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Topic: Environmental Quality Improvement Through Informal Settlement Upgrading. Case of Agatare, Kigali City

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DECLARATION

I, Emmanuel UWIRAGIJIMANA, hereby declare that the contents of this thesis entitled "**Environmental Quality Improvement Through Informal Settlement Upgrading. Case of Agatare, Kigali City**" represent my original work and have not been previously submitted to any university or other higher learning institution for academic credit or evaluation.

APROVAL

It is hereby confirmed that this thesis entitled "**Environmental Quality Improvement Through Informal Settlement Upgrading. Case of Agatare, Kigali City"** submitted by Emmanuel UWIRAGIJIMANA has been assessed and accepted by the post-graduate coordination team in the school of Architecture and Built Environment.

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ABSTRACT

Informal settlements refer to housing units built on land without legal claims or in violation of planning and building regulations, accommodating around one billion people worldwide. These settlements exacerbate challenges of rapid urbanization, such as housing shortages and environmental degradation, especially in developing Nations. In Africa, including Rwanda, informal settlements are rising, intensifying issues like insecurity and inadequate social services. Rwanda, particularly in Kigali, faces similar challenges due to rapid urbanization. To address these issues, the government, with World Bank support, has launched programs like the Agatare project to upgrade informal settlements by enhancing infrastructure and providing affordable housing. However, alongside socio-economic development, addressing environmental concerns like waste management and water drainage is crucial for holistic urban improvement. This study evaluates how informal settlement upgrading contributes to environmental sustainability in upgraded areas.

The study aimed to assess how the Agatare settlement upgrading project promotes sustainable residential neighborhoods, identify challenges hindering environmental quality improvement, and propose strategies to address these challenges. The study employed interpretive techniques to analyze field data, existing literature on informal settlement upgrading, and GIS techniques to analyze spatial data from various institutions. The findings revealed that the Agatare project significantly improved socio-economic infrastructure and environmental health by managing stormwater, planting trees along roads, encouraging home gardens, and facilitating solid waste management. Despite these efforts, persistent challenges remain, including open drainage systems that allow solid and liquid waste disposal, waste deposition in wetlands, and improper waste collection in some households. Addressing these issues is essential for maintaining a healthy environment in the upgraded area.

Key words: *informal settlement, informal settlement upgrading, and environmental sustainability*

List of Abbreviations

CBD: Central Business District

CBOs: Community-Based Organizations

CoK: City of Kigali

COPED: Company for Protection of Environment and Development

GIS: Geographical Information Science

GoR: Government of Rwanda

KCMP: Kigali City Master Plan

MININFRA: Ministry of Infrastructures

NGOs: Non-Governmental Organizations

NISR: National Institutes of Statistics of Rwanda

RHA: Rwanda Housing Authority

UN: United Nations

WB: World Bank

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Chap I. INTRODUCTION

I.1. Background Information

Informal settlements, often referred to as shantytowns in Asia or favelas in Latin America, are widespread global phenomena present in both developed and developing nations. These areas consist of housing units constructed on land without legal claims or in violation of planning and building regulations (UN-Habitat 2020). Approximately one billion people, accounting for roughly 14% of the world's population, currently reside in such informal settlements, as reported by the United Nations (Nikuze, Sliuzas et al. 2019). These settlements can be found across various regions, including Africa, Asia, the Middle East, Latin America, and even in some developed countries like the United States and Australia (Satterthwaite 2006).

More than half of the world's population already were living in urban areas by 2018. According to (UN-Habitat 2019); more than 60% of Sub-Saharan Africans, 35% of South Asians, 25% of Latin Americans, 13% of Middle Eastern and North Africans, and 6% of European and North American urban residents live in informal settlements. Most urban growth processes are now taking place in Africa and Asia, where growing rates are above the world's average (OECD 2020). The global