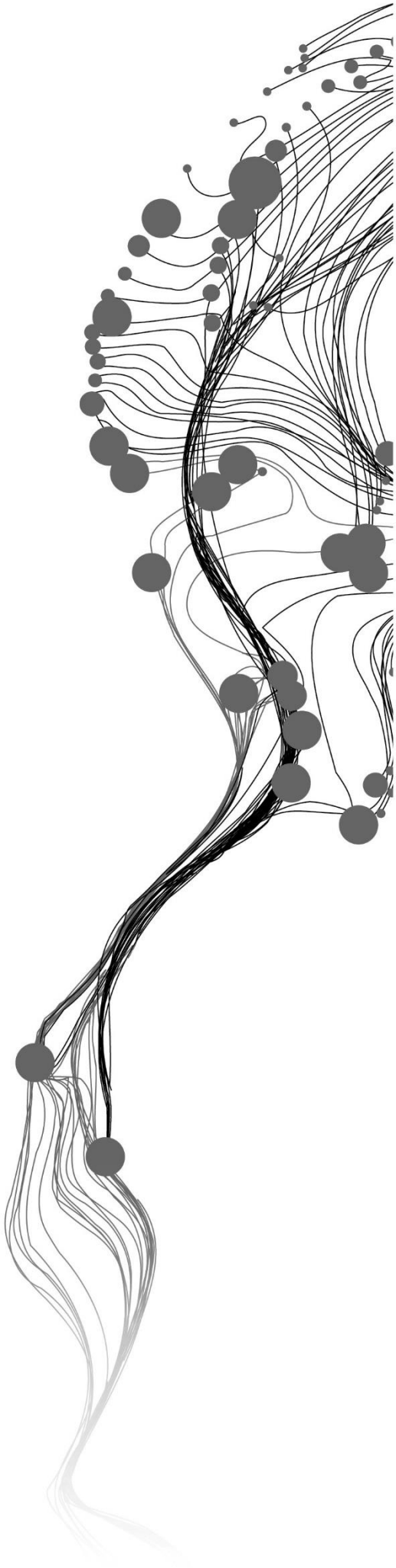

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Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
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ABSTRACT

In many African countries, spatial policies are yet to be adopted to guide participatory budgeting processes. To bridge this gap, this study sought to develop a participatory budgeting tool that integrates the SDF methods for Participatory Budgeting. The research used secondary data to establish the current budgeting process and the theoretical framework. The results of the secondary data review, helped in the development of the Participatory Budgeting prototype. The development process involved integration of the SDF methods in the Participatory Budgeting Application and the UTA algorithm in the Participatory Budgeting Manager Application. From the experimental data, the resulting PB prototype was able to prioritise and select spatially located projects. Hence, the conclusion that the developed prototype was able to integrate the SDF methods and thus adopting spatial policies in the budgeting process.

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1. INTRODUCTION

1.1. Background

The core of spatial planning management in national governance is the formulation of urban policies that are implemented for the coordination of physical, socio-economic and environmental development. Urban policies are described as public policies formulated to guide social, economic and environmental development of geographical territories (Cochrane, 2020; Le Galès, 2015; Mee, 2015). The implementation of such policies has been challenged by budget allocation due to available financial resources. Based on the studies on spatial planning in the United Kingdom, Healey (2006) emphasises the need for integrated approaches to achieve collaborations in policy implementation and funding. Participatory budgeting processes have been adopted as a solution for budget allocation in policy implementation at the local level in countries such as Brazil, United Kingdom, Spain, and Belgium (Cabannes, 2005; Sintomer, Herzberg, & Röcke, 2008).

The participatory budgeting (PB) process has its origin in Latin America, specifically in the city of Porto Alegre in Brazil. PB is known for involving citizen participation in decision-making to allocate budgets for policy implementation. It has been referred to as a policy process as well as an efficient method for resource distribution, social justice, democratic governance and participation for urban development (Calisto Friant, 2019; Wampler, 2007). Specifically in Africa PB has been adopted at the local levels for citizen participation in budget allocation for policy implementation in countries such as Zimbabwe, Tanzania, Zambia, Uganda, South Africa and Kenya (Sintomer, Herzberg, Allegretti, Röcke, & Alves, 2013). Some of the PB mechanisms that have been adopted in Brazil, United Kingdom and the United States include citizen surveys, citizen advisory committees; citizen-focused group discussion, expert focused approach, and third-party advocacy (Harkins & Escobar, 2015; Souza, 2001; Zhang & Liao, 2011). The PB mechanisms are place-based approaches that are adopted for policy implementation and development of territories. The PB processes are implemented at local levels. In contrast, many African countries decision-making processes for budget allocations and policy implementation at the local levels are centrally managed at the national level (Sintomer et al., 2013). Todes and Turok (2018) emphasise the importance of multilevel planning, decision making, and co-budgeting to enable local, regional and national perspectives to be integrated into urban policies.

However, Turok (2014) highlighted that governments are often challenged with lack of coherence and coordination of multi-project development and implementation processes between the concerned ministries, and agencies as key decision-makers. Some of the African countries have embraced the development of urban policies as place-based policies to guide spatial development as well as improve economic growth based on the financial allocation for each administrative jurisdictions. Turok (2018) refers to "place-based" policies as policies developed within a defined spatial context; therefore, for the research, place-based projects are defined as projects that have a geographical or spatial location for implementation. Todes and Turok (2018) describe place-based policies as development strategies tailored and embedded within various spatial contexts. A place-based policy being adopted are the National Urban Policies (NUP). In such NUP government plans to make the economic, social, ecological and institutional functions of cities and towns better, as well as help to accommodate future population growth efficiently and equitably (Todes & Turok, 2015; UN-Habitat, 2016). Also, such NUPs are government policies designed to guide urban growth for improved human wellbeing, ecological sustainability and regional

prosperity operationalised with spatial frameworks (Turok, 2015). Turok (2014) states that NUP have been adopted by several African countries to manage urbanisation as a driver of economic development. Also, the NUP is being adopted to coordinate economic, social, and environmental development in less urbanised cities to achieve urbanisation and economic prosperity. In Rwanda, the NUP has been adopted as a central policy for urbanisation.

The need for spatial implementation of NUP in Rwanda led to the development of spatial methods that can be adopted in countries faced with a lack of financial accountability and coordination within government organisations (Spaliviero, Boerboom, Gibert, Spaliviero, & Bajaj, 2019). An example of such spatial methods is the Spatial Development Framework (SDF) method developed by UN-Habitat. The SDF method is a strategic spatial planning tool designed to support governments in decision-making by setting out "spatial visions" of national territories and identifying development corridors, nodal towns and priority areas for geographical investments for NUP implementation (Boerboom, Gibert, Spaliviero, & Spaliviero, 2017). In some African countries, SDF has been developed to support the implementation of urban policies by providing spatial, strategic plans for development based on the identified priorities (Spaliviero et al., 2019). The SDF methods have been adopted in Darfur, Sudan and Rwanda to guide decision-makers in implementation of NUP objectives (Spaliviero et al., 2019). In spite of SDF adoption by decision-makers in governments to guide the selection of place-based projects from portfolios for implementation of NUPs, there is a wide gap in the integration of the spatial aspects in the budget planning stage. Hence, the study will explore how SDF methods can be integrated with PB for policy implementation by governments to achieve optimal investment benefits; balanced spatial and economic development with available financial resources.

1.2. Research problem

The implementation of spatial policies in many African developing countries is independent of participatory budgeting (PB) process for the allocation of financial resources. In Africa, NUP implementation in countries such as Morroco, Senegal, South Africa, and Swaziland are implemented to regulate urbanisation without PB process (Turok, 2015, p.351). Also, the implementation of the NUPs in these countries was independent of other national policies (Turok, 2015). Therefore, there is a need for the integration of NUP and other national policies for implementation to mitigate duplication of policy goals, conflicting dimensions and allocation of scarce financial resources for urban development objectives. Healey (2006) defines integration as "bringing together" or the coordination of different policy objectives for implementation. Healey (2006) further identifies different types of integration to achieve collaboration in spatial planning practice. The types of integration include coordination, framing, linking policy and action as well as linking multiple actors. The type of integration for coordination entails aligning policies and strategies for implementation at the national and local levels. The framing type of integration extends existing visions to accommodate new visions to achieve place-based implementation. Integration to link policy and action adopts specific methods for policy implementation. Lastly, the integration type that links multiple actors adopts a public participatory process for policy implementation. Therefore, the need to adopt an integration method that will bring together the policy visions, actors, for place-based policy implementation at the national and local levels. Specifically, an integration method that guides the NUP implementation as place-based projects will require prioritisation and selection of projects according to spatial needs and available financial resources. The existing weak planning systems in many developing countries have four issues impacting the decision-making process for multiple projects and makes coordination of place-based projects and implementation more challenging. First, lack of collaboration among government ministries, agencies and sectors responsible for planning and implementation of place-based projects have contributed to the failure to achieve policy objectives. Second, the presence of central decision-making but isolated work processes, coupled with little or no information sharing, repetitive

processes, as well as conflicting goals and interests among the ministries, sectors and agencies (Kidd, 2007). Third, the inadequate financial resources for project implementation have aggravated competition among implementation of policies by government ministries. Last is the complex decisions of *how* and *where* place-based projects should be implemented with the available limited budgets to achieve policy objectives. As a result, to make efficient decisions for the selection of "right projects" from different policies with various place-based project portfolios will necessitate the adoption of an integration method that will be contributing to achieving all policy objectives (Teller, Unger, Kock, & Gemünden, 2012).

Participatory budgeting has been used as a method for policy implementation (Calisto Friant, 2019). However, studies in countries where PB has been adopted have identified gaps in the need to link spatial planning with budgeting processes for policy implementation (Cabannes, 2015). Therefore, considering the integration of spatial frameworks with PB to efficiently and effectively guide in decision-making processes for policy implementation and budget allocation can achieve efficient use of scarce resources. In Africa, many development projects are planned by the different ministries, sectors and agencies that have different interests and goals at the national levels as such spatial implementation of such policies at the local levels is constrained by available financial resource allocation. Such conflicting interests have led to weak planning approaches for the planned place-based projects since the focus is on individual goals for project planning and implementation other than working together to achieving a common goal. Therefore, inefficient institutional coordination makes it challenging to regulate and monitor the implementation of projects at different levels of governments (Hughes, 2018, p.230; OECD, 2018, p.5). Consequently, the lack of PB methods for place-based projects to support NUP implementation has led to the duplication of functions[1] and inefficient use of limited financial resources at the local levels.

In Rwanda, the SDF method was adopted to guide decision-makers in the distribution of investments for place-based projects across development corridors, nodal towns and priority areas through the NUP implementation (Spaliviero et al., 2019). However, the developed SDF methods have not incorporated the budget allocation for local levels place-based project implementation within the available financial resources at the national level. Thus, an essential question considered by the research is *"how can a strategic spatial planning method such as the SDF method be integrated with PB to guide prioritisation and selection of projects for policy implementation?"*

The research considers the integration of the SDF methods with PB as a solution to guiding efficient place-based projects implementation according to policy objectives. It will contribute to bridging the gaps in multiple urban policies implementation experienced in some developing countries in the global south.

1.3. Research objective

The research objective is to develop a budgeting tool that integrates SDF methods for spatial policy implementation and evaluate the tool. The research objective will be implemented through a case study of Rwanda

1.3.1. Sub-objectives

There is a need to understand the budgeting process for spatial policy implementation. This can be achieved through the identification of frameworks for the participatory budgeting processes to enable the development of the budgeting tool. The research will also explore ways to evaluate the developed prototype for usability.

[1] Functions are defined as services, activities, equipment and facilities that have an impact on the economic, administrative, social and cultural aspects of human settlements *(UN-Habitat, 2016)*.

The following sub-objectives were formulated to achieve the main objective:

1. To identify current budgeting process for policy implementation.
2. To identify frameworks for the PB process development.
3. To evaluate the developed prototype for participatory budgeting.

1.3.2. Research questions

For the research, each identified sub-objectives will be operationalised through specific research questions, as indicated below:

1. To identify current planning and budgeting process for policy implementation

The current planning and budgeting processes for policy implementation will be identified through the stakeholders involved in the processes and their roles. The research will also identify the policies guiding the process; the procedure and methods used to identify the planning and budgeting processes.

RQ1a. Who are the *stakeholders* involved in the planning and budgeting process and their *roles*?
RQ1b. Which *policies* guide the planning and budgeting process?
RQ1c. What are the planning and budgeting *stages* and *methods*?

2. To identify the components of the PB process using theoretical frameworks for prototype development.

Based on the theoretical frameworks, the research will identify the components of PB process. Also, the research will use the components of the theoretical framework to develop a SDSS for PB. The research will then design criteria for integrating the SDF methods with the budgeting process for prototype development.

RQ2a. What are the components of the PB process?
RQ2b What are the components of developing SDSS for PB?
RQ2c What are the design *criteria* for integrating SDF methods and current budgeting process in Rwanda?

3. To evaluate the developed prototype for participatory budgeting.

The research will develop a prototype for PB based on the design criteria and use the evaluation as a method to understand its usability.

RQ3a. How can the SDF method(s) be integrated into the current budgeting process for policy implementation?
RQ3b. How will the developed prototype impact the budgeting process?

1.4. Conceptual Framework

The conceptual framework (Figure 1) explains the relationships between the concepts in this study. The concepts focus on the use of urban policies in Africa and the need to implement such policies within available financial resources. Also, it considers the adoption of participatory budgeting for spatial policy implementation and the adoption of strategic spatial planning methods such as Spatial Development Frameworks (SDF) to integrate spatial components in PB.

The main concepts that were considered for this research are urban policies, participatory budgeting, Spatial Development Frameworks (SDF) and the Spatial Decision Support Systems (SDSS). Strategic spatial planning methods have been used to guide the development of urban policies of territories. Participatory planning is an interactive strategic spatial planning method for decision-making by stakeholders to guide urban policy implementation. Urban policies such as place-based policies are translated into place-based projects for implementation. Like the participatory planning, participatory budgeting methods are participatory processes adopted to guide resource allocations for policy

implementation. The PB approaches require SDSS to guide resource allocation and enhance spatial implementation policies.

Therefore, this research will focus on understanding how SDF methods can be integrated as a SDSS to develop a PB prototype for the spatial implementation of urban policies within available financial resources for African countries.

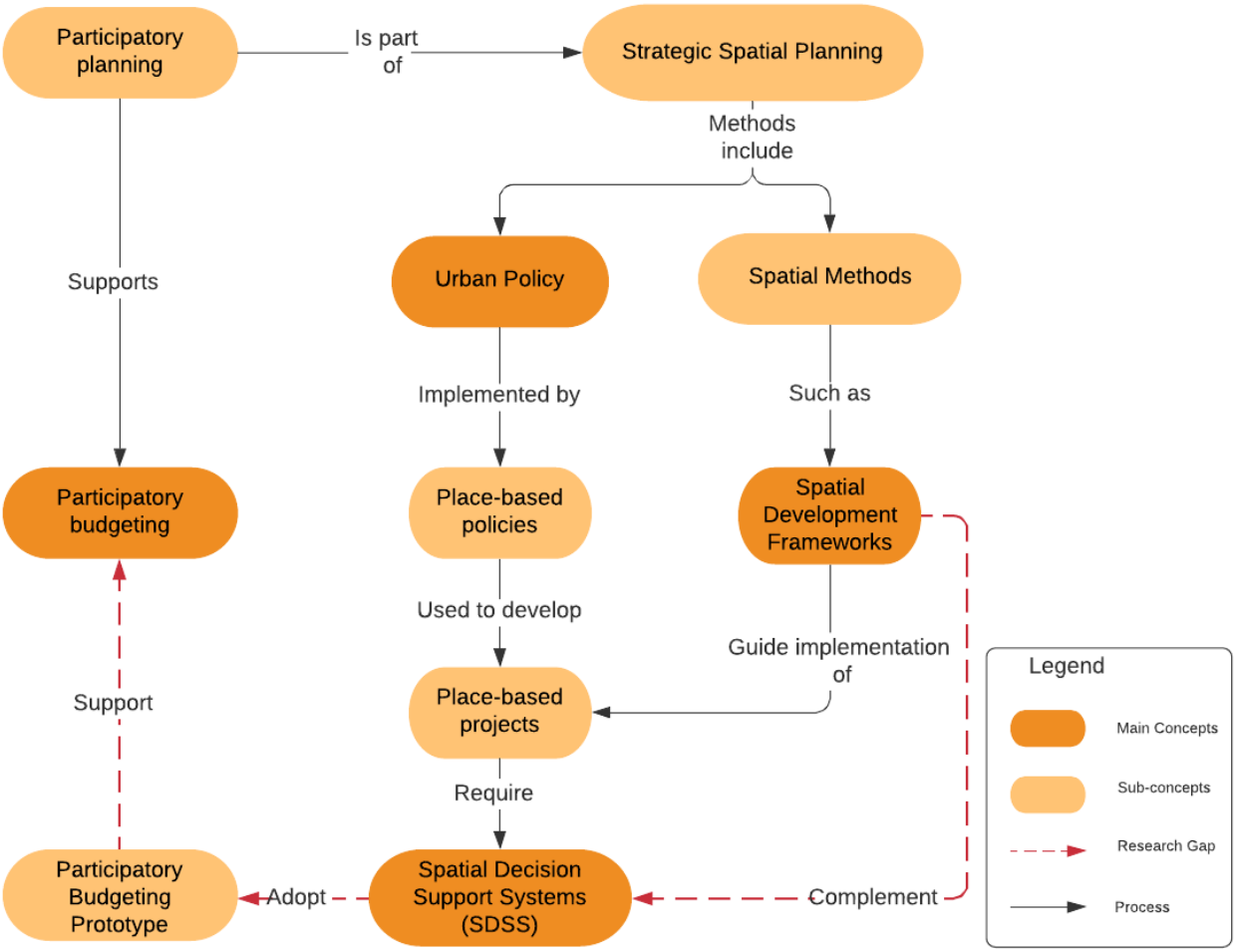

Figure 1: Conceptual Framework
Source: Author, 2020

1.5. Thesis Structure

This thesis consists of six chapters, as discussed below.

Chapter One: *Introduction,* includes the introduction of the research topic, gives the background information on the study, justification of the research problem, objectives and research questions.

Chapter Two: *Literature Review,* provides a review of literature on the key concepts of Spatial Development Framework (SDF) methods, Participatory Budgeting (PB), Spatial Decision Support Systems (SDSS), and Project Portfolio Management (PPM) methods. The chapter discusses relationships between strategic spatial planning and the SDF methods, as well as PB and strategic spatial planning. Also, it highlights the use of PB, PPM and theoretical frameworks for SDSS and prototype development.

Chapter Three: *Research Methodology,* describes the research strategy, research design matrix, case study area and justification for case study selection. The chapter provides an overview of the data collection methods

and sources. Also, the detailed explanation of the developed prototype and evaluation methods is discussed. Lastly, details of the ethical considerations that were observed during research are presented.

Chapter Four: *Results* provides details of findings based on the research questions. The detailed findings are on the stakeholders involved and their roles in the budgeting process: the policies guiding the budgeting process, the procedure and methods. Also, provided are the findings on the participatory budgeting using theoretical frameworks and the results of the developed prototype.

Chapter Five: *Discussion* provides a detailed discussion of the results based on the research questions. A detailed analysis is provided on the participatory budgeting process and evaluation of the developed prototype.

Chapter Six: *Conclusion*, a summary of significant study findings is presented, as well as the conclusion.

2. LITERATURE REVIEW

This chapter explains the main concepts from Figure 1: the Spatial Development Framework methods (SDF), Participatory Budgeting, Spatial Decision Support Systems (SDSS). Also, this chapter talks about the use of Project Portfolio Management (PPM) as a component of SDSS and their relationships. The chapter further discusses existing theoretical frameworks on participatory budgeting and Enhanced Adaptive Saturation Theory 2 (EAST2) that are used for evaluation of the prototype.

2.1. Strategic spatial planning and the Spatial Development Framework (SDF)

Studies identify the need to integrate the spatial component in participatory budgeting to enhance the spatial implementation of policies. Cabannes, (2015), investigated the use of Participatory Budgeting for essential service budgeting and implementation in several cities and countries in Europe, North America, Asia, Latin America and Brazil. The research was based on five dimensions, namely financial, participation, governance, spatial or territory and policy. The author's findings revealed that essential service budgeting of the identified needs was specific to territories; voting methods were applied as means of prioritising the identified needs for budgeting, the identified needs were categorised according to themes, and the identified needs vary between territories.

Also, Harrison, Galland, and Tewdwr-Jones (2020) identify data and technology as some of the challenges that have hindered spatial planning; as a result, the authors recommend their incorporation to guide policy implementation for urban development. Strategic spatial planning methods such as the SDF were developed to bridge gaps in spatial planning between policies and urban development (Boerboom, Gibert, Spaliviero, & Spaliviero, 2017). The SDF methods are interactive approaches that involve stakeholders in understanding the spatial structure of territories and identifying development gaps. More so, a vital role of SDF is to promote the implementation of urban policies managed by inter-sectoral governance systems, in countries with weak planning systems through the identification of territorial investment opportunities based on spatial structural analysis and harmonisation of development plans. As a result, decision-makers can make optimal use of available budget allocations for investment in the identified locations for future urban development (Spaliviero, Boerboom, Gibert, Spaliviero, & Bajaj, 2019).

In the case of Rwanda, the SDF method was implemented in two phases. The first phase comprised of three methods namely; Matrix of Functions, Consultative Workshops, Spatial Multi-criteria Evaluation, and National Strategic Action Plan that is currently being implemented in the second phase as shown by the SDF methodology flowchart in Figure 2. This research uses the outputs of the Matrix of Function (A2) and Spatial Multi-Criteria Evaluation (A5) methods to develop a PB prototype that can be adopted in the budgeting process for spatial policy implementation.

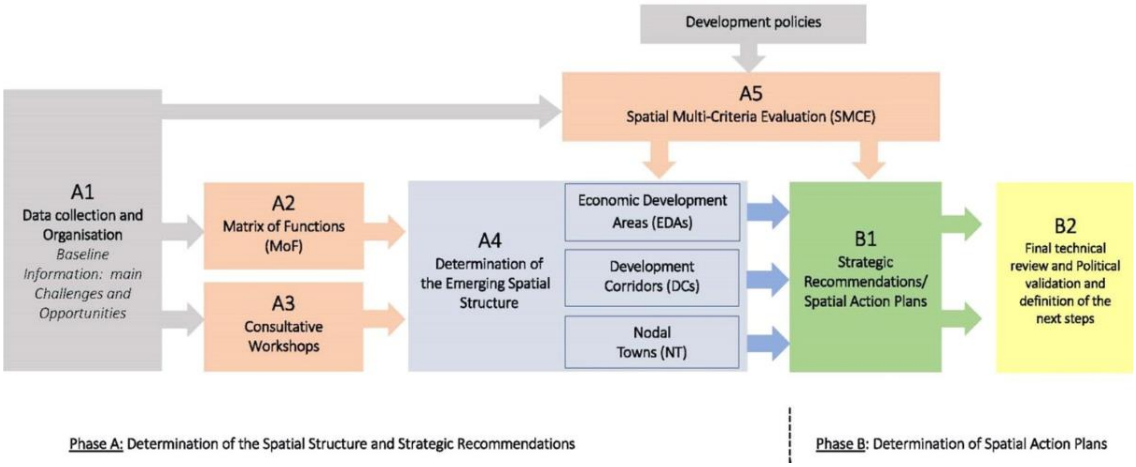

Figure 2: Spatial Development Framework (SDF) Methodology Flowchart
Source: Rwanda SDF, (UN-Habitat, 2016)

Matrix of Functions (MoF)

THE MOF METHOD WAS ADOPTED AS A PARTICIPATORY PLANNING METHOD FOR DATA COLLECTION BY LOCAL GOVERNMENT REPRESENTATIVES ON THE PRESENCE OR ABSENCE OF FUNCTIONS IN NETWORKS OF HUMAN SETTLEMENTS. THE FUNCTIONS INCLUDE PRIMARY SCHOOLS, HEALTH FACILITIES, POLICE STATIONS, COURTS AND THEATRES. THE COLLECTED DATA WAS ANALYSED BASED ON THE PRESENCE OR ABSENCE OF FUNCTIONS TO ESTABLISH THE SPATIAL STRUCTURE OF TERRITORIES AND NETWORKS BETWEEN SETTLEMENTS AND TERRITORIES. THE METHOD RESULTS IN A LIST OF BASIC, INTERMEDIATE AND CENTRAL FUNCTIONS, WHICH CLASSIFY SETTLEMENTS INTO RURAL CENTRES (RC), LOCAL URBAN CENTRES (LUC), INTERMEDIATE URBAN CENTRES 1 AND 2 (IUC1, IUC2), AND THE MAIN URBAN CENTRE (MUC) (SEE FIGURE 3). IN FIGURE 3 AND APPENDIX

Appendix 1, the sectors with the most functions are ranked in descending order, while the frequent functions are grouped to the left. The advantage of the MoF method is the ability to develop a hierarchy of settlements based on empirical data of the available and non-available functions. Thus, decision-makers have an understanding of the "clusters" of urban settlements and their socio-economic functions that complement each other (Boerboom et al., 2017). The role of the MoF is to categorise human settlement based on the presence or absence of functions for the prioritisation of spatial project needs. Although the MoF methods can effectively be used to compile functions and categorise them based on empirical data, they are, however, yet to be adopted to guide budgeting processes for efficient spatial budget allocation for the implementation of policies.

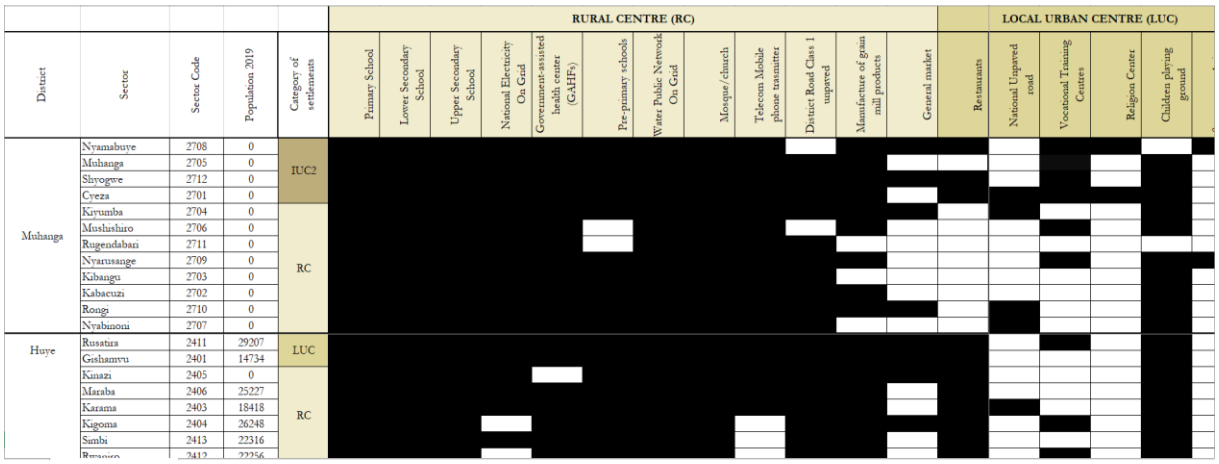

Figure 3: Extract of the Matrix of Function (MoF) output showing the presence of functions (black) and absence of functions (white)
Source: Rwanda SDF, (UN Habitat, 2019)

Spatial Muti-Criteria Evaluation (SMCE)

The SMCE is a spatial decision support methodology used for spatial analysis and evaluation of performance themes corresponding to the guiding policies in networks of urban settlements. For the SMCE, a criteria tree is defined, and it consists of an overall objective, sub-objectives aligned to policies and criteria derived from national standards and norms that are then applied to the indicator maps. The performance of territories is evaluated using the criteria regarding the formulated objectives. The outputs are standardised raster maps with pixel values between zero and one (i.e. unsuitable and suitable respectively) that are then aggregated using weighted summation (refer to *Figure 4*). The outputs are then

used to decide short, medium and long term planning investment recommendations (Boerboom et al., 2017). With the SMCE methods, decision-makers can compare settlements and determine spatial locations for investments based on the evaluated performances. Even though priority areas for investment have been identified, the incorporation of SMCE outputs with budgeting processes to guide policy implementation is yet to be explored.

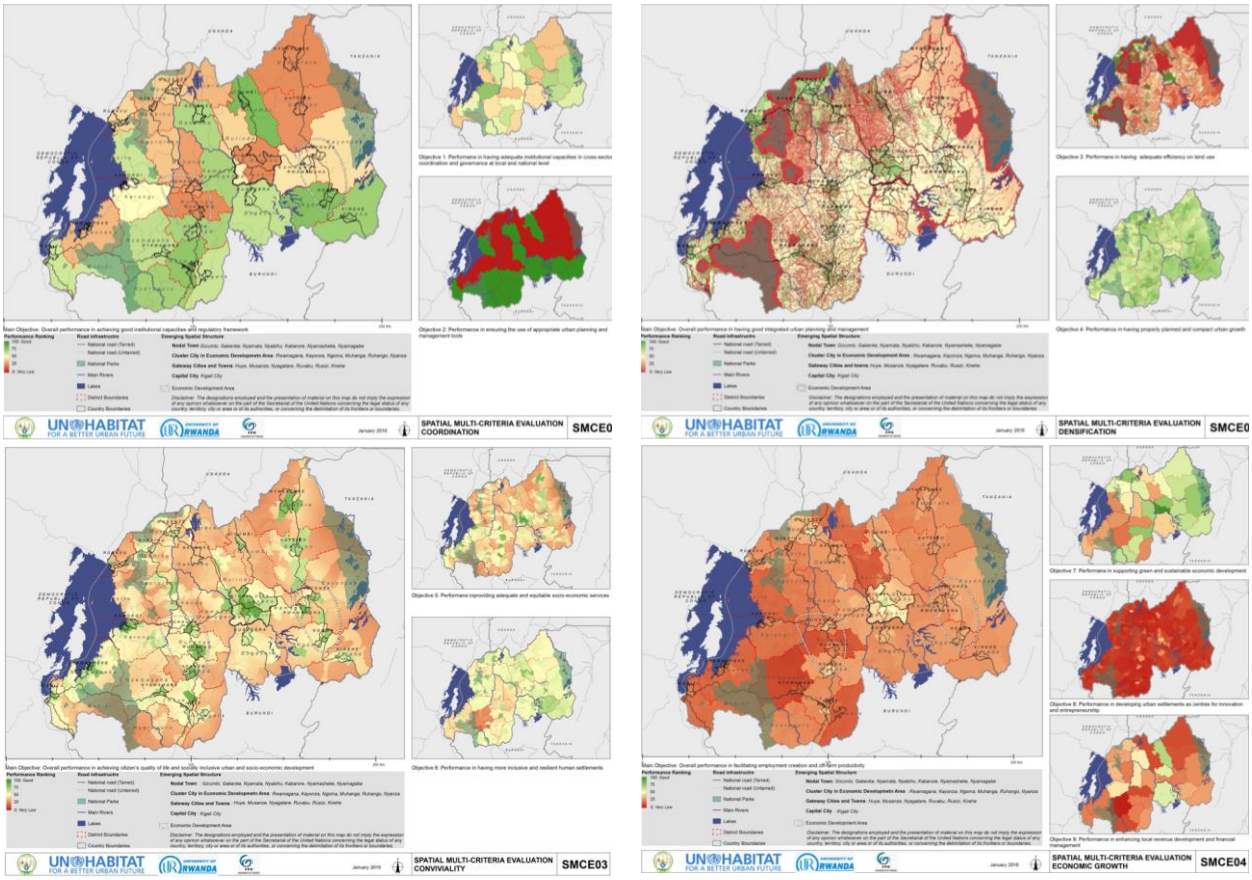

Figure 4: SMCE outputs showing performance of the Coordination, Densification, Conviviality and Economic Growth Pillars
Source: Rwanda SDF, 2016 (UN-Habitat, 2016)

The SMCE assesses the performance of settlements with existing policies and establishes investment priorities of spatial structures which can also be adopted for the budgeting process. Thus, the need to achieve policy objectives according to available budgets will require the integration of the MoF and SMCE for the spatial policy implementation to enhance the budgeting process. This research focuses on how MoF and SMCE methods will be integrated as a spatial attribute required in the budgeting process with the development of SDSS prototype that can be adopted for Participatory Budgeting across the global south.

2.2. Participatory Budgeting (PB) in Strategic Spatial Planning

A component of strategic spatial planning is stakeholders participation in the planning process. Participatory planning is an interactive process that involves communication between various stakeholders for problem identification, strategy development, policy formulation and implementation (Mostert, 2003). Participatory planning has been applied in different contexts of collaborative planning (Healey, 1997), communicative planning (Sager, 2001) and consensus-building (Innes, 2004). Despite the contextual

application, the common aspects of the studies are communication and interaction as vital aspects for multi-stakeholders decision-making at different administrative levels.

Participatory budgeting is a type of public participation process that originated in Brazil (Souza, 2001). It is an interactive procedural process that involves public participants in decision-making for resource distribution based on identified priorities (Panday & Chowdhury, 2020). Participation in participatory budgeting is a bottom-up method used by governments as a budget planning process at the national and local levels. There are five criteria in a participatory budgeting process (Sintomer, Herzberg, & Röcke, 2008: Sintomer et al., 2013). These include:

a. Financial or budget dimension: Participatory budgeting process that deals with the discussion of scarce resources and focuses on the optimal use of available resources.

b. Administrative level: Participatory process are delegated for the decentralisation of authority at the national and local levels.

c. Process cycle: Participatory Budgeting process as a planned periodic process that guides the budgeting cycle.

d. Public deliberations: Participatory budgeting processes are based on discussions between citizens and government organisations through meetings or fora.

e. Accountability: Participatory budgeting processes involve feedback on funding for the accomplished proposed projects.

Williams et al. (2017) add that PB varies based on context (spatial location) and dimensions from the degree of involvement, delegated power, and participants. The dimensions include the level of participation, type of involvement, stage of participation, methods of involvement, scale, the extent of PB redistribution, which either overlap or interact with each other. The level of participation involves the degree of control, citizen empowerment and the consultation methods and influence during the PB. The type of involvement includes citizens or representatives, technical experts and administrators. The stage of involvement entails the identification of needs, development of project proposals, selection of identified projects as well as monitoring. The methods of involvement include deliberation that involves debates among the participants and the aggregative method for voting by participants to reach a consensus. The scale dimension refers to the different administrative hierarchies, i.e. national and local, and types of participatory budgets that are either based on the territories either the city, regional or local level. Lastly is the extent to which PB is implemented as a redistributive tool to the less privileged people that live in less developed areas.

The identified context, criteria and dimensions of PB, the need to have government analytical and technical skills for decision-making, is required for the involvement of different stakeholders in the participatory process. Wampler (2000) identified some of the PB limitations to be the focus on specific programmes that created a lack of social justice, governments dependent, resulting in a lack of transparency. Due to the limitations and the complex nature of participation, various PB process frameworks such as the democracy cube and the ladder of citizen participation were developed to enhance the effectiveness of the PB.

2.3. Spatial Decision Support Systems (SDSS) for Participatory Budgeting (PB)

Spatial Decision Support Systems (SDSS) are tools that decision-makers can adopt for effective and collective use of information to address complex policy decision problems. SDSS are focused on decision-making processes for addressing spatial problems. Pontius and Si (2015) define SDSS as "computer-based systems that store, search and retrieve geographical information systems (GIS) with models and

optimisation models such as the Multi-Attribute Utility Theory (MAUT) to support decision-making for spatial and policy-related problems". While Leipnik, Kemp, and Loaiciga (1993), define SDSS as "integrated computer systems that support decision-makers in addressing semi-structured or unstructured spatial problems interactively and iteratively with functionality for handling spatial and non-spatial databases, analytical modelling capabilities, decision support utilities such as scenario analysis, and effective data and information presentation utilities." Both definitions identify SDSS as a spatial decision-making tool. However, Pontius and Si (2015) emphasises the ability to integrate optimisation methods. Therefore, the ability to integrate optimisation and SDF methods enhances SDSS as a tool for PB in guiding budget allocation for spatial policy implementation.

SDSS is a system that supports operational decision making for specific spatial implementation of policies such as budget allocation and location of infrastructure. Sugumaran and DeGroote (2011, p.15) highlight key attributes of SDSS as semi or ill-structured problem solving, easy to use, interactive user interfaces, spatial data management and analysis, iterative problem solving, spatial modelling capability, report generation, scenario evaluation and visualisation. SDSS have been developed and implemented to address several decision problems such as site selection, resource allocation, network routing, location-allocation and service coverage (Sugumaran & DeGroote, 2011). Research on SDSS reveals that despite their development, the tools are hardly used. Some of the identified reasons for failure to use SDSS include; too detailed, time-consuming and costly systems hence complicated for users, the uncertainty of the prototype output and the appropriateness of the tool in addressing decision questions (Uran & Janssen, 2003).

Geertman and Stillwell (2003) relate that SDSS and Planning Support Systems (PSS) have similar characteristics, although distinct roles. The similarities include the use of computer-based technology, database management and software modelling for complex problems. PSS is designed for short, medium and long term strategic planning while SDSS is designed to support short term decision tasks. Research on PSS has identified two approaches to development. The approaches include the traditional method of systems design and the socio-technical approach (Vonk & Ligtenberg, 2010). The authors state that the traditional methods of systems design include the establishment of requirements, implementation into a prototype and evaluation. At the same time, socio-technical methods entail the involvement and cooperation of users in the planning process to establish requirements for implementing the prototype. Furthermore, Pelzer (2017) in the research on the usefulness on PSS, stated that it is essential to understand how PSS function within specific contexts to establish its usefulness. Specifically, the usefulness in connection to the PSS and the planning tasks. Therefore, the study will adopt PSS methods to evaluate the developed prototype.

Therefore, many countries have explored the need to adopt less cumbersome decision-making processes for budget allocation and policy implementation. Budget allocations for the implementation of spatial policies have been executed with Participatory budgeting (PB) in developed and developing countries (Cabannes, 2015). PB involves complex decision-making processes to allocate budget resources for the identified projects based on policy objectives. The participatory budgets include annual plans with non-spatial information of the identified projects of territories. The identified projects have spatial locations, and this information is not included in the budgets. PB processes comprise decision problems characterised by spatial and non-spatial data. Spatial decision problems have geographical location coordinates and spatial relations such as proximity, overlaps and distribution patterns (Keenan & Jankowski, 2019). Naseer, Bimal, & Vinod Kumar (2015) established the use of SDSS as a web-based participatory e-budgeting tool in Kozhikode Municipal Corporation for budgetary decision making to achieve rational budgets allocations. Thus, the development of such SDSS for PB will require and integration method for the spatial and non-spatial data.

2.4. Project Portfolio Management (PPM) for PB prototype development

In participatory budgeting processes, decisions have to be made on how to allocate the available limited financial resources for urban development to implement policy objectives. More so, the multiple projects require decision-making methods and trade-offs for the available budget allocations. PPM is the art and science of the application of a set of knowledge, tools, skills and methods to a collection of projects to meet investment strategy (Meskendahl, 2010). Levine (2005, p.60) refers to PPM as a method that deals with the management of multiple projects aimed at maximising strategic coordination, alignment of projects, optimal budget allocations, effective use of resources and risk reduction. The PPM methods have been commonly applied in organisational and industrial research as an integrated approach for the strategic alignment of goals, decision-making, coordination through portfolio management (Martinsuo, 2013). In literature, the goals of Project portfolio management (PPM) include portfolio trade-offs, monitoring portfolio balance expected utility, and strategic alignment to objectives (Elonen & Artto, 2003; Maceta, Berssaneti, & Carvalho, 2017).

PPM has been applied in identification, prioritisation and selection of projects in a project portfolio, with the aim of effective management of multi-projects to avoid repetition and overscheduling given the limited budget allocations (Cooper et al., 2001b). The studies on PPM mainly focused on developing tools, methods and techniques for the selection, prioritisation, evaluation and monitoring of project portfolios (Archer & Ghasemzadeh, 1996; Cooper et al., 2001).

Archer and Ghasemzadeh (1996), established an integrated process for project portfolio prioritisation and selection method as an appropriate method for complex decision-making processes characterised with multiple and conflicting objectives when managing multi-projects. An advantage of the framework is its ability to integrate methods at every stage of the process (Archer & Ghasemzadeh, 1996, p. 31). The integrated method involves portfolio selection based on three stages, i.e. pre-processing stage, processing stage, and the post-processing stage (See **Error! Reference source not found.**). The pre-processing stage is the initial step of the project portfolio selection process. The stage is mainly composed of two sub-stages, i.e. proposed project pre-screening (define strategic guidelines and determining resource allocation) and model selection and development (is a strategic process for the selection and evaluation of the proposed project portfolio selection). The second stage is the process stage for projects evaluation, screening and portfolio selection for implementation for budget allocation (individual process analysis, screening optimal portfolio selection and portfolio adjustment). During the individual projects process analysis classification is made based on project characteristics and assessed to determine parameters for comparison between competing projects. The post-process stage combines the pre-process and process stages for portfolio balancing and adjustment according to resource allocation and availability. The focus of this research is to adopt the project portfolio selection process, as described by Archer and Ghasemzadeh (1996) for the development of the prototype.

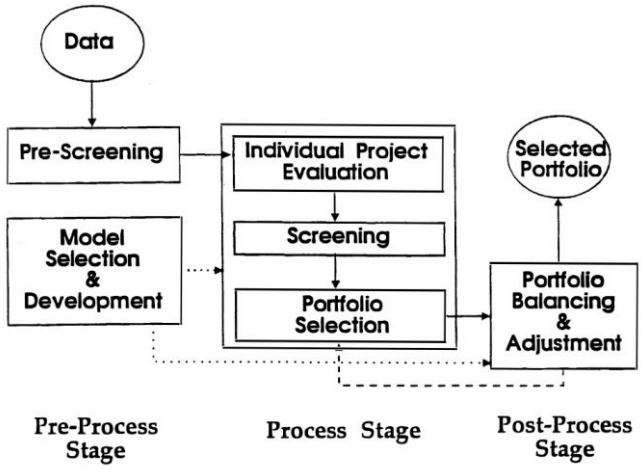

Figure 5: Project portfolio selection process
Source: Archer and Ghasemzadeh (1996)

Little is known about PPM application in prioritisation, selection and budget allocation for placed-based projects in policy implementation. Thus, the role of PPM as a vital method for guiding decision-makers in the prioritisation and selection of place-based projects for achieving implementation of urban policy objectives with allocated budgets needs to be explored. Mavrotas et al., (2006, p. 299) defined project portfolio prioritisation as the ranking or scoring of projects based on evaluation criteria. Project portfolio prioritisation aim is to rank projects according to the identified strategic or resource categories (Mathur, 2007). In contrast, project portfolio selection is a periodic activity that involves portfolio selection from project proposals and ongoing projects to meet government objectives without exceeding available financial resources and violating other constraints (Archer & Ghasemzadeh, 1999). A method that has been applied for project portfolio prioritisation and selection is the Multi-Attribute Utility Theory (MAUT) optimisation method.

Camasso and Dick (1993) refer to MAUT as a method useful for evaluating policies and projects based on multi-attribute decision analysis. The authors add that MAUT techniques provide a form for assessing needs, setting priorities which are similar to planning and budgeting. The MAUT are utility-based methods that use mathematical functions in guiding decision-makers in generating preferences (Ananda & Herath, 2009). Also, the MAUT is a multi-criteria decision-making approach used for the evaluation of decision problems to achieve an optimal solution. The MAUT assumes value or utility function of aggregated evaluation scores of criterion and decisions are then based on the comparison of individual criteria values (French, Bedford, & Atherton, 2005). Specifically, decision-makers can influence decisions by incorporating their preferences for the different criteria when risks are involved hence eliminating bias (Alinezhad & Khalili, 2019). Some of the MAUT methods used for project prioritisation and selection are the analytic hierarchy process (AHP) and the Utility-based trade-off (UTA). The AHP is a method that involves the structuring of criteria in a hierarchy and pairwise comparison in a matrix format (Kaiser, Futami, Valentina, & De Oliveira, 2019). In contrast, the Utility-based trade-off (UTA) algorithm that utilises the aggregation of utility functions for resources and benefits of projects.

The Utility-based trade-off (UTA) is an algorithm that helps decision-makers to make rational choices in multiple project developments. The algorithm is applied in scenarios where the projects cannot be implemented at the same time. Moreso, in situations where the decision-makers have multiple projects, objectives, scarce resources, and other attributes of interest to make decisions. Besides, the UTA algorithm enables priority setting, development of scenarios and sensitivity testing. The UTA uses the concept of utility/ disutility ratio similar to cost / benefit. The advantage of the UTA algorithm is it presents decision-makers with possibilities for objective satisfaction based on a range of preferences

between the benefits and resources. Also, the UTA applies an interactive process between decision-makers to analyse spatial data for project selection and budgeting (van den Toorn, 1985). This research adopts the UTA algorithm for integration in the prototype.

2.5. Theoretical frameworks

This section describes the democracy cube theoretical framework for the participatory budgeting and the EAST framework that the research adopts to evaluate the prototype.

2.5.1. The Democracy Cube Framework for Participatory Budgeting

The purpose of public participation is to collect opinions for integration in policy development and implementation. However, each public participation process is unique due to the different location, actors and governance processes in which they are conducted. As a result, frameworks have been adopted to understand and examine complex governance structures, institutions and the procedures for participation. The examples of the frameworks applied to study public participation processes in complex governance systems include a ladder of citizen participation (Arnstein, 1969) and the democracy cube framework (Fung, 2006a). The ladder of citizen participation identifies eight stages of citizen participation that are grouped into various degrees of nonparticipation, tokenism (symbolic effort) and citizen power (Figure 6). Arnstein (1969) describes the nonparticipation of therapy and manipulation, which does not recognise the actual participation of citizens. The tokenism includes informing, consultation and placation, that imposes decisions to the citizens during a participatory process. The citizen power recognises citizen control in the decision-making process through partnership, delegated power and citizens control. The ladder of citizen participation has been adopted for spatial planning processes such as urban renewal, socio-economic and model cities development (Arnstein, 1969).

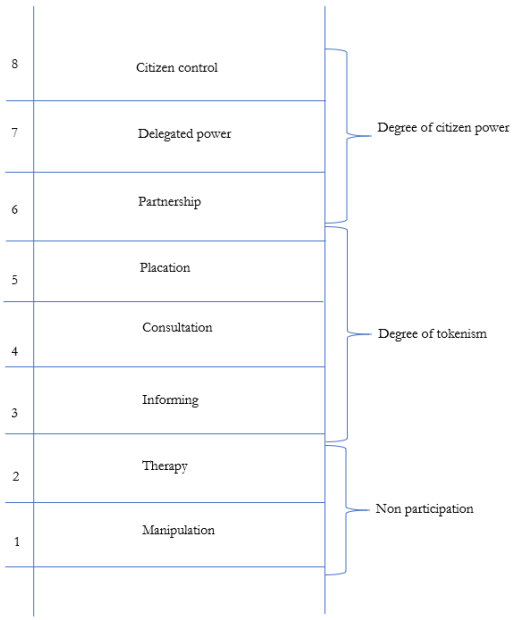

Figure 6: The ladder of citizen participation
Source: (Arnstein, 1969)

Fung (2006) states that the categorisations in the ladder of participation according to recent research participatory processes is outdated and unreliable. He highlights that the core of participatory process frameworks should address: who participates, how do they communicate to reach decisions, and what factors are considered before decisions consensus? The author explains the questions with three dimensions of participant selection, communication and decision mode and authority and power. The

participant selection describes who takes part in the participatory process. Specifically, the focus is the eligibility of participants and the procedure for selecting participants. The author identifies eight methods of participants selection that are also categorised as the most exclusive and inclusive. The most exclusive methods include the selection of expert administrators, elected representatives and professional stakeholders. The most inclusive methods involve the selection of 'lay stakeholders', randomly selected participants, selectively recruited participants, and self-selected participants. The communication and decision mode dimension entails how participants communicate and make decisions together during a participatory process. The modes of communication are categorised as least intense and most intense. The least intense include listening as spectators, expression of preferences and development of choices, and the most intense is for decision-making which comprises aggregation and bargaining, deliberation and negotiation, as well as the deployment of techniques and expertise. Fung (2006) states that when designing a participatory process, the level of intensity will ascertain the level of investment, knowledge and commitment of participants. Lastly, the authority and power dimension entails how participant discussions are related to policies and their implementation. As such, the influence of authority and power is categorised according to most authority (direct authority, co-governance and advice or consultation) and least authority (personal benefits, and communicative influence). Specifically, the democracy cube framework (Figure 7) was developed to understand the different options of public participation in complex government organisations (Fung, 2006a).

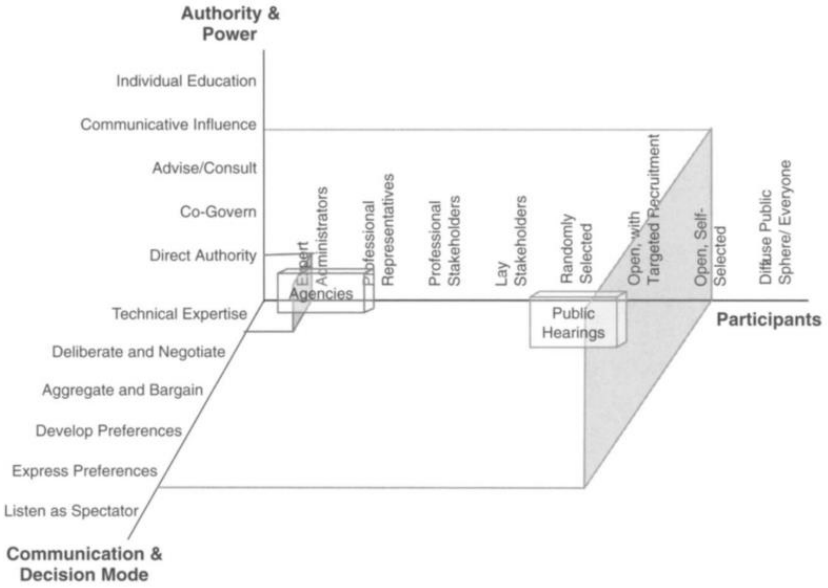

Figure 7: The Democracy Cube
Source: (Fung, 2006)

The democracy cube framework has also been applied in governance study for the "participation in flood risk management and the potential of citizen observatories" (Wehn, Rusca, Evers, & Lanfranchi, 2015). In the study, the authors established the lack of clear structures that affect decision-making and interaction of stakeholder participation in governance structures. The author highlights the difference in participatory processes by information communication technology (ICT) across territories (Doncaster-UK, Delfland-Netherlands and Vicenza-Italy) with three dimensions of the democracy cube framework. The democracy cube framework is relevant for this research because it will be used to identify the participants and their roles; establish the level of authority for the participants; the forms of communication used in the participatory budgeting process, using the three participatory dimensions from democracy cube

framework. Also, it will consider how the existing policies for planning and budgeting can be used to establish an integration with SDF methods.

2.5.2. Enhanced Adaptive Saturation Theory 2 (EAST2) Framework for PB Prototype

The Adaptive Saturation Theory (AST) is developed to understand the adaptation of technology and change in organisational structures for group decision support systems (GDSS) (DeSanctis & Poole, 1994). The author refers to GDSS as "types of information technology that combine computation, communication and decision support capabilities to aid group idea generation, planning, problem solving and choice making." The AST framework is used to examine the human-computer interaction in the organisational context (Giddens, 1984). However, one of its limitations is the ability to critically examine participatory processes within complex inter-organisations that make use of GIS. As such, the Enhanced Adaptive Saturation Theory 2 (EAST2) was developed on the foundation of the AST to evaluate how decision-makers can make use of GIS using complex decision problems in complex organisations. The framework helps to understand the effect of advanced spatial information technology on complex participatory processes and in an organisational context (Jankowski & Nyerges, 2001).

With the EAST2, the characteristics of inter-organizational decision-making processes can be explained based on three primary constructs; convening, process and outcome constructs. The convening construct describes the vital elements for establishing a decision task, e.g. goals and objectives, participants and organisations, and information technology that support decision-making processes. The process construct involves the effect of changes in using decision aids, management of phased decision responsibilities and generated information such as maps, models and databases. In the outcome, the construct includes the impact of the outputs from the decision tasks on social relations after task completion. Each construct is further subdivided into the eight constructs and 25 aspects for group decision-making, as shown in Figure 8. The advantage of the framework is it can be adopted to investigate a decision problem, the organisational context that influences the decision problem, stakeholder involvement and the influence of geoinformation technology on decision-making processes. Furthermore, the EAST 2 framework can be used to assess how the tool will address decision support needs in complex organisations. Therefore, the EAST 2 framework can be adopted as a comprehensive framework to evaluate the impact of geospatial support system for decision situations for complex multi-level and inter-organizational group participatory processes.

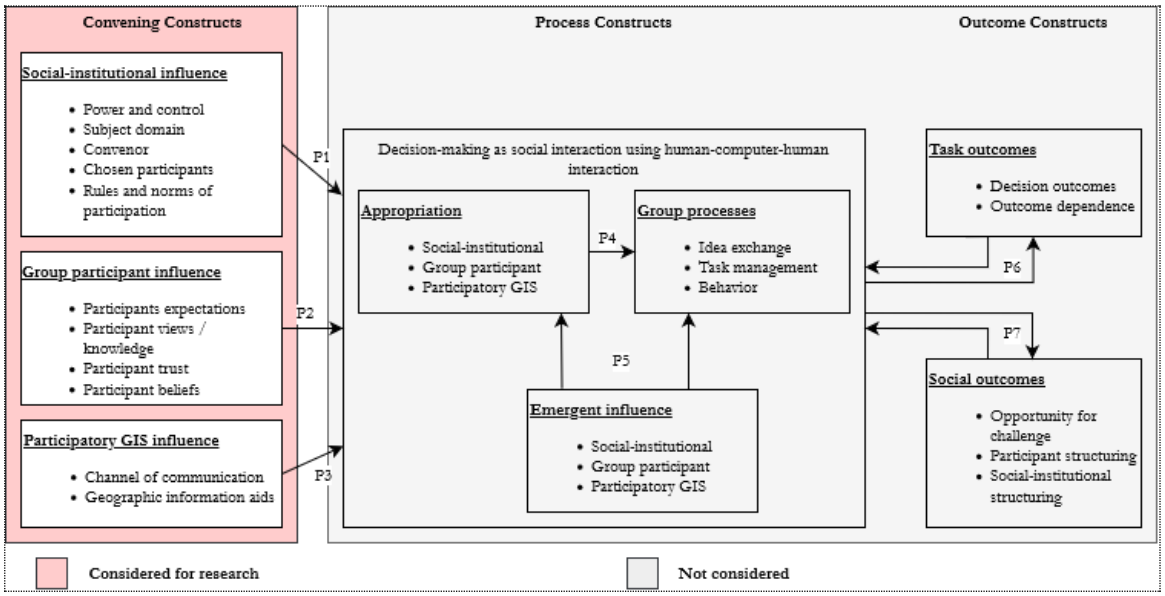

Figure 8: Enhanced Adaptive Saturation Theory 2 Framework

Source: Adapted from Jankowski & Nyerges (2001)

3. METHODOLOGY

This chapter describes the research methods adopted in addressing the research objective and questions. The first section explains the research strategy and research design matrix. The following section describes the study area, the prototype development followed by the last section explaining the ethical considerations that were considered for this study.

3.1. Research Strategy

Saunders, Lewis, and Thornhill (2009, p.177), state that the case study approach is essential for an in-depth understanding of the context and implementing the research methods to address the research questions. Specifically, Rwanda is adopted as the study area mainly because the SDF methods have been adopted as strategic spatial planning methods for policy implementation and identified as techniques for spatial components in planning and budgeting (UN Habitat, 2019). The two components of the SDF methods considered are important for PB because the MoF identifies the spatial structure of settlements and the SMCE categories the spatial structure by their potentials into hierarchies of settlements. On the other hand, the National Strategic Action Plan (NSAP) adopts the recommendations from the MOF into economic development areas, and the Consultative Workshop (CW) adopts the MoF outputs to understand the spatial structure of territories. Also, Rwanda engages citizen participation to identify needs at the local level based on existing national policies, and the current budgeting process uses non-spatial methods for policy implementation. Hence, in this context, a representative case study approach was adopted to understand "*how*" the SDF methods can be used for PB (Bryman, 2012, p.70).

The research used a secondary data review and developed a participatory budgeting prototype. The study also compared the Democracy Cube and the Enhanced Adaptive Saturation Theory 2 (EAST2) theoretical frameworks for the development of a PB process. The Democracy Cube was used in identifying the components of the PB process based on the three criteria; stakeholders in the participatory budgeting process, the authority and power as well as communication and decision-making. Also, the EAST2 framework was used to establish how the components of the PB process would be used to develop a PB prototype using the convening constructs. The convening constructs focused on the functionality, organisation and capabilities of the PB process for the prototype development.

Furthermore, the Democracy Cube and EAST2 frameworks were then used for evaluation of the prototype to establish its usability. The evaluation was achieved through an assessment of the prototype development objective, the generated results, how preferences are specified and user interface.

The evaluation of the developed prototype on the usability and adaptability was to be achieved through workshop and interviews with the stakeholders involved in the budgeting process during fieldwork. However, the fieldwork could not be achieved due to denied access to Rwanda. The denial was because of the geopolitical tension between the government of my home country (Uganda) and the case study area (Rwanda).

3.2. Research Design Matrix

The research design matrix identifies existing policies to understand the planning and budgeting process and methods. It also identifies theoretical frameworks used to understand the participatory budgeting process and how the SDSS can be adopted for policy implementation and further establish criteria for

prototype development. Lastly, the research design establishes how the developed prototype will be evaluated.

For this study, two techniques were used, namely the review and summary of documents as well as spatial analysis, as shown in Table 1**Error! Reference source not found.**. The summary of documents is secondary data collection methods that involved the review of policies and literature in extracting information to operationalise research objectives on planning and budgeting process, establish the use of SDF as a SDSS for PB and the development and evaluation of the prototype. The spatial analysis is a method used for spatial data processing and the generation of results. The spatial analysis method was used to operationalise research objective three.

Table 1: Research Design Matrix

Research Objective	Research Sub Objectives	Research Questions	Data Collection Method	Method of analysis	Anticipated Results	Source
To develop a participatory budgeting tool that integrates SDF methods for spatial policy implementation and evaluate the tool.	To identify the current planning budgeting process for policy implementation	Who are the *stakeholder s* involved in the budgeting process and their roles?	**Secondary Data** 1. Planning Policies 2. Budgeting policies	Review and Summary of policies	1. Stakeholders involved in planning process (**Table**) 2. Stakeholders involved in budgeting process (**Table**)	**Websites** **Planning** 1. Ministry of Infrastructure (**MININFRA**) 2. Ministry of Local Government (**MINALOC**) 3. Ministry of Natural Resources **(MINIRENA)** **Budgeting** 1. Ministry of Finance **(MINECOFIN)**
		Which *policies* guide the budgeting process?	**Secondary Data** 1. Budgeting policies and instructions 2. Literature Review	Review and Summary of policies *t* documents	Policies that guide planning and budgeting processes (**Table**)	**Websites:** 1. Ministry of Finance (**MINECOFIN**) 2. Online Journals or articles
		What are the budgeting *procedure* and *methods* ?	**Secondary Data** 1. Budgeting policies and instructions	Review and Summary of documents	Budgeting procedure and methods (**Diagram**)	**Websites:** 1. Ministry of Finance (**MINECOFIN**)
	To review PB process for policy implementation using theoratical frameworks	What are the existing frameworks for PB?	**Secondary Data** Literature Review	Review and Summary of documents	Aspects of the frameworks annd how they relate to the PB process (**Table**)	Online Journals or articles
		What are the existing frameworks for SDSS for policy implementation	**Secondary Data** Literature Review	Review and Summary of documents	Aspects of the frameworks annd how they relate to the PB process and the developed SDSS (**Table**)	Online Journals or articles
		What are the design *criteria* for integrating SDF methods and the current budgeting process in Rwanda? (prototype development)	**Secondary Data** Literature Review	Review and Summary of documents	List of Criteria for prototype development	Online Journals or articles
	To evaluate the developed prototype for participatory budgeting.	How will the developed prototype (SDF integrated) impact the budgeting process?	**Secondary Data** Literature Review	Summary of documents Spatial analysis	1. Alternatives of place-based projects (Map(s), Graphs, Charts) 2. Evaluation criteria	Online Journals or articles

Source: Author, 2020

3.3. Case study Area

Rwanda is one of the Sub-Saharan countries in the global south located in the Eastern Africa region. The country covers 26, 338 square kilometres and much of it is characterised by hilly terrain. The country's capital city is Kigali. At present, Rwanda is one of the fastest rapidly urbanising countries with the highest urban population growth rate in Sub-Saharan Africa. The country's current total population is estimated to be approximately 12million people with the annual growth rate at 2.3% (National Institute of Statistics, 2019). Furthermore, 20% of the total population is estimated to live in urban areas. The National Institute of Statistics of Rwanda (2014) estimates that by 2030, the urban population will increase by 30%, which have been supported by the development of various policies.

Such national policies include the Rwanda Vision 2050, National Strategy for Transformation (NST1), and the National Urbanisation Policies (NUP). Rwanda embraced urbanisation as a priority for strategic urban

development (Ministry of Infrastructure, 2019; UN-Habitat III, n.d.). The NUP considers urbanisation as an engine to achieve economic development and sustainable human settlements. The NUP has four pillars; coordination, densification, conviviality, and economic growth (Ministry of Infrastructure, 2015). This urbanisation process has created a high demand for urban development functions such as infrastructure; road network, water, electricity, housing and other social services to improve social-economic conditions for human development. The SDF methods were adopted and applied to implement the NUP.

At present budgeting for spatial implementation of projects does not include the spatial component for planning. The Ministry of Finance and Economic Planning (MINECOFIN) coordinates the planning and budgeting process with various stakeholders at the national and local levels. The policies that guide the planning and budgeting procedures for urban development include the Sector Strategic Plans (SSP), and the District Development Strategies (DDS). The Sector Strategic Plans (SSP) are planning policy documents for the Line Ministries and agencies at the national level, while the District Development Strategies (DDS) are planning policy documents for the districts at the local level. Moreover, MINECOFIN adopted the Medium-Term Expenditure Framework (MTEF) as a budget planning method for effective utilisation of available resources (Houerou, 2002). Also, the MTEF provides a link between the planning and budgeting processes.

However, the adoption of SDF methods to guide the budgeting process has not been explored. Therefore, to address this, this study developed a participatory budgeting prototype for spatial project prioritisation and selection according to available budget allocation.

Rwanda Southern Province

The selection of the study area was informed by reviewing the District Development Strategies (DDS) of Rwanda for the availability of data on the planned projects, as shown in see Appendix 2. The use of DDS is because they are annual planning policy documents for districts at the local level, which can be adopted for the integration of MoF and SMCE. All the reviewed DDS had both the DDS implementation plans and costings of the planned projects, although some of the Districts lacked details of this information. Specifically, the DDS implementation plan provided details of a list of types of planned projects according to Sectors, e.g. Agriculture, Education, and Health, planning of projects according to financial years. Also, the DDS indicated that the planned projects were according to administrative units, the cell to the sector level. However, the locations were not indicated for all planned projects in the reviewed DDS. As such, the southern province was adopted based on data available of the planned projects from the DDS implementation plans for six districts out of eight to enable the development of a method that integrates the SDF methods for PB (see **Error! Reference source not found.**). Rwanda comprises of five administrative provinces namely, Northern, Central, Eastern, Southern and Kivu Belt as categorised by the SDF methods. The Southern province consists of eight districts, namely; Muhanga, Ruhango, Nyanza, Huye, Nyaruguru, Nyamagabe, Gisagara, and Kamonyi (see Figure 9).

Table 2: Southern Province Data Availability

SDF Province	District	DDS Implementation Plan	Costing for Planned projects
Southern	Muhanga	Planned projects	Not available
	Ruhango	Planned projects	Not available
	Nyanza	Planned projects	Not available
	Huye	Planned projects	Not available
	Nyaruguru	Not available	Not available
	Nyamagabe	Planned projects	Not available

	Gisagara	Planned projects	Not available
	Kamonyi	Not available	Not available

Source: Author, 2020

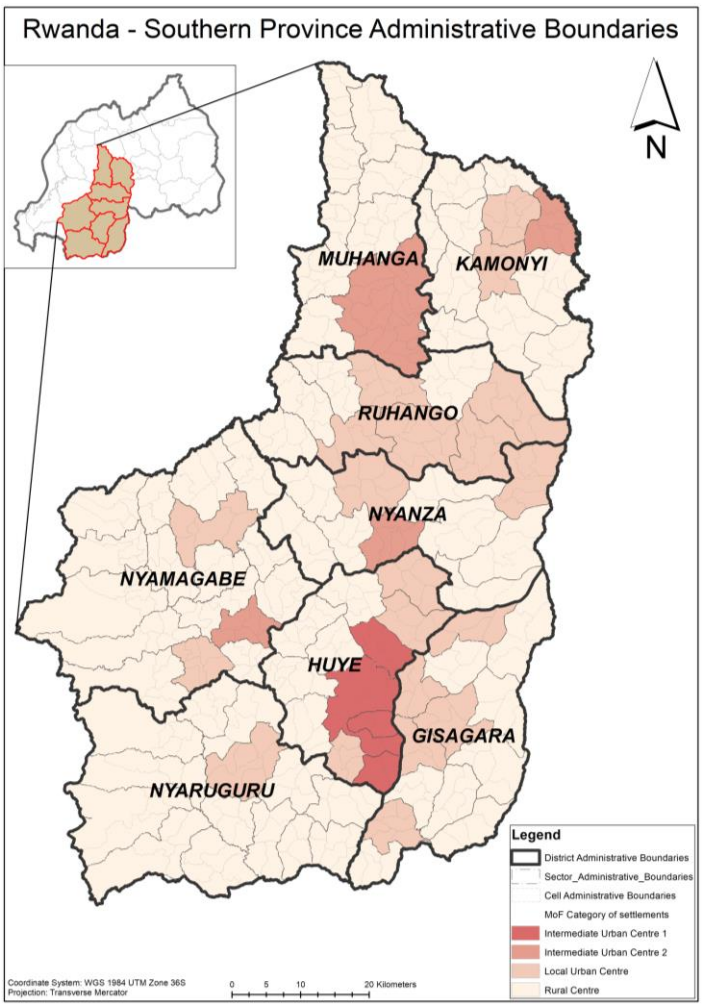

Figure 9: Map of Rwanda showing Southern Province and Districts Administrative Boundaries
Source: Rwanda SDF, ITC 2016

3.4. Data collection method and data sources

The research aimed to collect and use primary data for the study to establish the current Project Portfolio Management methods and how they can be integrated with SDF. Due to reasons beyond control, fieldwork in the study area could not be undertaken. Therefore, the data collection methods explored the use of secondary data sources to understand the current planning and budgeting processes, policies and methods to enable the development of a prototype that enables the prioritisation and selection of place-based projects for policy implementation.

The secondary data review included literature on theoretical frameworks from previous studies, grey literature obtained from the various Ministry websites, SDF methods reports, and the GIS shapefiles of administrative boundaries. Saunders, Lewis, & Thornhill (2009) refer to grey literature as primary literature comprised of government publications such as reports, memos and planning documents that can be analysed such as policies, circulars and frameworks. The analysis helps to understand the participants involved in the budgeting process, policies that guide the budgeting process, procedures and methods

used in the budgeting process and organisational structures. Details of the secondary data sources are as shown in Table 3 and Appendix 3.

Table 3: Secondary Data Sources

Documents	**Source**	**Data**	**Research Question (s)**
Planning & Budgeting Policies			
Vision 2050	Ministry of Finance and Economic Planning	The methods for planning and budgeting	RQ1b. Which *policies* guide the planning and budgeting process? RQ1c. What are the planning and budgeting *methods*?
National Strategy for Transformation (NST1)	Ministry of Finance and Economic Planning	The policy pillars and planning framework	RQ1b. Which *policies* guide the planning and budgeting process?
National Investment policy	Ministry of Finance and Economic Planning	The stakeholders in the planning and budgeting process, their roles and planning and budgeting process	RQ1a. Who are the *stakeholders* involved in the planning and budgeting process and their *roles*?
Result based performance management (RBM) policy for Rwanda public service	Ministry of Finance and Economic Planning, Ministry of Public Service and Labour	Planning Framework	RQ1c. What are the planning and budgeting *procedure* ?
MINECOFIN Service Charter	Ministry of Finance and Economic Planning	The roles of stakeholders in the budgeting process	RQ1a. Who are the *stakeholders* involved in the planning and budgeting process and their *roles*?
National Land Use Planning Guidelines	Ministry of Natural Resources	The process for land use planning guidelines	RQ1b. Which *policies* guide the planning and budgeting process?
National Urbanisation Policy (2015)	Ministry of Infrastructure	The policy pillars	RQ1b. Which *policies* guide the planning and budgeting process?
SDF methods Reports	ITC, Rwanda SDF, 2016 and 2019	The details of the SDF methods	RQ3a. How can the SDF method(s) be integrated into the current budgeting process for policy implementation?
District Development Strategies (DDS)	ITC, Rwanda SDF, 2019	The planned project ideas	RQ3a. How can the SDF method(s) be integrated into the current budgeting process for policy implementation?
Spatial Data			

SDF methods	ITC, Rwanda SDF, 2016	The details on the availability of functions, population per sector and the performance of Districts according to NUP Pillars	RQ3a. How can the SDF method(s) be integrated into the current budgeting process for policy implementation?
Administrative Boundaries	ITC, Rwanda SDF, 2016	Districts, Sector and Cells	RQ3a. How can the SDF method(s) be integrated into the current budgeting process for policy implementation?

Source: Author, 2020

3.5. Prototype Development

The research objective was to develop a SDSS PB tool that integrated SDF methods (MoF and SMCE) with PB using UTA algorithm to guide spatial policy implementation. The tool development was realised using ArcGIS online web-based solutions for Local Government installed on the ArcGis online server. The implementation was achieved in five steps (A, B, C, D, and E), as shown in Figure 10 (also see Appendix 4). The prototype development involved the use of ArcGIS Pro for desktop, ArcGIS online, Javascript and python software for each of the steps undertaken.

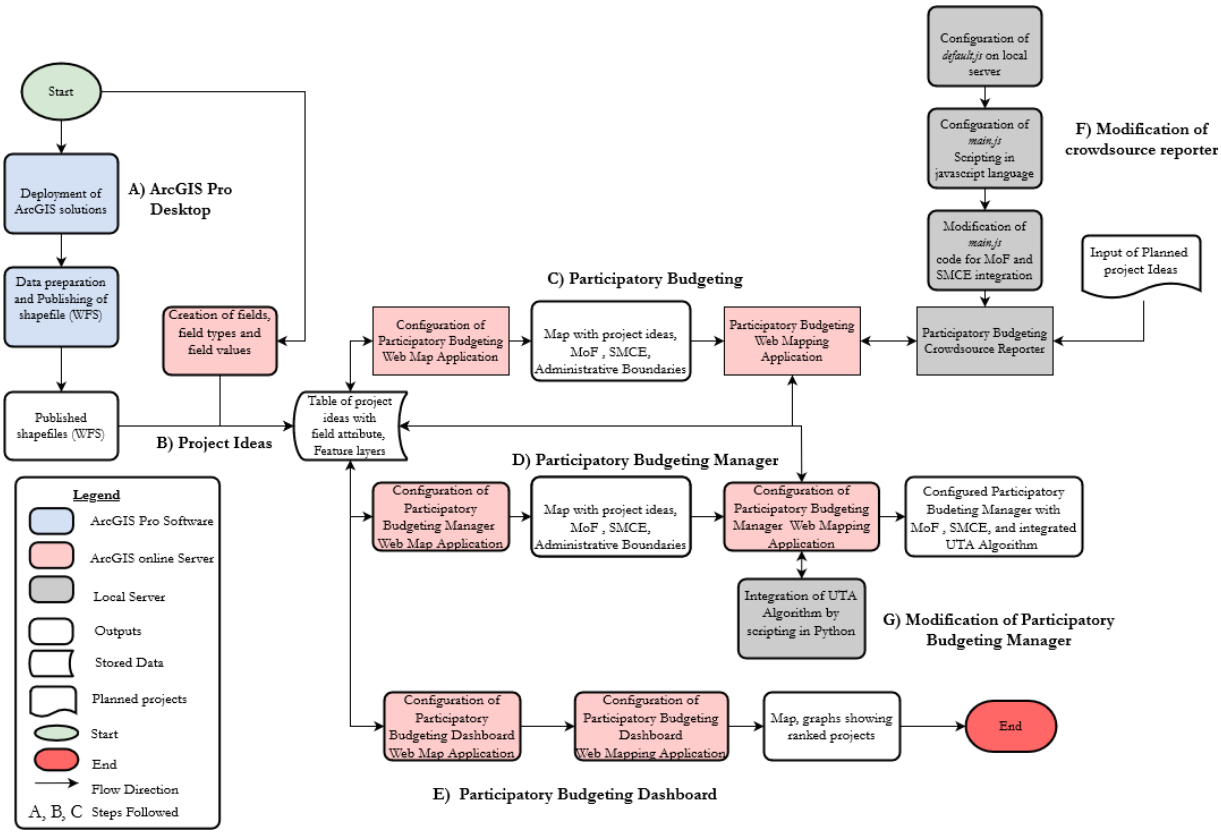

Figure 10: Prototype development flow diagram
Source: Author, 2020

The preliminary step A of the prototype development involved the deployment of the ArcGIS solutions for local government, specifically the Participatory Budgeting tools using the ArcGIS pro for desktop.

This procedure entailed downloading of the ArcGIS solution an ArcGIS Pro add-in. The tool was deployed using the tasks tab under the share button in ArcGIS Pro (see Figure 11). The deployment was necessary to install the add-ins in the ArcGIS online server for prototype development. The Participatory Budgeting (PB) is a local government budgeting tool for public participation that can be deployed by government agencies to collect feedback, monitor, verify and assign project ideas to agencies responsible for budgeting. The PB tool is comprised of three main applications; Participatory Budgeting (C), Participatory Budgeting Manager (D) and Participatory Budgeting Dashboard (E), as shown in Figure 10 and Figure 11. The Participatory Budgeting Application is an application that can be used to identify project ideas for implementation. The Participatory Budgeting Manager is an application used to review, approve and manage budget allocations for the submitted project ideas. Lastly, the Participatory Budgeting Dashboard is an application used by decision-makers to monitor the submitted project ideas. The output from each of the three applications is the public project ideas (B) that store information in a tabular format. Each PB tool comprises of both a web map and web mapping application, as shown in Figure 10 (also see Appendix 5). The web map applications were used to upload the shapefiles referred to as feature layers in ArcGIS online such as the MoF, SMCE, administrative boundaries. Each Web Map was configured to enable the organisation of the attribute fields of the feature layers and visualisation of maps before data input. As a result, the configured maps from the Web Map were automatically integrated into the Web Mapping Application.

Moreso, modifications to the ArcGIS solutions to operationalise the objective were mainly done in step F for the Participatory Budgeting application to enable the integration of the SDF methods. In step G, the Participatory Budgeting Manager application was modified to enable the integration of the UTA algorithm. Both steps F and G are further elaborated in Section 4.3.

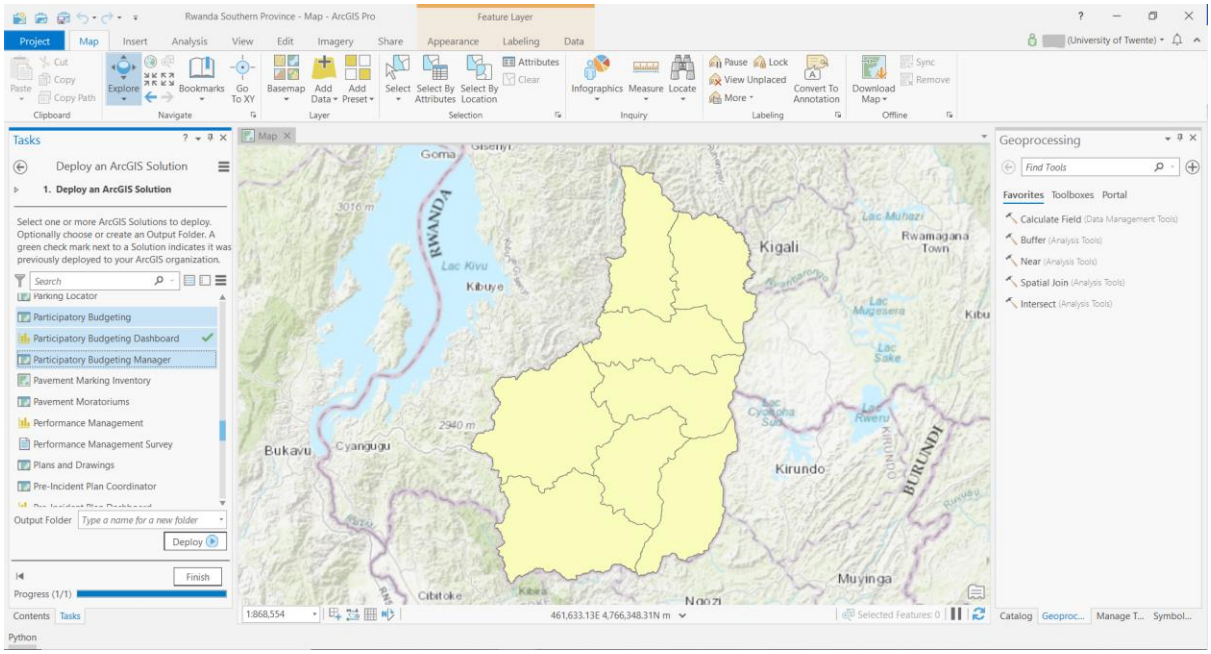

Figure 11: An extract of the ArcGIS Pro deployment of Participatory Budgeting Applications
Source: Author, 2020

3.6. Data Preparation and Storage

The study required the preparation of spatial and non-spatial data that would be used for prototype development. For this process, the preparation of the spatial and non-spatial data sets involved the use of ArcGIS Pro, ILWIS and Microsoft Excel softwares. In the case of the non-spatial data, Microsoft Excel

software was used to compile data on the planned projects for the Southern province from the DDS annual policy documents. The purpose of this procedure was to compile the proposed projects for the Districts in the Southern province. Some of the critical variables for the proposed projects included costings financial year, locations and categorisations. This step was crucial in understanding the missing project variables before integration with the SDF methods for PB. For each district, the planned projects were categorised according to the sectors, planned financial year and identified at either the sector or the cell administrative unit (see Appendix 7).

The ILWIS software was adopted to convert the SDF Spatial Multi-criteria Evaluation (SMCE) raster maps into polygons. The conversion involved slicing the raster imagines into five slices with minimum and maximum values ranging between 0-1 (refer to Appendix 8). The sliced raster images were then vectorised and exported as shapefiles (see Appendix 8)

The ArcGIS Pro software was used to extract the Southern province for both the MoF and the SMCE datasets by clipping and published the shapefiles as feature layers and further published as web feature services (WFS) as shown in Figure 12.

Also, as part of the data preparation process, additional fields, field types and values were created in the project ideas within the ArcGIS online to enable input of the SDF methods as well as the UTA algorithm properties. The fields were later integrated into the Participatory Budgeting and the Participatory Budgeting Manager Applications.

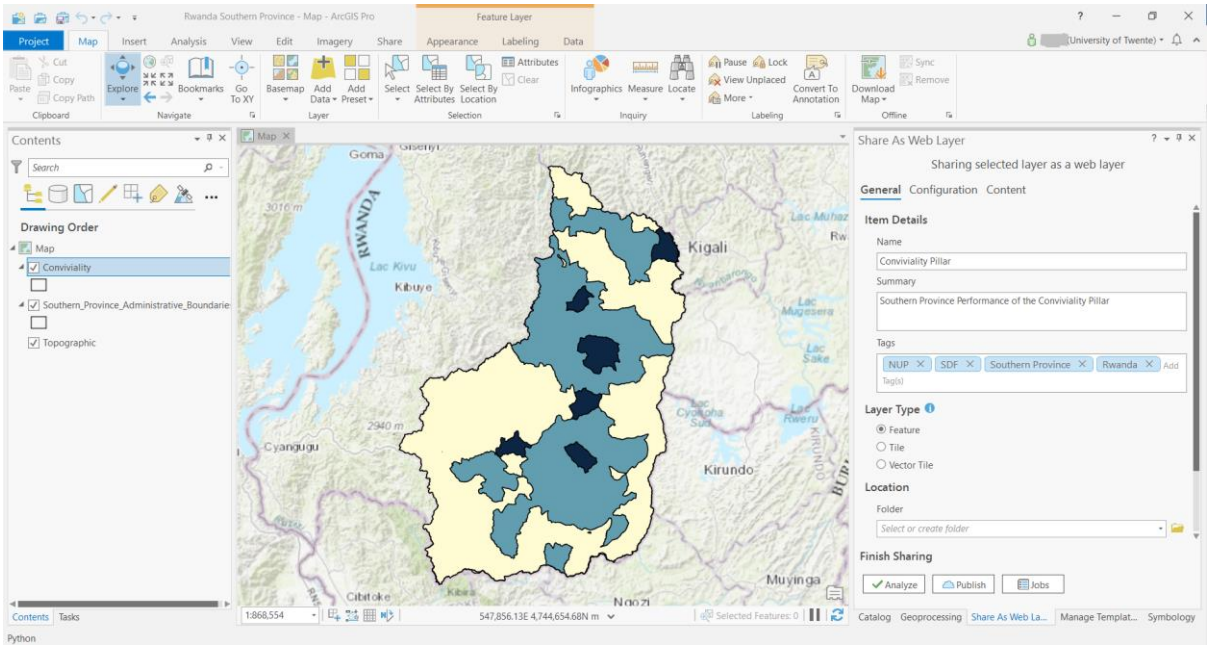

Figure 12: Extract of ArcGIS Pro showing the process of publishing shapefiles

3.7. The project prioritisation and selection method

The research conducted a secondary literature review to identify methods for project prioritisation and selection into portfolios. In the review, two algorithms were reviewed the AHP and the UTA. The limitation of the AHP is the complex computation process (include citation). In the context of this study, the UTA algorithm was adopted because it enables the computation of benefit to cost ratio and decision-makers can compare projects based on different criteria (van den Toorn, 1985). The UTA algorithm was computed in three steps, as shown in Figure 13. The first step is the normalisation of project objectives and resources. The second step is the computation of aggregation of objective and resource performance of the projects. Lastly, the third step is the computation of the comprehensive relative project efficiency.

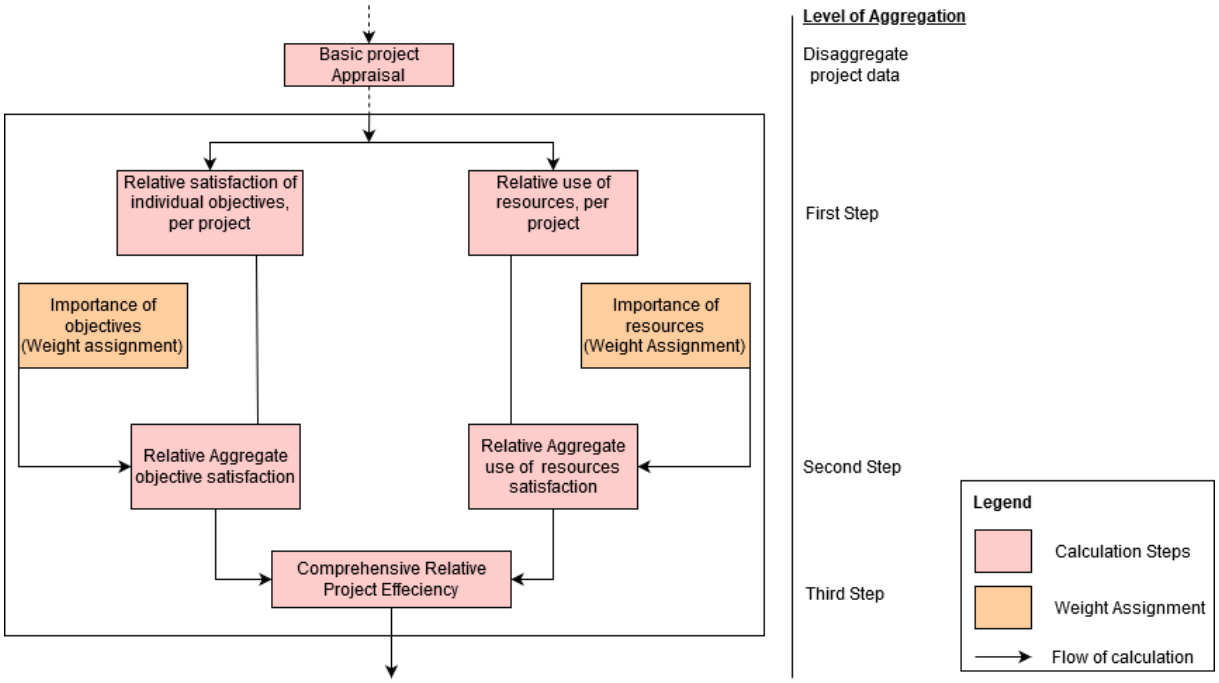

Figure 13: Procedure for computing the benefit (utility) and (cost) dis-utility using the Utility-based trade-off Algorithm
Source: Adapted and edited from van den Toorn, (1985)

3.7.1. The normalisation of project objectives and resources

The first step entailed normalisation of the values for the objectives and the resources such as financial, working hours for the individual projects. The normalisation was done by dividing each value with the maximum value (Brucker, Verbeke, & Macharis, 2004). For instance, for objective normalisation ($\emptyset_i^p$), was calculated by dividing each objective value (o_i^p) with the maximum objective value (o_i^{p-max}). The normalisation was achieved using **Error! Reference source not found.** for the *relative satisfaction of individual objectives* (objectives) and **Error! Reference source not found.** for the *relative use of resources per project* (resources). The advantage of the normalisation method is the values range between zero and one.

$$\emptyset_i^p = \frac{o_i^p}{o_i^{p-max}}$$ **Error! Reference source not found.**

Where; $\emptyset_i^p$ is normalised objective values *i* for all projects *p* (*where p = 1…q* and *i = 1…m)*
o_i^p is all objective values *i* for all projects *p*
o_i^{p-max} is the maximum objective value o_i^p found in *p = 1…q*

$$R_j^p = \frac{r_j^p}{r_j^{p-max}}$$ **Error! Reference source not found.**

Where; R_i^p is normalised resource values *j* for all projects *p* (*where p = 1…q* and *i = 1…m)*
r_i^p is all resource values *j* for all projects *p*
r_i^{p-max} is the maximum resource value r_i^p found in *p = 1…q*

3.7.2. The computation of relative aggregate objective satisfaction and relative use of resources per project

The second step involved the aggregation of objective and resource performance of the projects. The aggregated objective and resource performance of each project were calculated using the normalised

objective and the normalised resource values multiplied by assigned criteria weights for each project using ***Error! Reference source not found.*** and ***Error! Reference source not found.***, respectively. The sum of the assigned weights should be equal to one.

$$U_v^p = \sum_{i=1}^{m} \emptyset_i^p * \alpha_{vi}$$

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Where; U_v^p is the relative aggregate objective satisfaction of project *p* under alternative objective weight set *v*, *v = 1…y*

α_{vi} is the weight assigned to objective *i* under alternative weight set *v*

$$D_w^p = \sum_{j=1}^{n} R_j^p * b_{wj}$$

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Where; D_w^p is the relative aggregate use of resource satisfaction of project *p* under alternative objective weight set *w*, *w = 1…z*

b_{wi} is the weight assigned to resources *j* under alternative weight set *w*

3.7.3. The comprehensive relative efficiency per project

The final step included the computation of the efficiency of each project. At this stage, the efficiency was computed using **Error! Reference source not found.**. the values generated were used to rank the projects. The highest value was ranked first. Besides the projects can be grouped based on the efficiency into portfolios.

$$C_{vw}^p = \frac{U_v^p}{D_w^p}$$

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Where: C_{vw}^p is the efficiency of project *p*.

3.8. Prototype Evaluation

The evaluation of the prototype was the last step of the prototype development. The purpose of this step is to assess the usability and added advantage of the developed participatory budgeting prototype based on the human-technology impact. However, the user's perception of the prototype cannot be evaluated due to the limitations of the research. For this study, the evaluation is operationalised using the PSS evaluation methods to assess the added value of the tool. The added value is assessed based on the usefulness to the participatory budgeting task using the integrated project portfolio selection framework mentioned in section 2.4. The assessment methods are as shown in Table 4.

Table 4: Prototype assessment methods

Method of evaluation	**Question (s)**
Development Objective	Does the developed prototype achieve the objective?
Usability and the added advantage	How does the developed prototype guide the budgeting process?

Source: Author, 2020

3.9. Ethical Considerations

Research ethics are formulated to guide and regulate researchers on the interests and needs of the people and fields in the area of study (Flick, 2009). Furthermore, Flick, (2009) states that consent, privacy and communication of the research aim should be considered when conducting the research. For this study, all documents, reports, memos and spatial data were duly referenced, and sources acknowledged.

4. RESULTS

The chapter presents the results of the policy and literature review relating to the research objectives. The first section explains the budgeting process for policy implementation, identifies the stakeholders involved in the planning and budgeting process and the stages from the policies guiding planning and budgeting in Rwanda. Moreover, the chapter describes the PB process with the two theoretical frameworks, the design criteria for prototype development and lastly the developed prototype.

4.1. The budgeting process for policy implementation

This section highlights the stakeholders in the planning and budgeting process, the policies that guide the planning and budgeting process. The section also explains the planning and budgeting stages and the methods used for planning and budgeting.

4.1.1. The stakeholders in planning and Budgeting process

In Rwanda, the planning and budgeting process at the local and national levels varies. Each level has different institutions as stakeholders playing diverse roles. The planning process is an annual planning procedure that takes place at the local and national level. The local level planning includes the Districts, while the national level planning involves Line Ministries, and agencies to establish projects for implementation. At, the national level the budgeting process entails the allocation of a "resource envelope" [2] for the budgeting agencies [3] by the Ministry of Finance and Economic Planning (MINECOFIN) (MINECOFIN, 2010a, p. 12). This result was to establish the stakeholders in the planning and budgeting process to guide the prototype design and developments. Table 5 shows the different stakeholders and their roles in the planning and budgeting process.

Table 5: Stakeholders in the Planning and Budgeting process

Institutions	Role in Planning and Budgeting processes
Line Ministries, Agencies	• Identify suitable projects aligned with sector strategies. • Coordinate required activities during the planning and implementation of projects.
Districts	• Identify suitable projects aligned to strategic guidelines set by national policies. • Development of the DDS
Ministry of Finance and Economic Planning (MINECOFIN)	• Chairs the Public Investment Committee (PIC) and Local Government Projects Advisory committee
National Development Planning and Research Department (NDPR)	• Serve as technical secretariat for Public Investment Committee (PIC). • Provides information, analysis, and research for implementation of National Investment Policy • Develop proposed projects for financing and implementation in the medium term.

[2] "Resource envelope" refers to the projected budgets.

[3] Budgeting agencies are entities whose activities are the executing institutions; their responsibility covers the proper handling of investments from identification to implementation and operation according to respective rules and regulations (MINECOFIN, 2017, p. 11).

	• Monitors implementation of development projects.
National Budget Department (NBD)	• Coordination and formulation of the annual national budget and Medium Term Expenditure Framework • Budget policy formulation, i.e. forecasts, monitors and reports on the implementation of the National Budget
Local Administrative Entities Development Agency (LODA)	• Administrative procedures for planning and implementation of projects at the local government

Source: MINECOFIN (2017)

4.1.2. The policies guiding the planning and budgeting process

The planning and budgeting process in Rwanda is a non-spatial process guided by the different policies, as shown in Table 6. However, the planning and budgeting processes are guided by the national planning framework that establishes a method for coordination across government institutions (see Figure 14). The framework specifies the hierarchy of the policies guiding the planning process. The policies are categorised in the long term, medium-term and annual periods at the national and local levels.

Table 6: List of policies that guide the planning and budgeting processes

Documents	**Responsible Institutions**	**Planning and Budgeting Phases**
Planning policies		
Vision 2050	Ministry of Finance and Economic Planning	Long term
National Strategy for Transformation (NST1)	Ministry of Finance and Economic Planning	Medium Term
Sector Strategic Plans (SSP)	Line Ministries and Agencies	Medium Term
Institutional Strategic Plans (ISPs)	Line Ministries and Agencies	Medium Term and Annual
District Development Strategies (DDS)	Districts	Medium Term and Annual
National Urbanisation Policy	Ministry of Infrastructure	Long term
Budgeting Policy		
National Investment policy	Ministry of Finance and Economic Planning	Medium Term

Source: Author, 2020

At the national level, the planning process is guided by the Rwanda Vision 2050 that is currently being implemented as a long term national planning policy with the NST1. The Vision 2050 identifies long-term strategic development goals which are then translated and reflected in the medium-term and annual planning policies. The medium-term planning involves the translation of the long-term development goals into medium-term implementation goals. The NST1 is a seven-year medium-term policy that provides a basis for implementing the Rwanda Vision 2050 through its policy priorities and strategies (Ministry of Finance and Economic Planning, 2012).

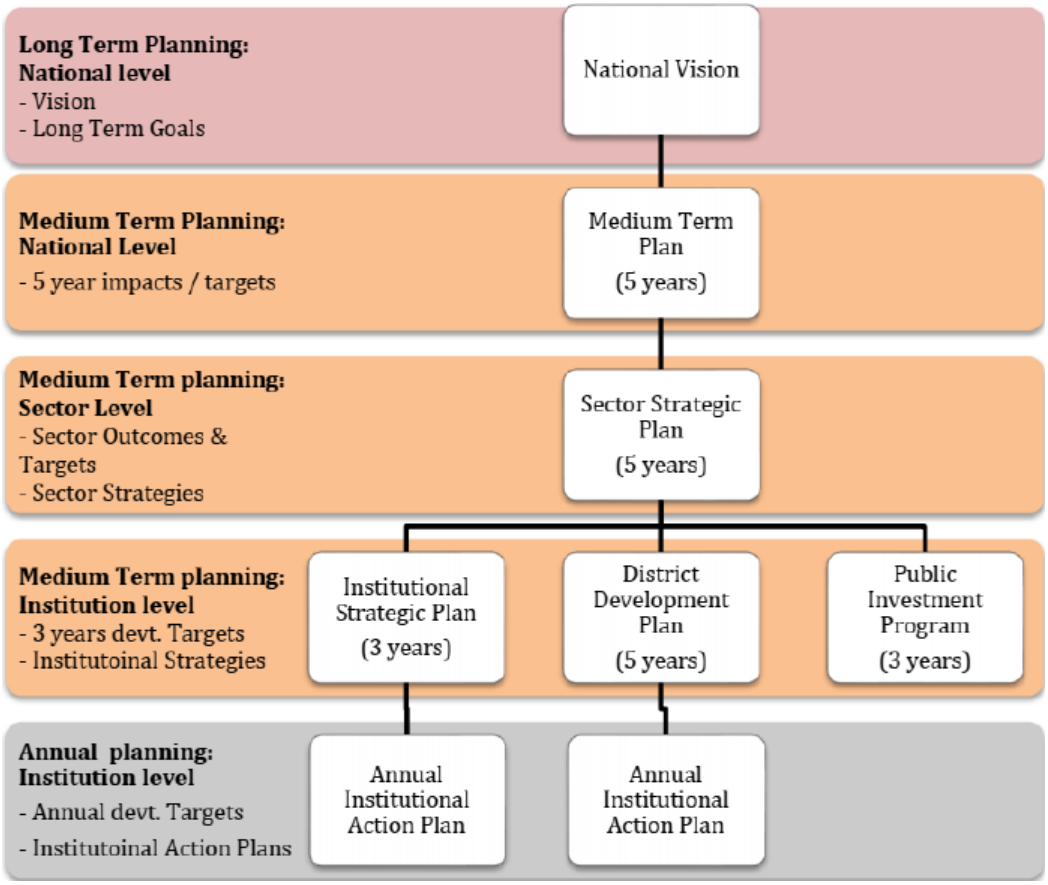


Figure 14: Rwanda national planning framework and policies
Source: (MIFOTRA & MINECOFIN, 2015)

Furthermore, Sector Strategic Plans (SSP) and District Development Plans (DDP) are also five-year medium-term policies. However, the DDP is currently referred to as the District Development Strategies (DDS) (see Table 6). The Institutional Strategic Plans (ISPs) are three-year policies used for budget planning. The SSP is a planning document for the line Ministries and their agencies such as Housing, Infrastructure, Health and Education at the national level that lay a framework for implementing the priority areas of the NST1. Besides, ISPs are plans highlighting detailed activities used by the Line Ministries and agencies related to the organisational mandates and aligned to the SSP strategies. Whereas, at the local level, the districts develop the DDS as planning documents aligned to the SSP. Both the ISP and the DDS are also annual planning policies that highlight activities to be implemented annually.

The planning and budgeting process is guided by the National Investment Policy (NIP), which is a three-year budgeting policy providing guidelines for budgeting and investment of the planned activities. The policy also highlights the planning, budgeting and monitoring procedures for both the local and national levels. Additionally, the policy identifies the stakeholders involved in the budgeting process referred to as budget agencies, as well as their roles. Besides, the Ministry of Infrastructure (MINIFRA) also uses the NUP as a sectoral policy to guide budget planning.

It was essential to understand the policies guiding the planning and budgeting process for the prototype design and development process. In particular, the DDS annual plans were adopted as policies because they indicated development priorities that were used during the prototype development.

4.1.3. The planning and budgeting stages

In Rwanda, the planning and budgeting cycle entails two separate procedures at the national level referred to as central and local government levels (MINECOFIN, 2017, pp 15-17). The planning and budgeting are in two stages and start from the local level to the national level. The annual cycle starts with a budgeting call circular for planning, and this is followed by a second budget call circular for the budgeting procedure.

At the local government level, the planning procedure involves;

- 1st planning and budgeting call circular issued by the MINECOFIN for the local governments requesting for projects proposals. The budgeting call circular is a document issued by MINECOFIN to the Budgeting Agencies requesting for new project proposals for funding and information on ongoing projects regarding their funding needs.
- The submission of proposed projects by the Districts are made through the Local Administrative Entities Development Agency (LODA) to MINECOFIN. The Local Administrative Entities Development Agency (LODA) is an agency under the Ministry of Local Government (MIANLOC).
- The projects submitted are evaluated by LODA in collaboration with MINECOFIN. Presentation of findings and recommendations by LODA to the Local Government Projects Advisory Committee (LGPAC) for advise on investment priorities. Also, District Councils then review and approve investment decisions.

The budgeting procedure involves;

- After consultations between LODA and MINECOFIN on budget ceilings, the 2nd budget call circular is made. The circular related to District investment plans are issued by MINECOFIN to begin the budgeting process at the local level.
- LODA, in collaboration with MINECOFIN, consults with each district to finalise budget proposals with funding availability and final allocation for each district.
- LODA submits development investments and budgets to Districts. Also, presentations of development projects by each district are made to the respective District Councils.
- Approval of budget by Parliament into law and implementation of the approved budget by Districts within budget limits.

The central government level, the planning and budgeting procedure involves;

- 1st planning and budgeting call circular to Budgeting Agencies requesting for projects proposals and ongoing projects for funding by the Ministry of Finance and Economic Planning (MINECOFIN) specifically the National Development Planning and Research Department (NDPR).
- NDPR evaluation of proposed and ongoing projects from the Central government involving the screening of the proposed projects based on policy alignment, economic and financial feasibility. However, the research could not establish how the alignment of projects based on policies is done; this is important for consideration during the design and development of the PB prototype.
- NDPR presentations of findings and recommendations from planning consultations to the Public Investment Committee (PIC) that determines the priorities for investment

The budgeting procedure involves;

- 2nd budget call circular initiating the budgeting process and is issued by the National Budget Department (NBD) decisions on allotted budget are informed by the Public Investment Committee (PIC).
- Compilation of results from the budget negotiations in the National Investment Program.
- Approval of budget by Parliament into law and implementation of the approved budget by Ministries within budget limits.

4.1.4. Planning and Budgeting Methods

The planning and budgeting methods in Rwanda comprise of Medium-Term Expenditure Framework (MTEF) and the Integrated Financial Management Information Systems[4] (IFMIS). The MTEF was developed by the World Bank and the International Monetary Fund (IMF) for developing countries to enable financial resource management through short term planning and annual budgeting methods (Mutuku, 2017). Furthermore, the MTEF involves the allocation of the national-local level resource envelope, with the local-national level making estimates of the current and medium-term costs of existing policies and matching the costs to available budget allocation (Houerou, 2002). The MTEF is a method that ensures that government expenditures are aligned to policy priorities and budget allocations (Houerou, 2002, p.2; Short, 2003). In Rwanda, the MTEF is a three years framework that was adopted by the government to promote transparency, efficient budget allocation and coordination, between the government and the budgeting agencies (Mutuku, 2017). The Sector Strategic Plans and the District Development Strategies are translated into action plans with costs and implemented through the MTEF (Ministry of Finance and Economic Planning, 2012). However, although MTEF is used as a strategic planning model for budget allocation, it does not consider spatial policies for allocation of budgets for projects. The MTEF is then linked to the IFMIS for budgeting allocation for the Line Ministries and Budgeting Agencies Figure 15.

[4] "IFMIS are financial management reform practices aimed at promoting effeicency, effectiveness, accountability, transparency, security of data management and comprehensive financial reporting" (Hendriks, 2012).

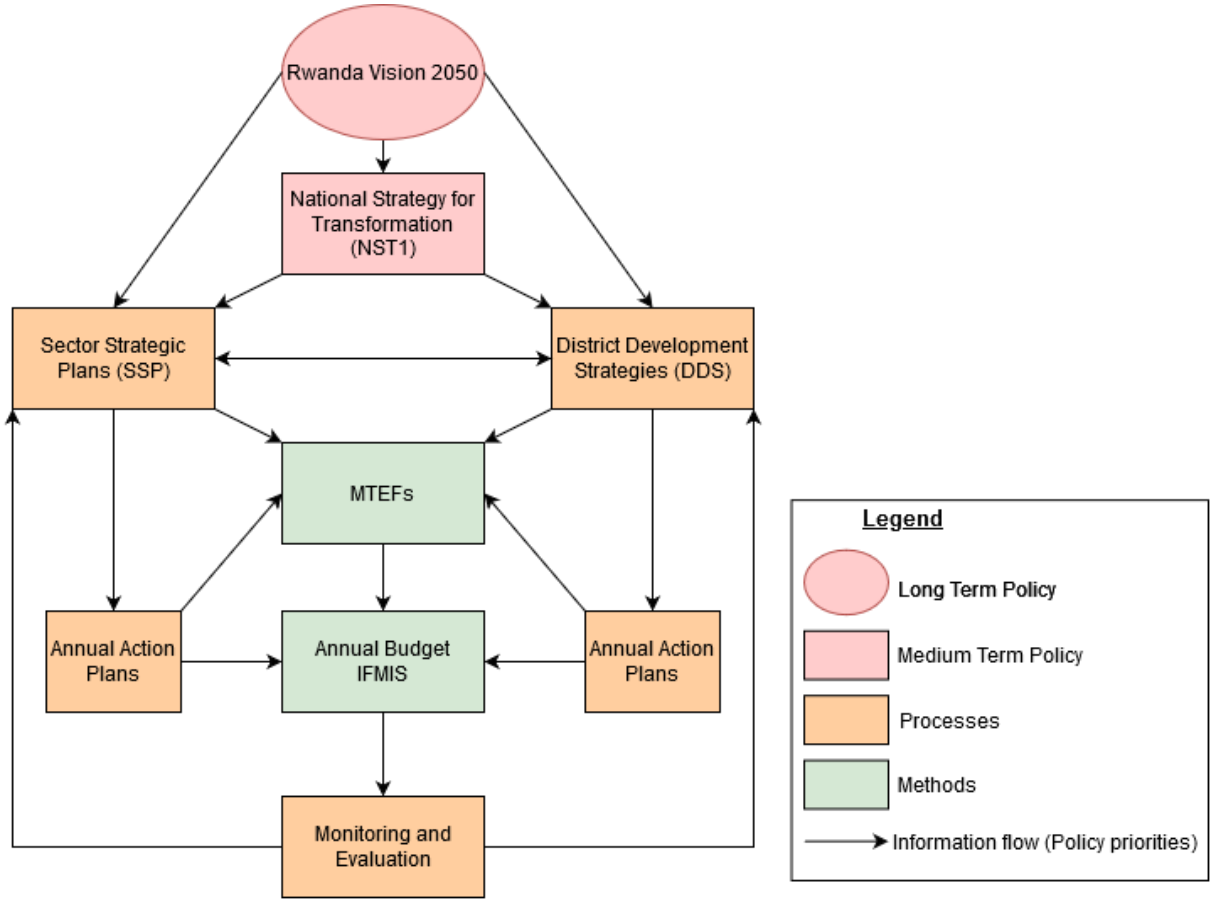


Figure 15: Shows the planning and budgeting process and the methods used to link the processes.
Source: Adapted and edited from the Ministry of Finance and Economic Planning (2012)

4.2. Rwanda Participatory Budgeting process

This section describes the participatory budgeting process based on the Democracy Cube and the Enhanced Adaptive Saturation Theory 2 (EAST2) frameworks. The section uses the frameworks to identify components of the budgeting process for the development of a SDSS for PB.

4.2.1. Participatory Budgeting process and the Democracy Cube Framework

Several frameworks have been used in assessing participatory budgeting processes (see section 2.5.1). According to Williams et al. (2017), the PB process is characterised by the level of participation, type of involvement, the delegation of power and the stage of participation. The planning and budgeting procedure in Rwanda is a Participatory Budgeting process and will be described using the democracy cube framework. Fung (2006) democracy cube is a three-dimension method used to understand participation within institutions. It identifies who participates (participant selection), how participants communicate with one another and make decisions (communication and decision-making) as well as how the discussions are linked to policies or actions (power and authority).

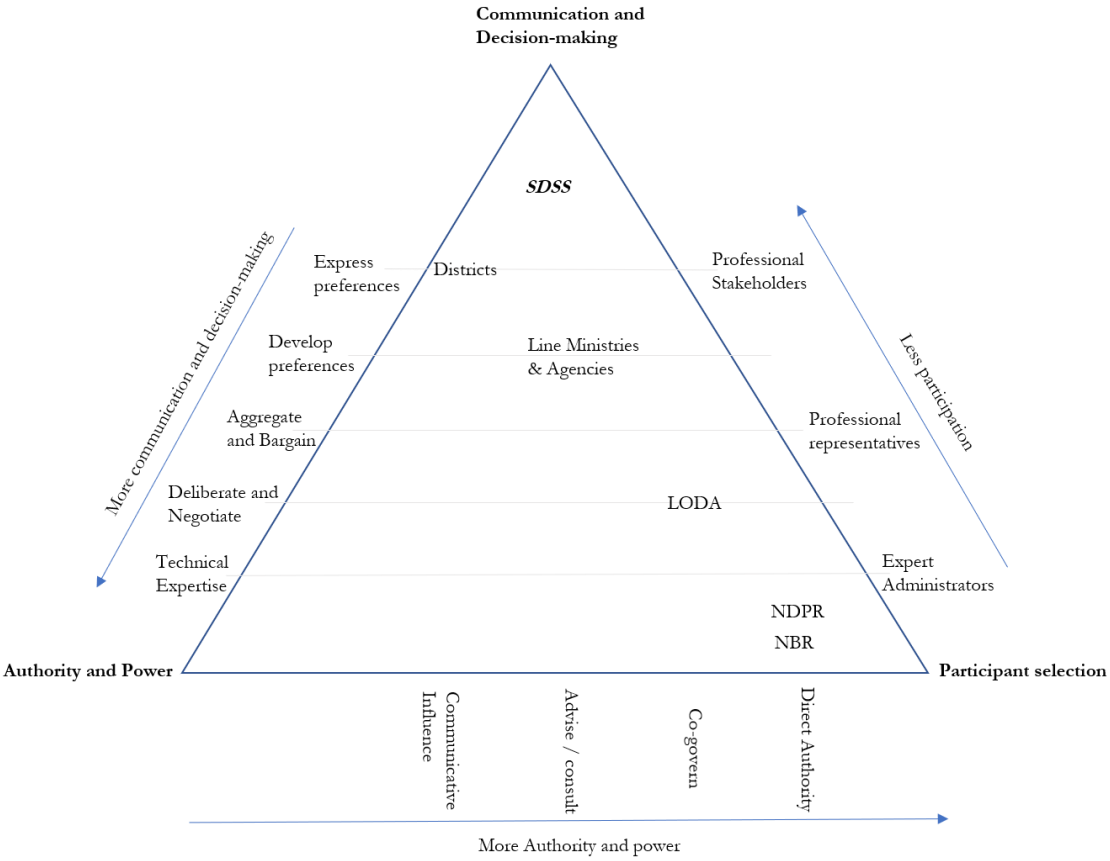


Figure 16: Participatory Budgeting three-dimension triangle
Source: Adapted and edited from Fung (2006)

The participatory budgeting process in Rwanda was presented using a two-dimension axis for the presentation of the findings (See Figure 16). The PB process comprises of expert administrators, professional representatives and professional stakeholders as the selected participants of the process (see Table 7). Specifically, expert administrators such as the NDPR, the NBD, LODA have the technical experience in the budgeting and planning process with more decision-making power. Although LODA is categorised as one of the expert administrators, it plays a co-governance role between the Districts and MINECOFIN and also deliberates and negotiates the budget allocations for Districts. The Line Ministries and Agencies are professional representatives of the expert administrators that develop preferences based on policies which are then shared with the Districts with no decision-making power during the budgeting process. They also provide advice to the Districts during the planning process. Lastly, are the professional stakeholders who include the Districts that have the authority to communicate and influence the budgeting process by expressing their preferences aligned to those of the Line Ministries and Agencies have no decision-making power. Based on the democracy cube, participant selection, authority and power, communication, and decision-making dimensions can be integrated using the SDSS to guide the participatory budgeting process for policy implementation.

Table 7: Participatory Budgeting process in Rwanda

Dimensions	Participation Types	PB in Rwanda
Participant selection	Expert Administrators, Professional Representatives Professional Stakeholders	MINECOFIN: NDPR and NBD, LODA Line Ministries and Agencies, Districts

Communication and decision	Technical Expertise	MINECOFIN: NDPR and NBD, LODA
	Develop and express choices	Line Ministries, Agencies and Districts
Authority and Power	Direct Authority, Co-governance, Advise and consult	MINECOFIN: NDPR, NBD MINALOC: LODA

Source: Fung (2006) and Author, 2020

4.2.2. Participatory Budgeting process and the EAST 2 framework

EAST2 framework provides a basis for tool development and selecting an appropriate tool required group support systems for specific decision settings (Jankowski & Nyerges, 2001, p.263). Therefore, the EAST2 framework using the convening constructs helps identify the participant values, goals, objectives, and the decision support tool to benefit the collaborative process (see Figure 17). In this context, the framework was adopted to identify the participatory process, to provide a basis for a SDSS design and development. More so, the three convening constructs were used to identify and characterise significant aspects of the PB decision-making process based on the social institutional, group participants and the participatory GIS influence (see Table 8).

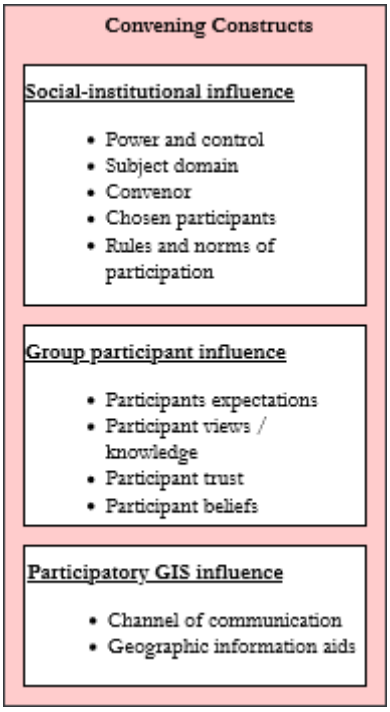


Figure 17: Extract of the EAST2 Framework showing the Convening Constructs
Source: (Jankowski & Nyerges, 2001)

The social-institutional influences provided an understanding of how the decision-making process function. The influences involve the rules and regulations that guide the decision process and the type of task to be accomplished by the various stakeholders. In Rwanda, the policies such as Rwanda Vision 2050, NST1, SSP, and DDS and organisational or institutional mandates specify the values, goals, objectives criteria and roles of the institutions in the PB decision-making process. For example, the NBD mandate includes the use of budget policies and procedures to develop and implement national budgets (MINECOFIN, 2020). This mandate grants the department power and control in the budgeting process.
The subject domain influence, common goals such as the implementation of policy objectives through needs identification planning and implementation with allocated budgets, create a basis for inter-

organisational conditions for a collaborative partnership. Concerning the tasks, the PB process involves two processes with different roles at the national and local level as well as between the Line Ministries and Agencies (inter and intra-organisational). Also, the organisational structure influences the participatory process; the structure entails the national and local hierarchy as well as the inter-organisation or sector coordination.

MINECOFIN is the convenor of the planning and budgeting process**.** The ministry plays an influential role in guiding the process for discussion; therefore, plays a crucial role in coordinating the PB decision making process. Whereas the chosen participants guide the level of analysis for decision situations that are presented by inter-sectoral, inter-organisational groups in a decision-making process. The participants include professionals with diverse knowledge ranging from planners, GIS experts, Agriculturalists, Education, Health and Administrators

The group participant influence concerns the organisation of how the participants are convened in the PB process. These influences include participant knowledge and expectations. In this context, the MINECOFIN knows the budgeting process and therefore expects the Line Ministries, Agencies and Districts to implement the policy objectives based on the budget allocations. Whereas the MININFRA knows spatial planning, and it expects to guide the budgeting process and policy implementation based on spatial analysis for proper decision- making.

The participatory GIS influence gives an insight into the capabilities of the tool precisely the type of information provided for decision situation. The influences include the channel of communication and geographic information aid.

Table 8: The EAST2 framework and the PB process in Rwanda

Constructs	**Types of influence**	**PB in Rwanda**
Social-institutional influence	**Power and control:** Policies, and mandates **Subject domain:** Tasks, purpose, structure **Convenor:** Organisations **Chosen participants:** Type and diversity	**Policies:** Vision 2020, NST1, SSP, DDS and NUP **Mandates** of Institutions and departments involved in the PB process **Tasks:** **<u>Planning</u>** Needs identification, Coordination, Planning, implementation (Districts, Line Ministries and Agencies) **<u>Budgeting</u>** Development of projects for implementation Coordination and formulation of the annual budgets **Structure:** National-Local (Vertical) and Inter and intra-organisation (Horizontal) ***Convenor:*** MINECOFIN **Type:** Professionals **Diversity:** Planners, GIS experts, Agriculturalists, Education and Administrators
Group participant influence	**Participant expectations:** issues and goals	**Issues:** Policy implementation and Budgeting **Goals:** policy objectives and prioritisation of projects
Participatory GIS influence	**Channel of communication:** distributed meeting **Geographical information aids:** Cartographic visual	***Channel of communication:*** **Distributed meeting:** Web application ***Geographical information aids:*** Participatory Budgeting (Crowdsource reporter/form) PB Manager

	tools, spatial query tools, analytical tools	Dashboard

Source: Jankowski & Nyerges (2001) and Author, 2020

From the EAST2 framework, as shown in Table 8, the types of influence (socio-institutional, group participation and participatory GIS) were essential for the development of the PB prototype. In particular, the participant goals, objectives indicated the priorities and roles that were considered during the prototype development. The tasks of participants and the organisational structure in the PB process helped identify the components of the tool that would be used for the respective tasks. Also, the convenor for the PB process was used to identify who should be in charge of the participatory process and had authority and power over the process (also see Figure 16). Based on the diverse knowledge of the participants, this was important in determining how complicated the tool should be during the prototype development. During the prototype development, the participant's expectations were used as inputs to guide the development of the tool. Lastly, the channel of communication and choice of the geographic aids were used as a basis for selecting components of the tool for the PB process during the development process.

4.2.3. The design criteria for integrating SDF methods and the current budgeting process

The design criteria for the prototype development was based on Healey (2006) integration types; coordination, framing, linking policy and action as well as linking multiple actors. The coordination involves policies and strategies alignment for implementation at the national and local levels. In that case, the prototype aims at linking the Districts at the local level and Line Ministries and Agencies at the national level. The framing type of integration entails existing visions to accommodate new visions to achieve place-based implementation. In the context of this research, framing integration involves extending national policy visions to achieve place-based implementation at the local level. The integration to link policy and action adopts specific methods for policy implementation. Therefore, the SDF methods are adopted to link participatory budgeting for policy implementation. Lastly, the integration type that links multiple actors adopts a public participatory process for policy implementation. Thus, the SDSS prototype links multiple actors in the planning and budgeting process for policy implementation (see sections 4.2.1 and 4.2.2).

Table 9: Table showing the prototype design criteria

Type of integration	**Design Criteria**
Coordination (Multi-level co-aligning)	Districts (local level) Line Ministries and Agencies
Framing (Widening the policy frame)	National policies for planning and budgeting
Linking policy and action (Connecting policy and delivery methods)	SDF methods
Linking multiple stakeholders (Involvement of key stakeholders in the participatory process)	SDSS prototype as an integration methods

Source: Healey (2006) and Author, 2020

4.3. Participatory Budgeting prototype

This section gives an overview and describes results from the deployment of the ArcGIS solutions for Local Government tools; specifically the participatory budgeting tools. The next section describes the results of the developed participatory budgeting and participatory budgeting manager application with the integrated SDF methods (MoF and SMCE) for spatial policy consideration in locating projects. The last

part of the section describes the participatory budgeting dashboard used to visualise the outputs of the developed prototype.

4.3.1. Deployed Participatory Budgeting tools

The deployment of the ArcGIS solutions for Local Government described in section 3.5 led to the Participatory Budgeting tool. The Participatory Budgeting tool comprises of three components; the Participatory Budgeting, Participatory Budgeting Manager, and Participatory Budgeting Dashboard. Each of the Participatory Budgeting tool components was used to implement steps F and G, as shown in Figure 10. Figure 18 shows the results of the deployed tools (the Participatory Budgeting and the Participatory Budgeting Manager) stored in the content manager.

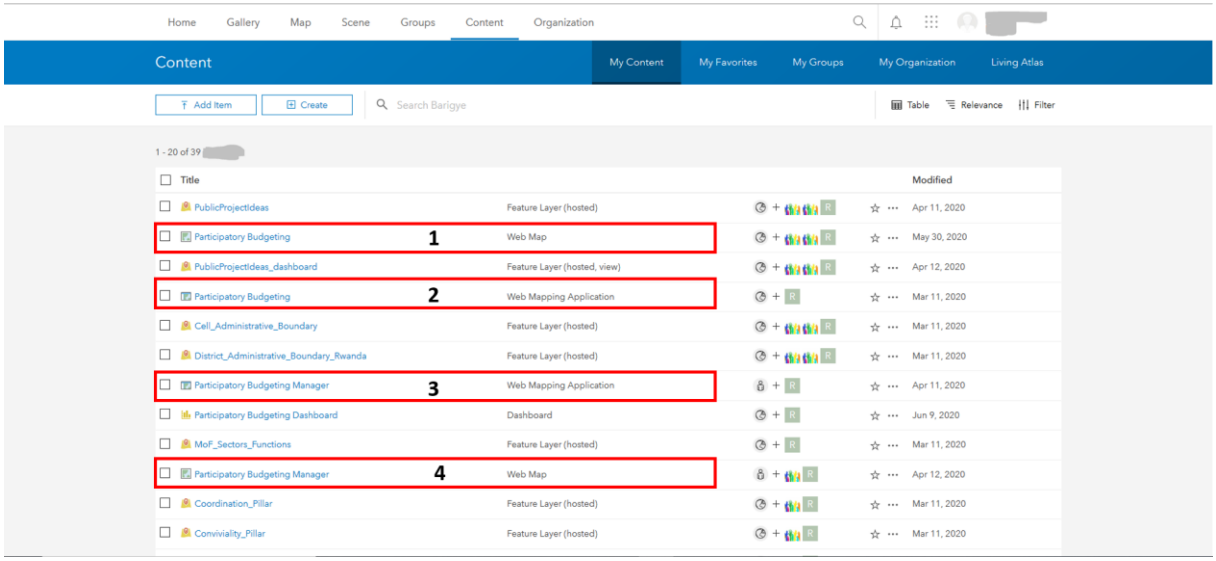


Figure 18: Extract of the content manager showing the deployed Participatory Budgeting and the Participatory Budgeting Manager applications

There are four main components for the prototype, as found in Figure 18. The Participatory Budgeting web map (1) in the first interface that was used to upload feature layers (MoF, SMCE, administrative boundaries shapefiles) using the add tab, configure and organise the feature layer attribute fields for visualisation (see Figure 19).

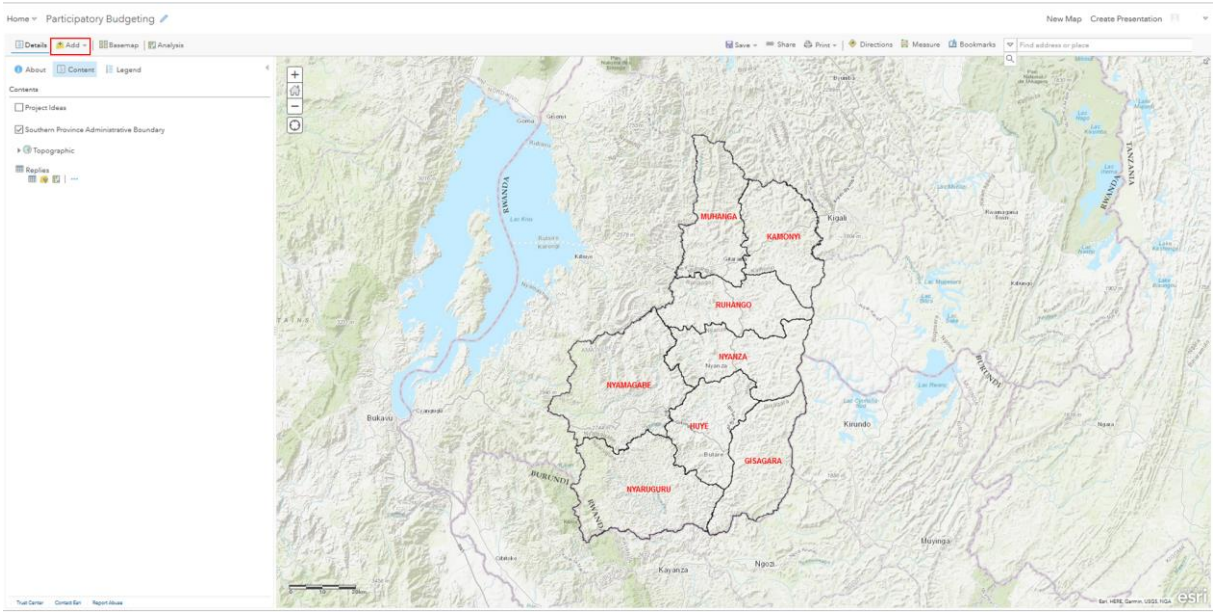


Figure 19: Extract of a Participatory Budgeting Web Application

In the Participatory Budgeting Web mapping application (2) the second interface, the feature layers from the Participatory Budgeting Web map application were automatically integrated into the web mapping application. The web mapping application consists of the crowdsource reporter (A), which is a form through which participants submit project ideas, review submitted ideas, comment and vote on projects submitted by other users (refer to Figure 20). Also, in Participatory Budgeting Web mapping application, the crowdsource reporter was customised to integrate the MoF and the SMCE and also input the planned project ideas (DDS, SSP). The Participatory Budgeting Web mapping application can be utilised by GIS specialists (Districts, the Line Ministries and Agencies) for the spatial location of planned project ideas.

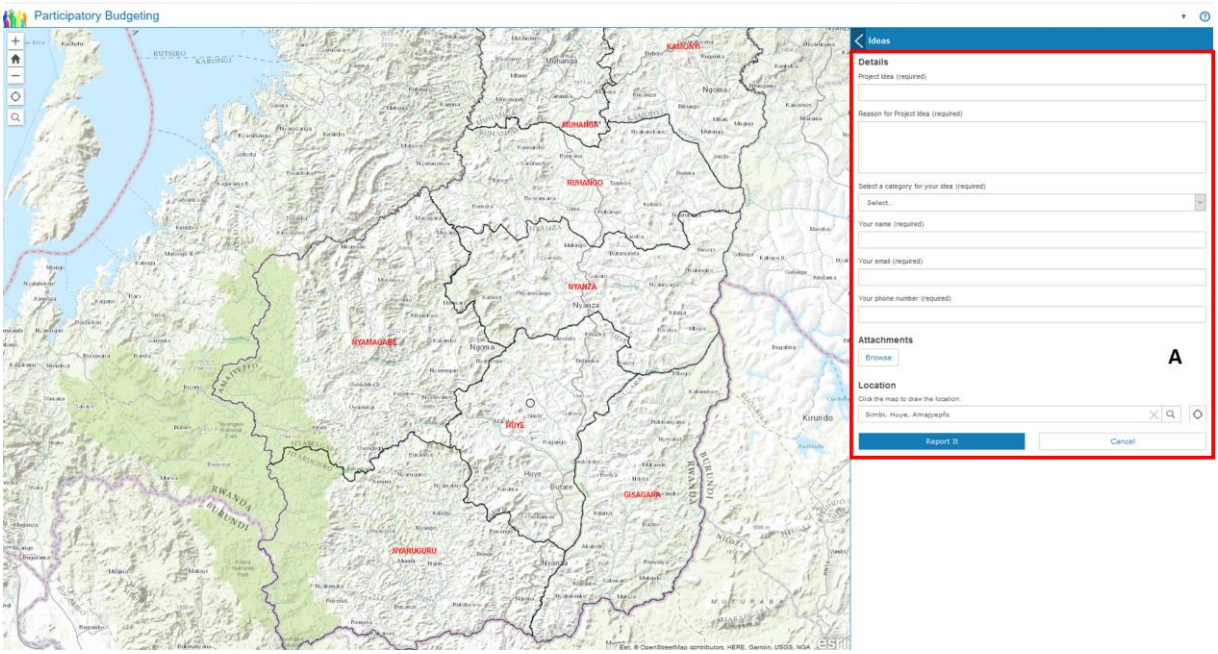


Figure 20: Extract of the Participatory Budgeting Web Mapping Application

Similar to the Participatory Budgeting web application, the Participatory Budgeting Manager web map (3) the third interface, was also used to upload feature layers (A) using the add tab. Also, the web map was

used to configure and organise the feature layer attribute fields and the input planned projects for visualisation (refer to Figure 21).

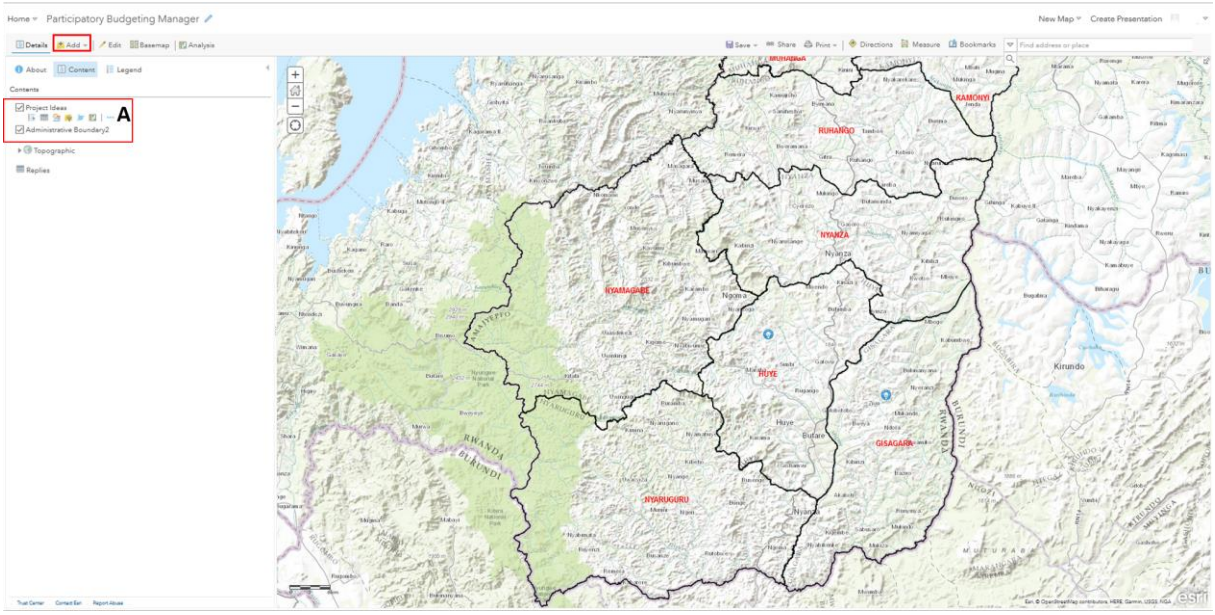


Figure 21: Extract of the Participatory Budgeting Manager Web Map Application

Lastly, from the Participatory Budgeting Manager Web map application the fourth interface, the feature layers and the planned projects (A) project details (B) were automatically integrated into the web mapping application (see Figure 22). The Participatory Budgeting Manager Web mapping application (4), is an application used by decision-makers to manage and prioritise submitted project ideas. Therefore, the web mapping application was used to integrate the UTA algorithm to enable ranking of projects for the PB process.

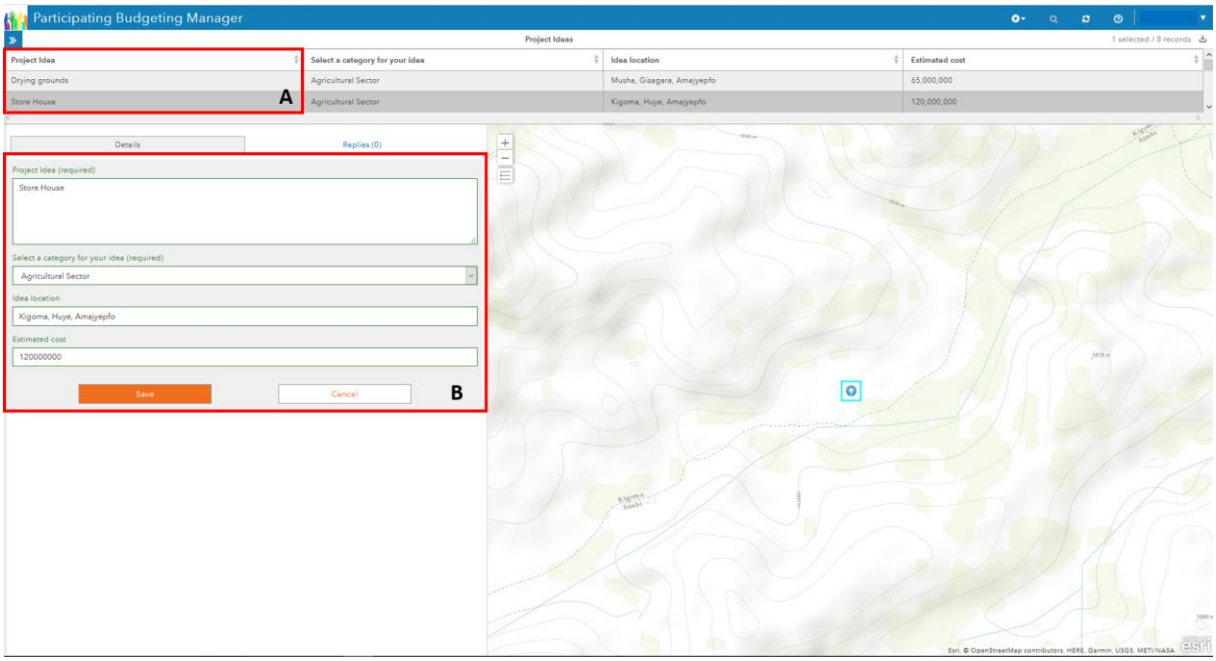


Figure 22: Extract of the Participatory Budgeting Manager Web Mapping application

4.3.2. Participatory Budgeting Application

The developed prototype provided the spatial component for PB, scenario development, evaluation, generation of outputs and visualisation (see section 2.3). The crowdsource-reporter template (ESRI, 2014) was adopted and uploaded on the ITC local server to synchronise the template with the Participatory Budgeting Web map and Web Mapping applications on the ArcGIS online server. The synchronisation was done using the "*default.js*"[5] code of the crowdsource-reporter template(see Appendix 9). In the "*default.js*", the link between the crowdsource-reporter template and the Participatory Budgeting Web map on the ArcGIS online server was done using the web map parameters indicated as "webmap"[6]. Also, within the "*default.js*" the Participatory Budgeting web mapping application on the ArcGIS online server was linked to the template using the web mapping application parameter shown as the "appid"[7]. Based on the link between the applications, the "*main.js*" code was customised to extract attributes of the MoF and SMCE (refer to Appendix 10 and Appendix 11).

In the public project ideas, fields were created to enable input of the feature layer attributes specifically from the MoF and the SMCE. The fields details (name, types,) and settings (length and editable) were created for each of the MoF and the SMCE attributes (see Appendix 12 and Appendix 13). The fields created in public project ideas were then incorporated in the crowdsource reporter. Also, the crowdsource reporter interface was customised to suit the study area context for integrating fields that enabled the population of data from the MoF (A) and the SMCE (B) methods at the point of data entry as well as the input of planned project idea details (see Figure 23**Error! Reference source not found.**).

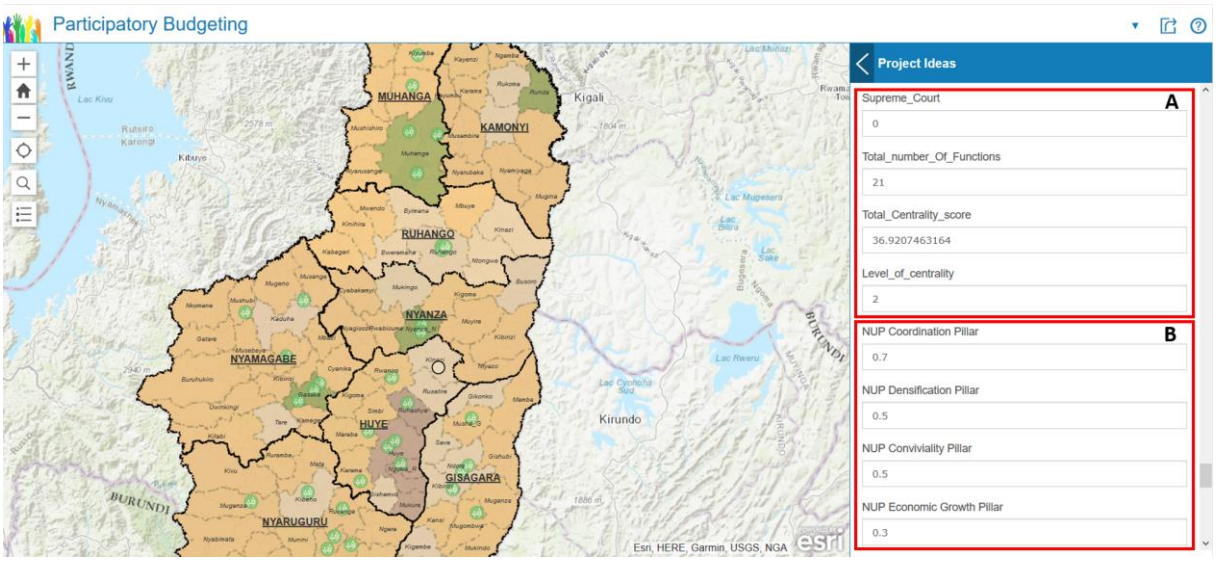


Figure 23: PB prototype showing integrated MoF and SMCE data

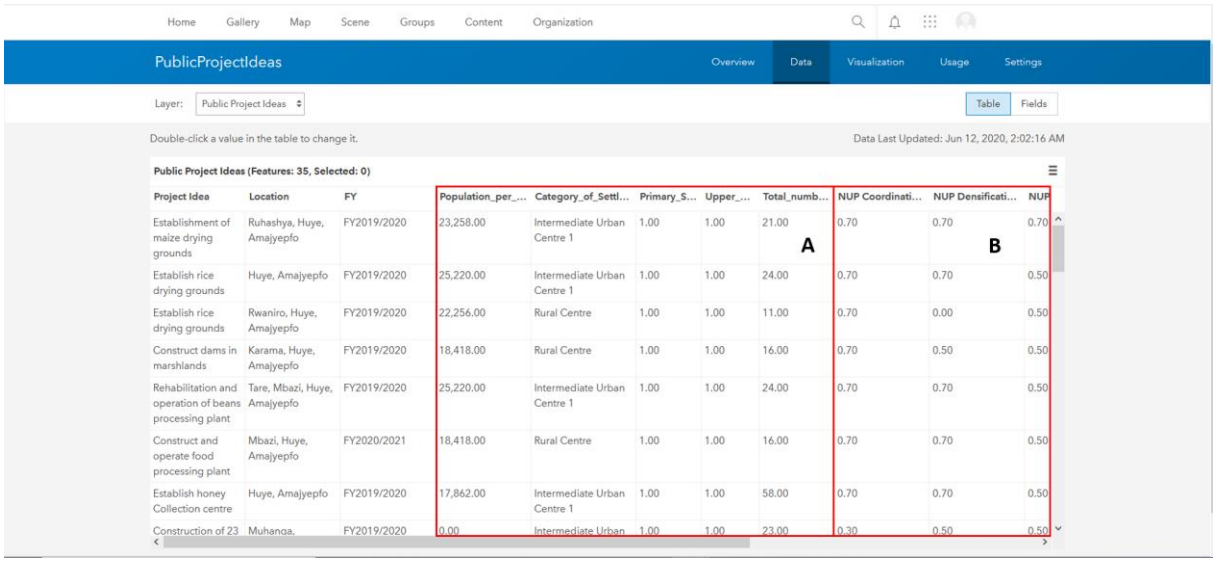
In the ArcGIS Server (see Figure 10), the published spatial data sets were stored as feature layers. The input planned project ideas were automatically stored as public project ideas in the content manager. The project ideas are outputs of the three components (Participatory Budgeting, Participatory Budgeting Manager and the Participatory Budgeting Dashboard) of the participatory budgeting tool and are stored as

[5] *Js* is an abbreviation for JavaScript file.
The codes for the "*default.js*" and "*main.js*" are hosted on the ITC local server.

[6] "webmap"refers to the web map application id on the ArcGIS server and input in the code on the ITC Local server.

[7] "appid" refers to the web mapping application id on the ArcGIS server and input in the code on the ITC Local server.

feature layers. After customisation of the crowdsource-reporter, the planned project ideas of the Agricultural sector were input and stored as project ideas in a table. The attributes of the MOF (A) and SMCE (B) were also integrated into the project ideas (refer to **Error! Reference source not found.**).



Project Idea	Location	FY	Population_per_...	Category_of_Settl...	Primary_S...	Upper_...	Total_numb...	NUP Coordinati...	NUP Densificati...	NUP
Establishment of maize drying grounds	Ruhashya, Huye, Amajyepfo	FY2019/2020	23,258.00	Intermediate Urban Centre 1	1.00	1.00	21.00	0.70	0.70	0.70
Establish rice drying grounds	Huye, Amajyepfo	FY2019/2020	25,220.00	Intermediate Urban Centre 1	1.00	1.00	24.00	0.70	0.70	0.50
Establish rice drying grounds	Rwaniro, Huye, Amajyepfo	FY2019/2020	22,256.00	Rural Centre	1.00	1.00	11.00	0.70	0.00	0.50
Construct dams in marshlands	Karama, Huye, Amajyepfo	FY2019/2020	18,418.00	Rural Centre	1.00	1.00	16.00	0.70	0.50	0.50
Rehabilitation and operation of beans processing plant	Tare, Mbazi, Huye, Amajyepfo	FY2019/2020	25,220.00	Intermediate Urban Centre 1	1.00	1.00	24.00	0.70	0.70	0.50
Construct and operate food processing plant	Mbazi, Huye, Amajyepfo	FY2020/2021	18,418.00	Rural Centre	1.00	1.00	16.00	0.70	0.70	0.50
Establish honey Collection centre	Huye, Amajyepfo	FY2019/2020	17,862.00	Intermediate Urban Centre 1	1.00	1.00	58.00	0.70	0.70	0.50
Construction of 23	Muhanga,	FY2019/2020	0.00	Intermediate Urban	1.00	1.00	23.00	0.30	0.50	0.50

Figure 24: Extract of Public Project Ideas showing integrated MoF (A) and SMCE (B) attributes

4.3.3. Participatory Budgeting Manager Application

Similar to the Participatory Budgeting application, fields for the criteria and UTA algorithm were created within the public project ideas. The fields were configured using the Participatory Budgeting Manager Web Map for integration into the Participatory Budgeting Manager Web Mapping application. They (created fields) were automatically added to the Web Mapping Application. The aim of integrating the criteria fields was to enable the assignment of weights based on priorities. Figure 25 shows the Participatory Budgeting Manager Web Mapping application, with an integrated weight assignment fields interface marked (A).

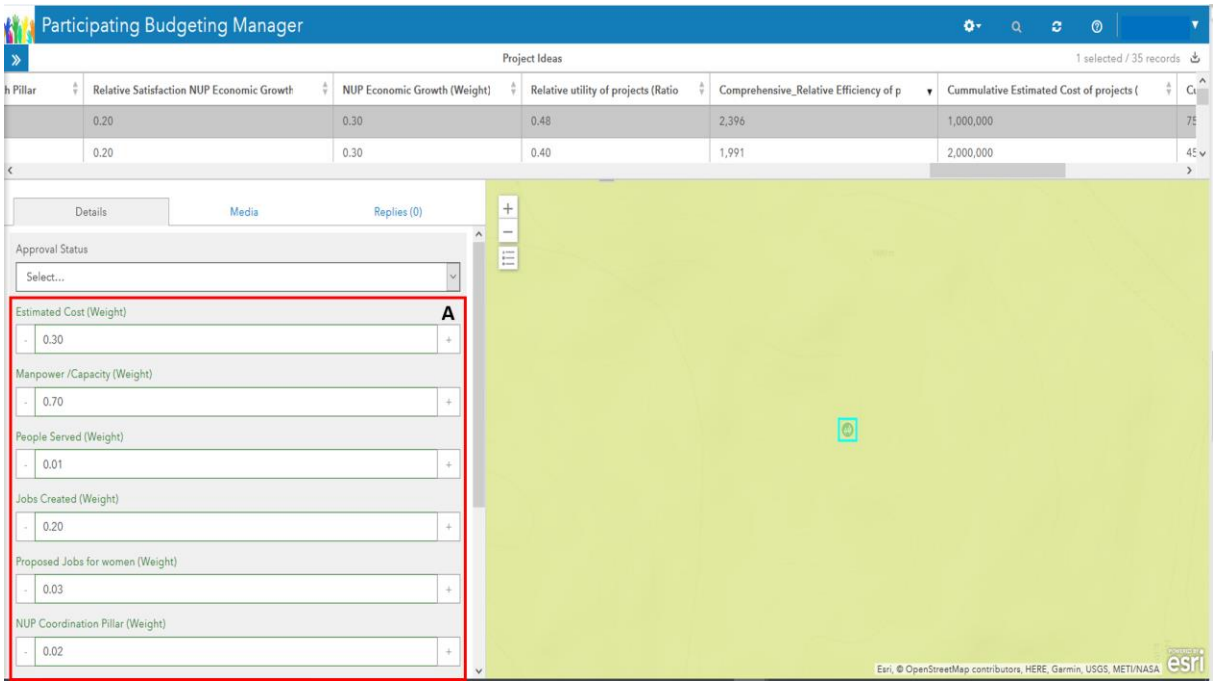


Figure 25: Extract of the Participatory Budgeting Manager showing the weight assignment interface

Also, in the Participatory Budgeting Manager Web Mapping application, the UTA algorithm was implemented according to the three steps in Python code (refer to section 3.7). In Figure 26, the Participatory Budgeting Manager Web Mapping application interface shows an extract of project details with the UTA computations. As shown in Figure 26, the integrated SDF method, the (SMCE) indicated G was used as an objective criterion for the UTA computation and the location of projects. The first step, the normalised values for resources (A) were computed using (Equation 2), while the objective values (C) were computed using (Equation 1) (see section 3.7.1). The normalisation was done to enable the comparison of projects.

In the second step, the relative aggregate use of resources (dis-utility) (B) and the relative aggregate objective satisfaction (utility) (D) were achieved by multiplying the normalised values from (A) and (C) with assigned criteria weights. Both the relative aggregate objective satisfaction (utility) and the relative aggregate use of resources (dis-utility) were computed using Equations 4 and 5, respectively (refer to section 3.7.2). The outputs of the second step were used to prioritise (rank) the projects.

The third step, the comprehensive relative efficiency of projects (E), was computed using Equation 5 (refer to section 3.7.3). In this step, the projects were sorted in descending order, and the project with the highest score was ranked first (H) while the project with the lowest score, ranked last. The projects were also ranked using discontinuities in the comprehensive relative efficiency scores, as shown in Figure 27 (B, C and D). The project's added value was determined using the utility and disutility compared to the comprehensive relative efficiency scores.

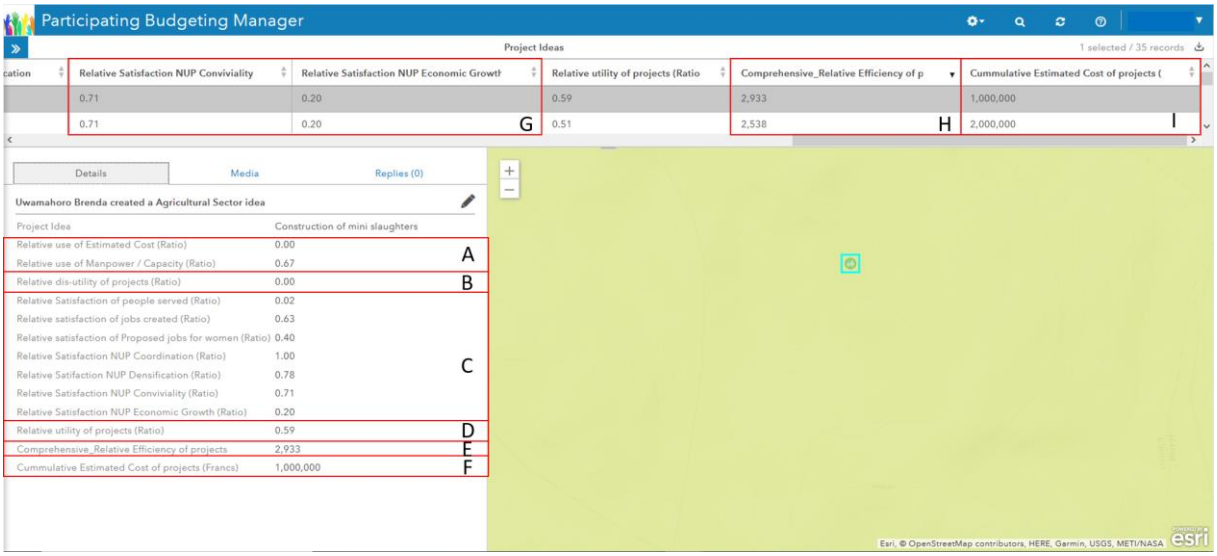


Figure 26: Extract of the Participatory Budgeting Manager showing UTA computation

Based on the highest-ranked project shown in Figure 27 as A, the cumulative estimated costs were computed for all the projects (see Figure 26, F and I).

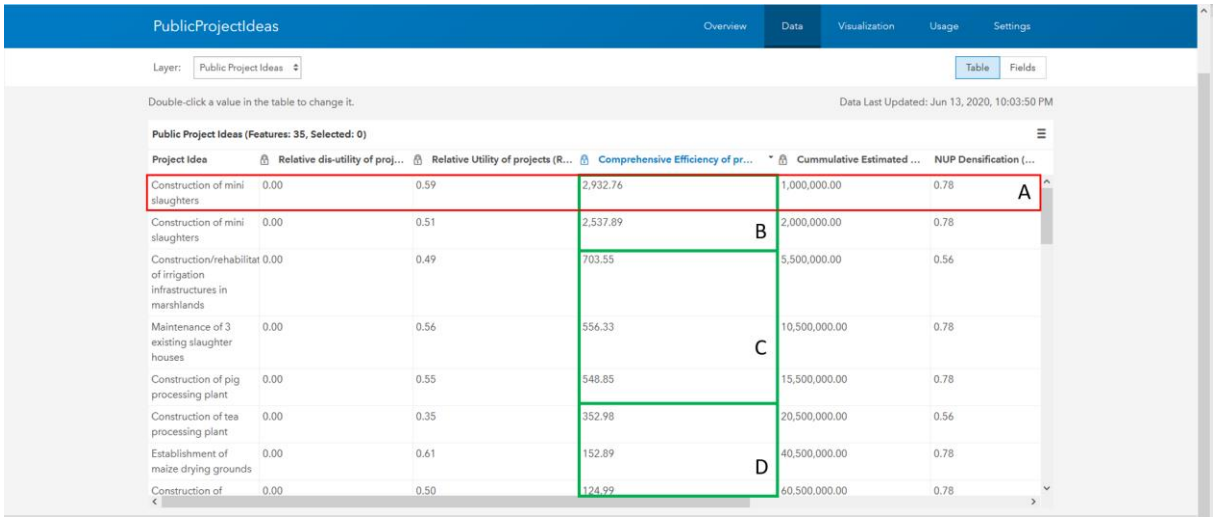


Figure 27: Extract of the Public project Ideas showing outputs of the UTA algorithm computation

4.3.4. Participatory Budgeting Dashboard

From the UTA computation of relative satisfaction of benefits (utility), the relative use of resources (dis-utility) and cumulative efficiency of projects in section 4.3.3, the results for the highest-ranked projects were visualised in the Participatory Budgeting Dashboard Web Application. The projects with the highest score (A) were ranked and grouped into portfolios (E) according to the weights (F) of the predefined criteria (see Appendix 14). Also, the total cost (D) of the selected projects, the spatial location (C) and project details (B) are as shown in Figure 28.

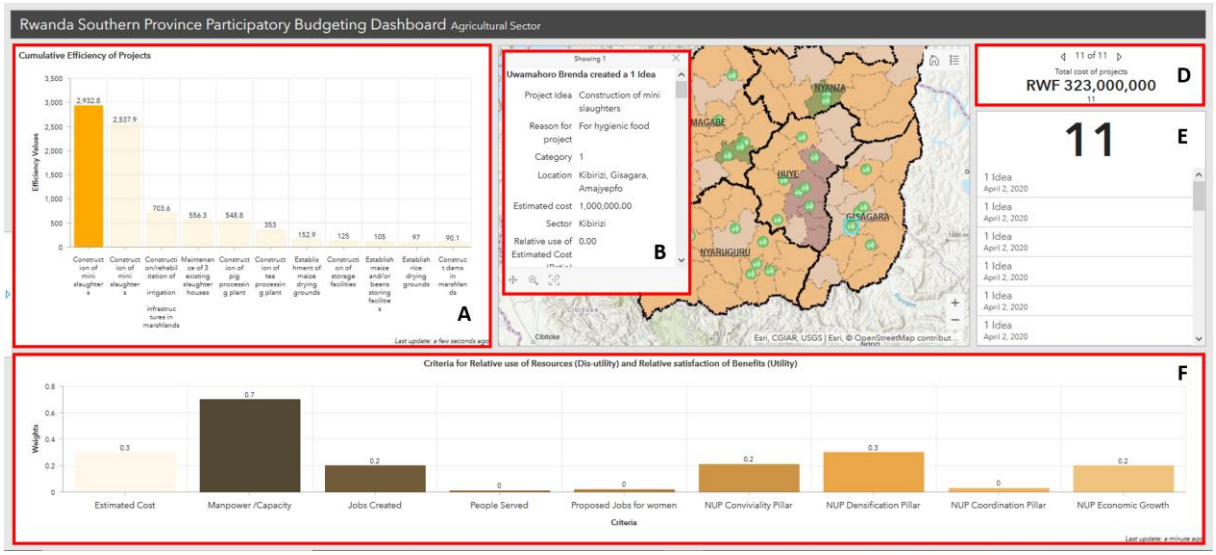


Figure 28: Extract of the participatory Budgeting Dashboard showing the highest-ranked project

5. DISCUSSION

This chapter discusses the findings of the research in chapter four, as per the research objective. It discusses the participatory budgeting process and its relation to the prototype. The first sub-objective is not discussed cause it summarised the planning and budgeting process. The chapter also discussed the evaluation of the prototype. Lastly, the chapter discusses the limitations of the research and recommendations.

5.1. Participatory Budgeting (PB) process

The research aimed to develop a budgeting tool that integrated SDF methods for spatial policy implementation. In geo-information systems development such as (SDSS), traditional methods of systems design have been used for developing planning tools. Traditional methods have been referred to as an approach that involves the identification of system requirements, implementation of the prototype and testing the improved prototype (Vonk & Ligtenberg, 2010). During this process, users are not involved in the development process. This research adopted the use of traditional methods for prototype development. It involved the identification of software for prototype development and implementation of a prototype and testing. Furthermore, the stakeholders involved in the budgeting process, their roles, the stages and methods used in the budgeting process were identified from the reviewed policies (refer to Section 4.1). However, users input was not considered during the tool development due to the limitations of the research (refer to Section 5.3).

The results in Section 4.2.1 reflect the participants of the planning and budgeting process in Rwanda. The process involves stakeholders that communicate to make decisions within the participatory process (Fung, 2006). The different participants have varying levels of authority and power in the decision-making process (see Figure 16). The participatory process follows an organisational structure (in **Error! Reference source not found.**) that can be related to the socio-institutional influence (Jankowski & Nyerges, 2001). The organisational structure includes the national-local level and the horizontal level between Line Ministries and Agencies. The prototype provides access to many users in different locations (Sugumaran & DeGroote, 2011). The tool helps link the national and the local level through a web-based application that enables ease of access. The link is illustrated the participatory budgeting tool (crowdsource reporter) in Figure 23 provides for the collection of identified priorities by the Districts at the local level and Line Ministries and Agencies at the national level. The submitted priorities by the Districts can be monitored and approved by LODA. Also, at the national level, the participatory budgeting manager in Figure 25 allows decision-makers to screen, approve or exclude submitted project ideas by the budgeting agencies that don't meet the policy objectives. The ability to access the tool (as a web-based application) enables NBD and LODA to participate in a decision-making process at the national level.

Besides, the organisational structure, policies and mandates guide the participatory budgeting process. The national policies such as Rwanda Vision 2050 and the NST1 are used for the strategic alignment of identified projects to policy objectives (see Section 4.1.3). Although the NUP policy exists and is in use by MINIFRA as a sector policy for spatial implementation, it has not been considered in the alignment of projects to achieve policy objectives. Therefore, the prototype supports the integration of the NUP using the SDF methods with the identified projects to achieve policy objectives, as shown in (Figure 23 and Figure 24). The NUP integration guides the PB process through the location of projects with the available budget allocations.

The impact of the policies is evident through participant roles in the process and the institutional mandates that can be exercised using the tool developed. The roles include the identification of priorities by Districts and Line Ministries, coordination and implementation of policy objectives by LODA and NDPR; and the development of projects for implementation by the NDPR and NBD. Among the stakeholders. MINECOFIN plays a coordinating role in the PB process and authority and power over the process. Although MINECOFIN is the convenor of the PB process, the MINIFRA that houses the SDF methods is suitable for operating the PB prototype. The structure includes participants from diverse fields ranging from Agriculturalists, Planners, GIS experts and administrators (see Table 8). Each participant in the process has expectations based on defined policy goals and objectives within the planning and budgeting process. At the national level, MINECOFIN expectations include the implementation of identified priorities based on available budget allocations. With the prototype, participant expectations are achieved by integrating the policies objectives through identified projects using the participatory budgeting tool. In the Participatory Budgeting Manager, the decision-maker then incorporates the policy objectives in the decision-making process as criteria. The tool provided

As discussed above, Figure 29 shows a summary of the link between the national and local level using the prototype and the stakeholders in the participatory budgeting process. It also shows the current participatory budgeting process and the integration of the SDF methods into the budgeting process.

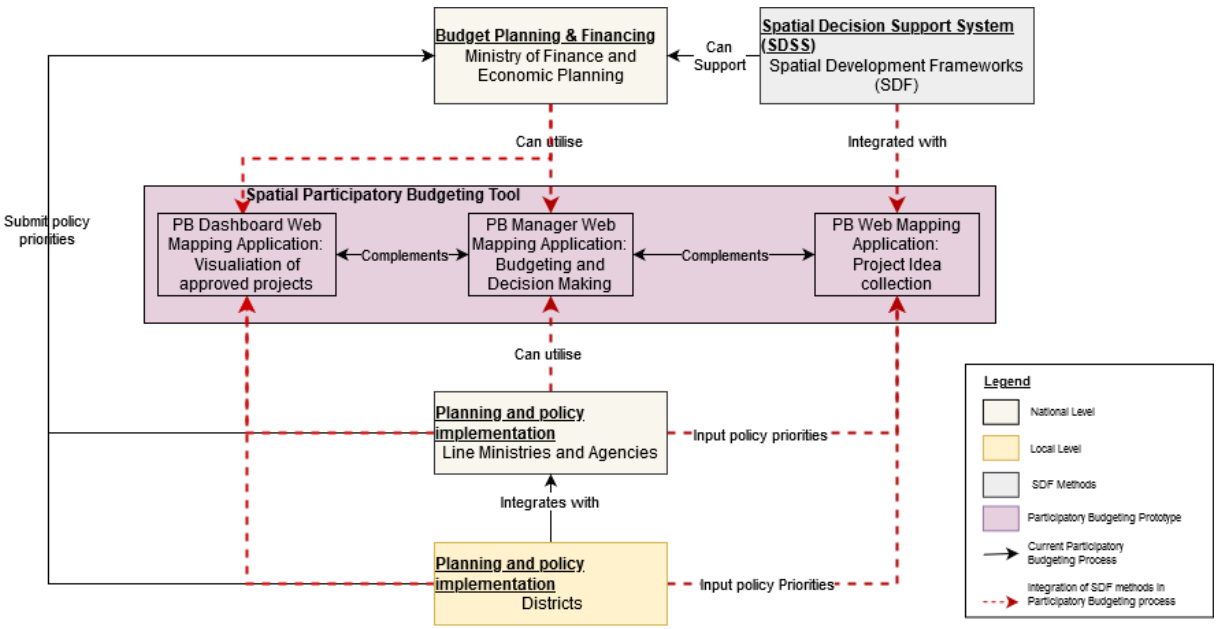


Figure 29: Participatory Budgeting process using participatory budgeting tools

5.2. Participatory Budgeting prototype Evaluation

The research developed a participatory budgeting prototype that integrated SDF methods for spatial policy implementation. Also, the prototype adopted the UTA algorithm to enable the prioritisation and selection of projects for allocated budgets. In the participatory budgeting application, the SDF methods were integrated with the planned project ideas from the DDS. Notably, the map of the hierarchy of settlements as an MoF output and the composite index maps evaluating the NUP pillar objectives as outputs for the SMCE (refer to Figure 4). According to the integration method for project portfolio selection, the pre-processing stage is the preliminary step of the project portfolio selection process. The stage comprises the proposed project pre-screening (define strategic guidelines and determining resource

allocation) and model selection and development (is a strategic process for the selection and evaluation of the proposed project portfolio selection). The participatory budgeting application can be related to the pre-processing stage of the integration for project portfolio selection (Archer & Ghasemzadeh, 1996). At this stage, projects are aligned to policy objectives.

The second stage referred to as the process stage involves projects evaluation, screening and portfolio selection for implementation of budget allocation (individual process analysis, screening optimal portfolio selection and portfolio adjustment). During the individual projects process analysis classification is made based on project characteristics and assessed to determine parameters for comparison between competing projects. Consequently, in the participatory budgeting manager application, projects are screened, ranked and selected into project portfolios using the aggregate relative satisfaction of objectives, the relative use of resources and the comprehensive relative efficiency of projects. Likewise, the participatory budgeting manager application is related to the process stage of the integration for project portfolio selection.

Lastly, is the post-process stage that combines the pre-process and process stages for portfolio balancing and adjustment according to resource allocation and availability. The participatory budgeting dashboard application is used to balance and adjust the selected project portfolios based on project performance according to predefined criteria and allocated budgets. The portfolio adjustment in participatory budgeting dashboard is similar to the post-process stage (see Figure 30). Therefore, based on the integrated project portfolio selection, it can be argued that the developed prototype can locate projects for PB using the SDF methods as a spatial policy.

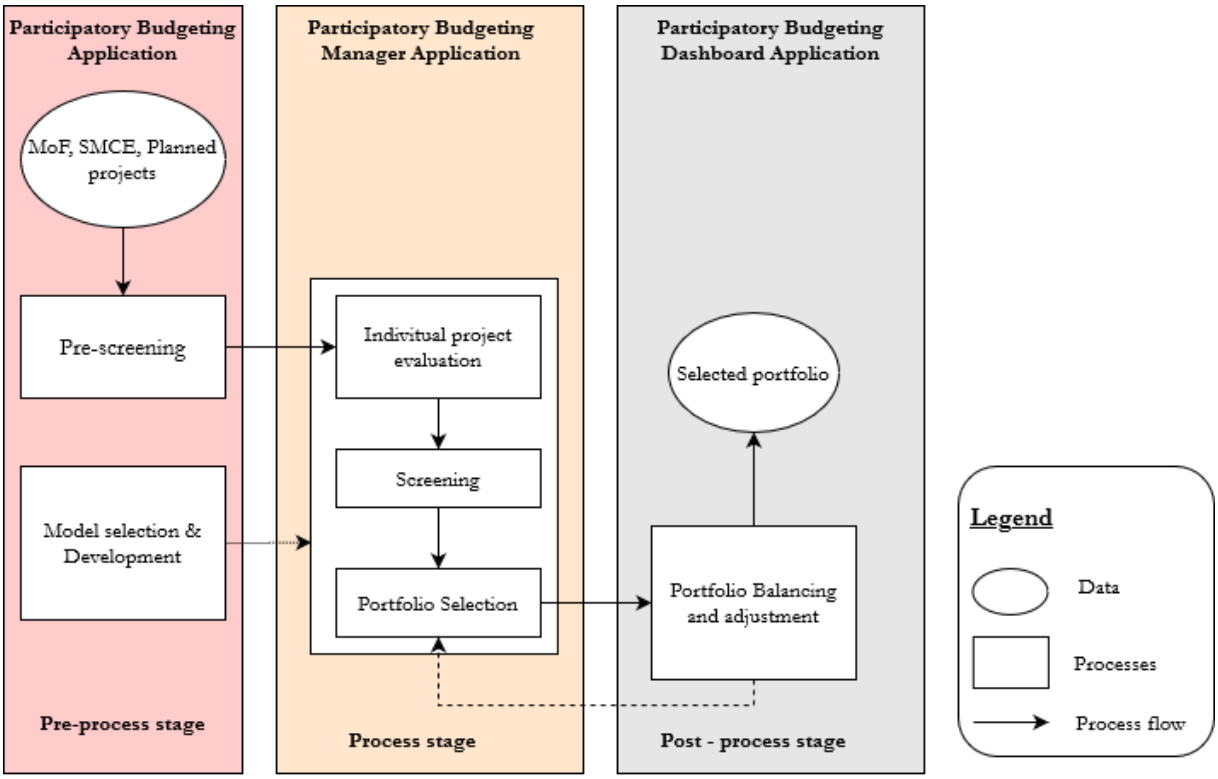


Figure 30: Project portfolio selection framework
Source: Adapted and edited from Archer & Ghasemzadeh (1996)

5.3. Limitations of the research

The study aimed to participatory budgeting prototype that integrated SDF methods for spatial policy implementation and evaluate the prototype. Some methodological limitations encountered during the research include;

- Geopolitical tension between the government of my home country (Uganda) and the case study area (Rwanda) hence, fieldwork was not possible.
- Due to the lack of fieldwork, it was impossible to get the user input during the development of the prototype.
- Also, the evaluation of the prototype using the stakeholders in the planning and budgeting process to establish its useability could not be done; therefore, the evaluation of the tool was based on theoretical frameworks.
- As part of the research, it was crucial to establish the methods used in the planning and budgeting process. Although the reviewed policies highlighted the methods, the details and application of the methods could not be established. The methods were influential in establishing how they were used for the alignment of identified priorities with policy objectives

The technical limitations included;

- The ArcGIS software is a commercial software and there customisation and extending the functions was challenging.
- The customisation and extension of the functionality required programming skills. However due to the limited programming skills, it was at times difficult to implement some of the required functionalities since two different programming languages were used.
- One of the limitations of the prototype is limited ability to visualise the computed outputs.

5.4. Recommendations for further study

The research provides areas for further researchon the participatory budgeting tool. They include;

- The developed prototype needs to be collaborated with empirical findings using stakeholders involved the planning and budgeting process on the usability of the developed prototype.
- Also, further research needs to be done on spatial analysis of projects to determine project portfolios based on spatial policy for participatory budgeting.
- Even though this research extended the functionality of the Participatory Budgeting tool, further automation needs to be done to link the python code with Participatory Budgeting Manager web mapping application to enhance the tools effiency.
- Furthermore, extended the functionality of the participatory budgeting dashboard need to be done to enable automation and visualisation of more outputs.

6. CONCLUSION

The aim of the study was to develop a budgeting tool to integrate the SDF methods as a spatial policy considered in locating projects for Participatory Budgeting. A traditional approach was adopted for the development of the prototype.

Theoretical frameworks were used to identify the components of the PB process in Rwanda. The frameworks were able to identify the components and these were used as a design criteria for the prototype development.

Based on the results, the Paticipatory Budgeting tools lack the capability to locate projects using spatial policies. However, with the PB prototype has been enhance to integrate SDF methods that can be considered in the location of projects for PB. The tool has also been enhanced with UTA integrated to enable decision-makers prioritise and select projects with consideration of spatial policy.

In addition, the prototype indicates that the SDF methods can be integrated with project portfolio management methods such as the UTA algorithm for participatory budgeting. The planned projects can be screened, ranked, and evaluated based on predefined policy objectives. The projects can also be grouped into portfolios.

In conclusion, the integration of the SDF methods has been achieved using a SDSS for participatory budgeting. Although the tool was developed as an experiment for one sector, this can be adjusted to other sectors. The developed tool can also be adapted to guide planning and budgeting processes for policy implementation.

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APPENDIX

Appendix 1: Extract of the Matrix of Function for Southern Province

					NTRE 1 (IUC1)																MAIN URBAN CENTRE (MUC)																
District	Sector	Sector Code	Populations 2019	Category of settlement	Heliport	Prison (not including jail in a police station)	National Prison	National Public University	International school	Intermediate Court	Manufacture of chemicals and chemical products	Headquarters offices of Banks	National Referral Hospitals	Prison Dispensaries	High Court and its Chambers	Public Library	Specialized Hospital/clinic	Trade \ Labor Union office	Television broadcasting station	Municipal ship (unpaved/grass strip, not for any	Private Hospital	Head office of Civil Society Organisation	International university	Research and development centre	Fire Station	Processing and preserving of fish, crustaceans and	Police/Military Hospital	Manufacture of rubber and plastics products	Auditorium	Airport (with tarmac strip)	Sewage network	University Hospital	Commercial High Court	Supreme Court	Total number of fuctions
	Mwendo	2607	0																																	20
Nyanza	Busasamana	2101	46260	IUC2											■	■		■							■											52
	Mukingo	2106	39442	LUC			■							■																						24
	Busoro	2102	37382	RC																																24
	Nyagisozi	2109	27880																																	18
	Muyira	2107	37565																																	22
	Ntyazo	2108	30445																																	22
	Kigoma	2105	41332																																	18
	Rwabicuma	2110	20177																																	16
	Kibilizi	2104	35920																																	17
	Cyabakamyi	2103	24790																																	11
Nyamagabe	Gasaka	2503		IUC2		■	■		■					■																						49
	Kaduha	2505	22,831	LUC		■																					■									22
	Tare	2516	25,393																																	28
	Kitabi	2509	28,590	RC																																23
	Musebeya	2513	20,487			■																														16
	Uwinkingi	2517	26,364																																	15
	Musange	2512	20,481																																	12
	Buruhukiro	2501	27,146																																	15
	Gatare	2504	17,411																																	14
	Kamegeri	2506	15,435																																	14
	Mushubi	2514	14,217																																	15
	Cyanika	2502	25,641																																	14
	Kibumbwe	2508	13,823																																	13
	Nkomane	2515	17,566																																	12
	Kibirizi	2507	23,777																																	12
	Mugano	2511	19,577																																	11
	Mbazi	2510	13,078																																	11
Huye	Ngoma	2409	17862	IUC1	■		■	■	■	■	■		■	■		■		■						■				■	■			■				71
	Huye	2402	25220													■																				24
	Tumba	2414	29895																																	30
	Mukura	2408	22162																																	26
	Ruhashya	2410	23258																																	21
	Mbazi	2407	33653			■																														22
	Rusatira	2411	29207	LUC																				■												22
	Gishamvu	2401	14734													■																				21
	Kinazi	2405	30165	RC																																24
	Maraba	2406	25227																																	18
	Karama	2403	18418																																	15
	Kigoma	2404	26248																																	19
	Simbi	2413	22316																																	14
	Rwaniro	2412	22256																																	12
Ngororero	Ngororero	3511	36,460	LUC								■																								31
	Kageyo	3505	15,550																																	7
	Kabaya	3504	31,752	RC																																25
	Gatumba	3502	22,216																																	18
	Muhanda	3508	26,620																																	11
	Nyange	3512	18,638																																	13
	Hindiri	3503	24,440																																	14
	Muhororo	3509	20,288																																	11
	Kavumu	3506	26,340																																	8
	Ndaro	3510	21,480																																	8
	Matyazo	3507	24,108																																	9
	Bwira	3501	18,800																																	7
	Sovu	3513	23,616																																	7

Source: Rwanda SDF, ITC 2016

Appendix 2: DDS Review Findings

SDF Province	District	DDS Implementation Plan	Costing
Northern	Burera	Available Data	Missing Data
	Gakenke	Available Data	Available Data
	Musanze	Missing Data	Missing Data
	Nyabihu	Missing Data	Missing Data
	Rubavu	Missing Data	Missing Data
Central	Bugesera	Available Data	Missing Data
	Nyarugenge	Missing Data	Missing Data
	Gasabo	Missing Data	Missing Data
	Kikuciro	Available Data	Missing Data
	Rulindo	Missing Data	Missing Data
	Kamonyi	Available Data	Missing Data
Eastern	Rwamagana	Available Data	Missing Data
	Nyagatare	Missing Data	Missing Data
	Gatsibo	Missing Data	Missing Data
	Ngoma	Missing Data	Missing Data
	Kirehe	Available Data	Missing Data
Southern	Muhanga	Available Data	Missing Data
	Ruhango	Available Data	Missing Data
	Nyanza	Available Data	Missing Data
	Huye	Available Data	Missing Data
	Nyaruguru	Missing Data	Missing Data
	Nyamagabe	Available Data	Missing Data
	Gisagara	Available Data	Missing Data
	Kamonyi	Missing Data	Missing Data
Kivu Belt	Karongi	Missing Data	Missing Data
	Ngororero	Missing Data	Missing Data
	Nyamasheke	Missing Data	Missing Data
	Rusizi	Available Data	Missing Data
	Rutsiro	Missing Data	Missing Data

Source: Author, 2020

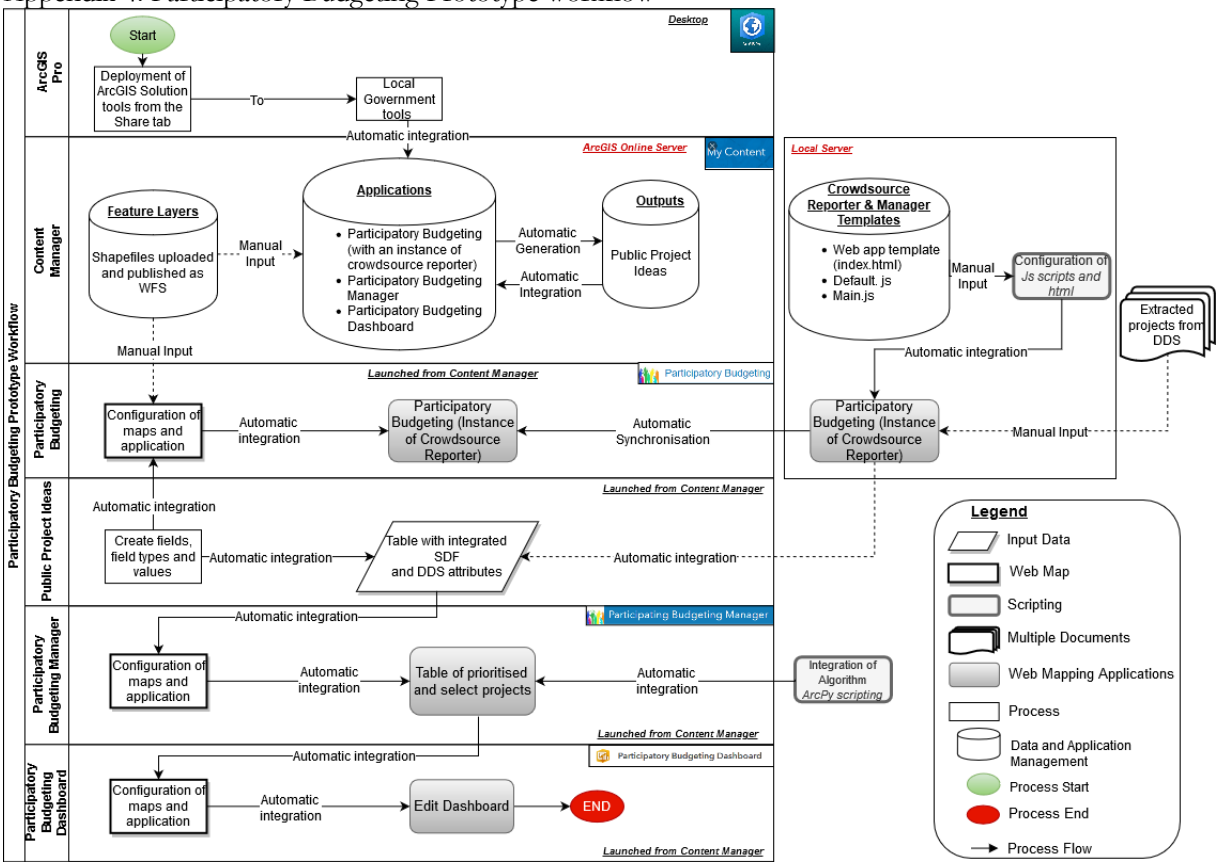
Appendix 3: Secondary data sources

Documents	Source	Website
Planning & Budgeting Policies		
Vision 2050	Ministry of Finance and Economic Planning	http://www.minecofin.gov.rw/fileadmin/templates/documents/NDPR/Vision_2020_.pdf
National Strategy for Transformation (NST1)	Ministry of Finance and Economic Planning	http://www.minecofin.gov.rw/fileadmin/user_upload/MINECOFIN_Documents/NST_A5_booklet_final_2.04.19_WEB.pdf

National Investment policy	Ministry of Finance and Economic Planning	http://www.minecofin.gov.rw/fileadmin/templates/documents/NDPR/National_Investment_Policy_25_April_2017.pdf
Result based performance management (RBM) policy for Rwanda public service	Ministry of Finance and Economic Planning, Ministry of Public Service and Labour	http://www.minecofin.gov.rw/fileadmin/user_upload/FINAL_RBM_POLICY_11-8-2015.pdf
MINECOFIN Service Charter	Ministry of Finance and Economic Planning	http://www.minecofin.gov.rw/fileadmin/user_upload/MINECOFIN_SERVICE_CHARTER_FD.pdf
National Land Use Planning Guidelines	Ministry of Natural Resources	http://www.rlma.rw/uploads/media/LUP_Guidelines_Final_Published.pdf
National Urbanisation Policy (2015)	Ministry of Infrastructure	https://www.mininfra.gov.rw/fileadmin/user_upload/Rwanda_National_Urbanization_Policy_2015.pdf
SDF methods Reports	ITC, Rwanda SDF, 2016 and 2019	
District Development Strategies (DDS)	ITC, Rwanda SDF, 2019	
Spatial Data		
SDF methods	ITC, Rwanda SDF, 2016	
Administrative Boundaries	ITC, Rwanda SDF, 2016	

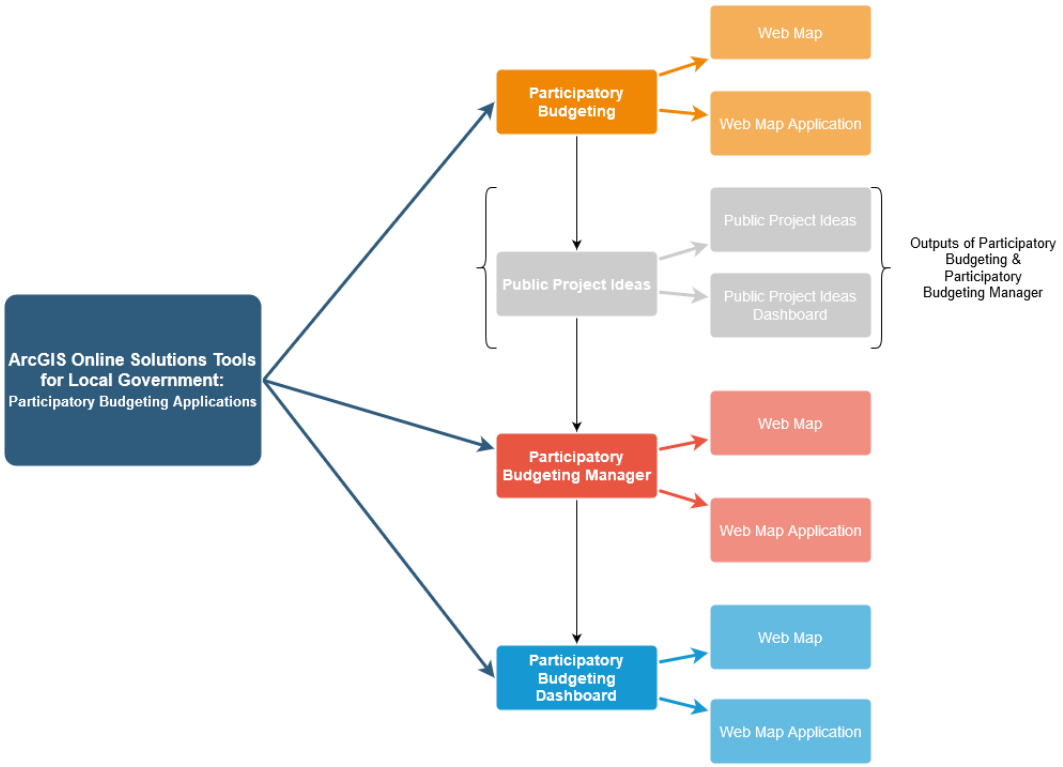
Source: Author, 2020

Appendix 4: Participatory Budgeting Prototype workflow



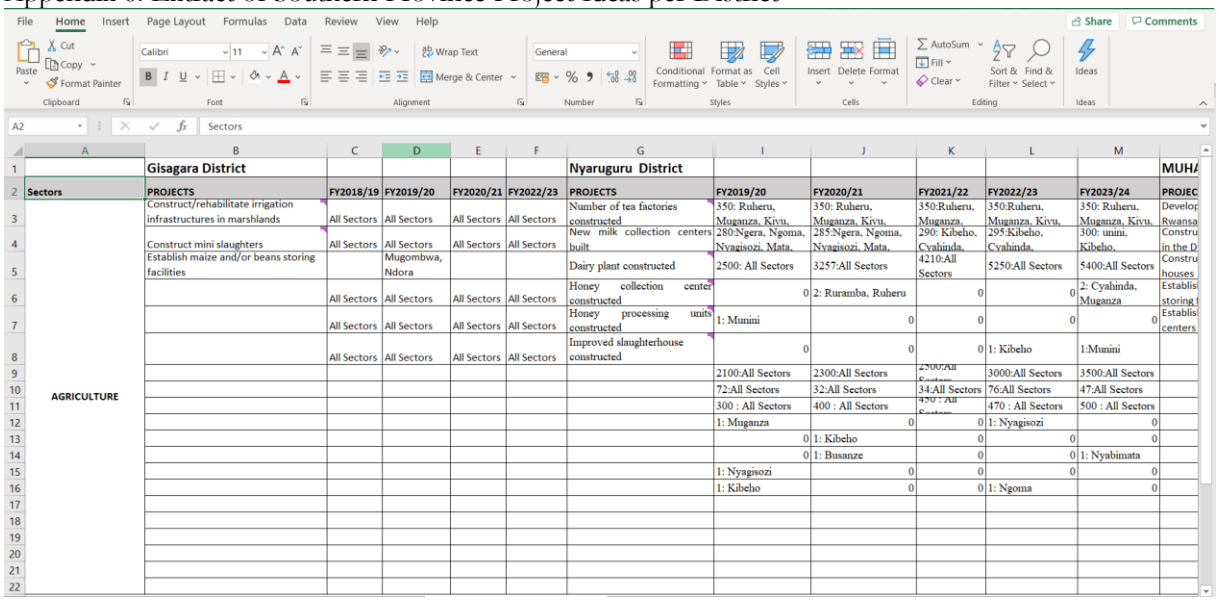
Source: Author, 2020

Appendix 5: Participatory Budgeting Applications



Source: Author, 2020

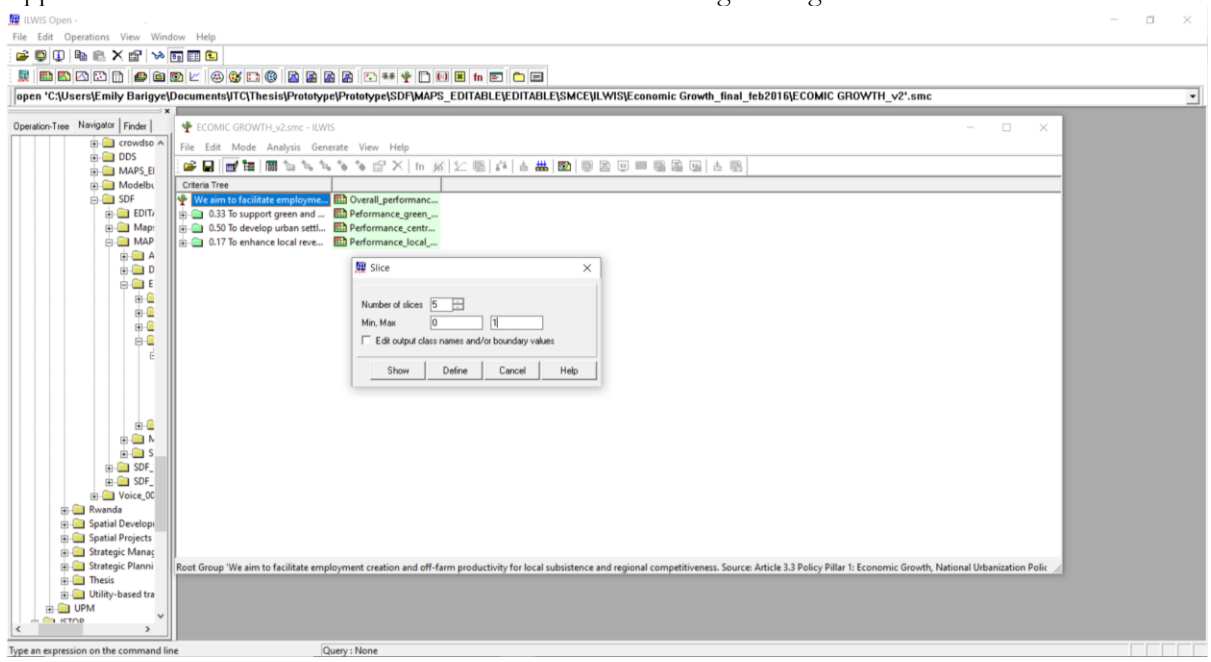
Appendix 6: Extract of Southern Province Project Ideas per District



		Gisagara District					Nyaruguru District						
2	Sectors	PROJECTS	FY2018/19	FY2019/20	FY2020/21	FY2022/23	PROJECTS	FY2019/20	FY2020/21	FY2021/22	FY2022/23	FY2023/24	PROJEC
3		Construct/rehabilitate irrigation infrastructures in marshlands	All Sectors	All Sectors	All Sectors	All Sectors	Number of tea factories constructed	350: Ruheru, Muganza, Kivu,	350: Ruheru, Muganza, Kivu,	350:Ruheru, Muganza,	350:Ruheru, Muganza, Kivu,	350: Ruheru, Muganza, Kivu,	Develop Rwansa
4		Construct mini slaughters	All Sectors	All Sectors	All Sectors	All Sectors	New milk collection centers built	280:Ngera, Ngoma, Nyagisozi, Mata,	285:Ngera, Ngoma, Nyagisozi, Mata,	290: Kibeho, Cyahinda,	295:Kibeho, Cyahinda,	300: unini, Kibeho,	Constru in the D
5		Establish maize and/or beans storing facilities		Mugombwa, Ndora			Dairy plant constructed	2500: All Sectors	3257:All Sectors	4210:All Sectors	5250:All Sectors	5400:All Sectors	Constru houses
6			All Sectors	All Sectors	All Sectors	All Sectors	Honey collection center constructed	0	2: Ruramba, Ruheru	0	0	2: Cyahinda, Muganza	Establis storing
7			All Sectors	All Sectors	All Sectors	All Sectors	Honey processing units constructed	1: Munini	0	0	0	0	Establis centers
8			All Sectors	All Sectors	All Sectors	All Sectors	Improved slaughterhouse constructed	0	0	0	1: Kibeho	1:Munini	
9								2100:All Sectors	2300:All Sectors	2500:All	3000:All Sectors	3500:All Sectors	
10	AGRICULTURE							72:All Sectors	32:All Sectors	34:All Sectors	76:All Sectors	47:All Sectors	
11								300 : All Sectors	400 : All Sectors	450 : All	470 : All Sectors	500 : All Sectors	
12								1: Muganza	0	0	1: Nyagisozi	0	
13								0	1: Kibeho	0	0	0	
14								0	1: Busanze	0	0	1: Nyabimata	
15								1: Nyagisozi	0	0	0	0	
16								1: Kibeho	0	0	1: Ngoma	0	
17													
18													
19													
20													
21													
22													

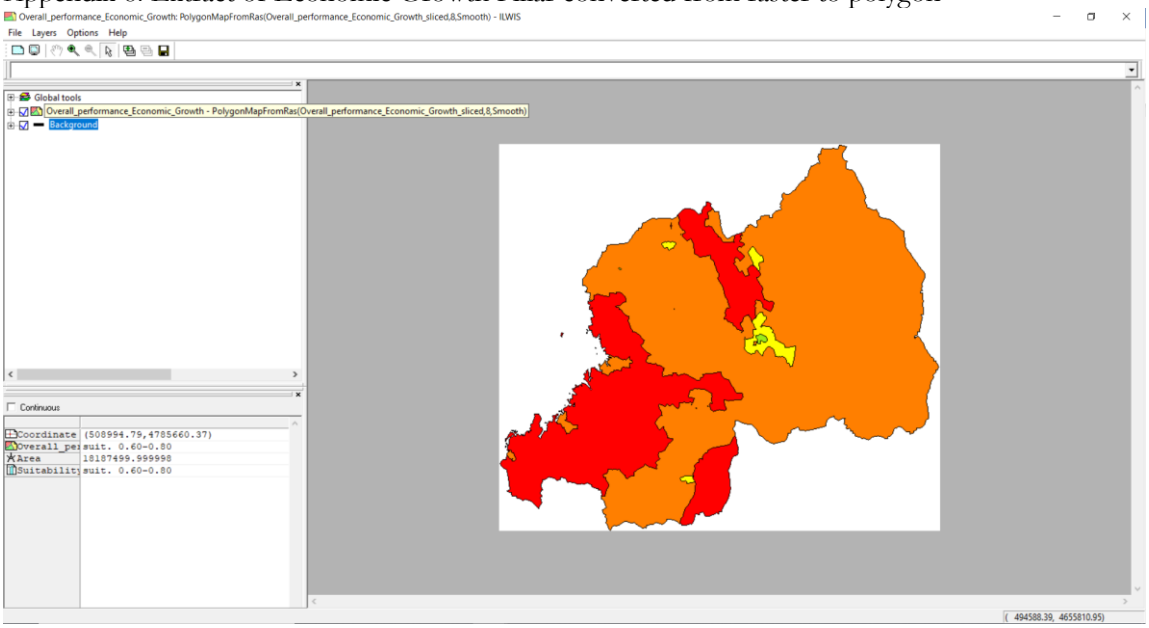
Source: Rwanda SDF, ITC 2019

Appendix 7: Extract of the Economic Growth Pillar raster image slicing in ILWIS



Source: Rwanda SDF, ITC 2016

Appendix 8: Extract of Economic Growth Pillar converted from raster to polygon



Source: Rwanda SDF, ITC 2016

Appendix 9: Extract showing default.js

define({

```
   //Default configuration settings for the application. This is where
you'll define things like a bing maps key,
   //default web map, default app color theme and more. These values can
be overwritten by template configuration settings and url parameters.
   "appid": "0bb9795474ed462ebe9872254ce3be57",
   "webmap": "509d3c87a26e4ddc8a87e0befecc81bf",
   "oauthappid": null,
   //Group templates must support a group url parameter. This will
contain the id of the group.
   "group": "520b1bd79fa74f0f9f3d13315dab6915",
   //Enter the url to the proxy if needed by the application. See the
'Using the proxy page' help topic for details
   //http://developers.arcgis.com/en/javascript/jshelp/ags_proxy.html
   "proxyurl": "proxy/proxy.ashx",
   "proxyThesePrefixes": [],
   "bingKey": "", //Enter the url to your organizations bing maps key if
you want to use bing basemaps
   //Defaults to arcgis.com. Set this value to your portal or
organization host name.
   "sharinghost": location.protocol + "//" + "utwente.maps.arcgis.com",
   "units": null,
   //If your applcation needs to edit feature layer fields set this
value to true. When false the map will
   //be created with layers that are not set to editable which allows
the FeatureLayer to load features optimally.
   "editable": false,
   "helperServices": {
    "geometry": {
      "url": null
    },
```

Appendix 10: Java Script code for extracting MoF attributes from main.js

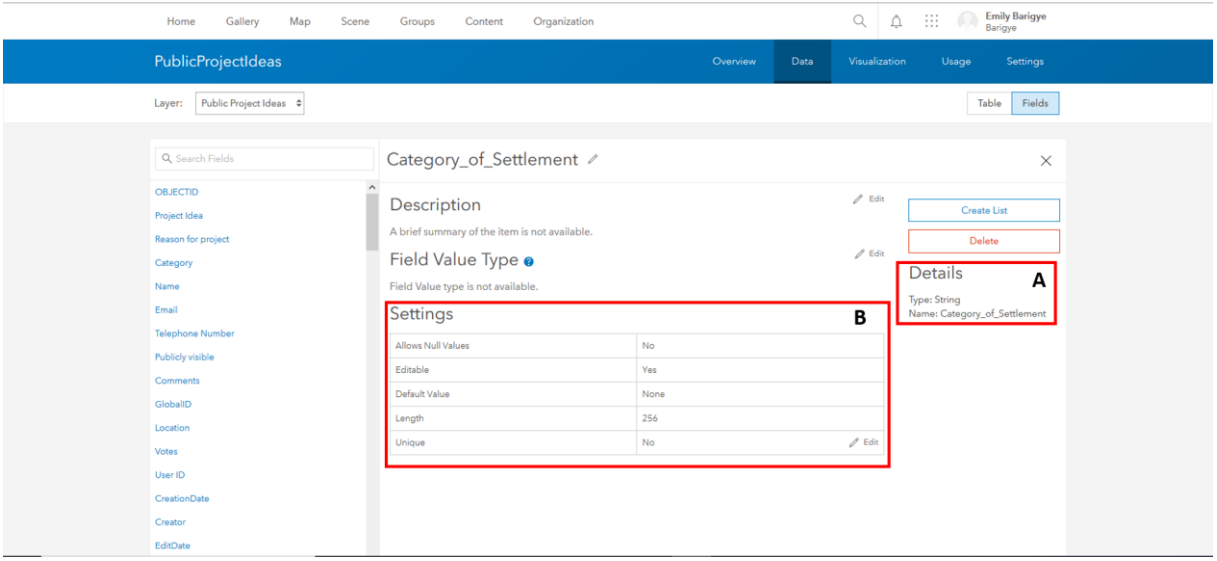
```
// Extract SDF MoF attributes: Sector_Code, Category_of_Settlement,
Sector, Population_per_Sector etc..
if (evt.graphic && evt.graphic.attributes) {
        document.getElementById("Sector_Code").value =
evt.graphic.attributes.Code_Sect;
        document.getElementById("Category_of_Settlement").value =
evt.graphic.attributes.Category_o;
        document.getElementById("Sector").value =
evt.graphic.attributes.Sector;
        document.getElementById("Population_per_Sector").value =
evt.graphic.attributes.Population;
        document.getElementById("Primary_School").value =
evt.graphic.attributes.Primary_Sc;
        document.getElementById("National_Electricity_on_grid").value =
evt.graphic.attributes.National_E;
        document.getElementById("Government_Assisted_Health_Centre").val
ue = evt.graphic.attributes.Government;
        ..................................
        document.getElementById("Supreme_Court").value =
evt.graphic.attributes.Supreme_Co;
        document.getElementById("Total_number_Of_Functions").value =
evt.graphic.attributes.Total_numb;
        document.getElementById("Total_Centrality_score").value =
evt.graphic.attributes.Total_cent;
        document.getElementById("Level_of_centrality").value =
evt.graphic.attributes.Level_of_c;
        }
```

Appendix 11: Java Script code for extracting SMCE attributes from main.js

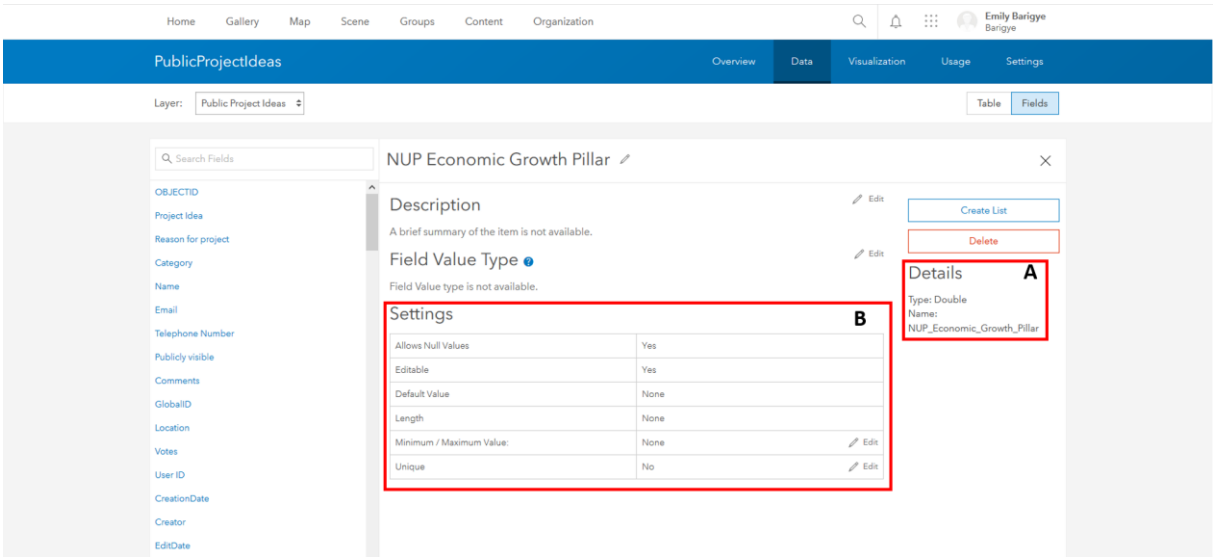
```
    _showPopupForNonEditableLayer: function (evt) {

// Extract SDF SMCE, Coordination_Pillar attributes.
                console.log(evt);
                //create identify tasks and setup parameters
                var newQuery, newQuery2, identifyParams;
                newQuery = new Query();
                newQuery.geometry = evt.mapPoint;
                newQuery.returnGeometry = false;
                newQuery.outFields = ["Coordina_1"];
                //Coordination Pillar Query
                var          queryTaskCoordination          =          new
QueryTask("https://services1.arcgis.com/fpPKDlJ3n8eBtEzb/arcgis/rest/ser
vices/Coordination_Pillar/FeatureServer/0");
                queryTaskCoordination.execute(newQuery, dData);
                function dData(result){
                console.log(result);
                document.getElementById("NUP_Coordination_Pillar").value
= result.features[0].attributes.Coordina_1;
                }
```

Appendix 12: Extract of the Public Project Ideas showing created fields for the MoF - Category of settlements



Appendix 13: Extract of the Public Project Ideas showing created fields for the SMCE - NUP Economic Growth Pillar



Appendix 14: Extract of the Participatory Budgeting Application showing the ranking of projects, and Criteria weights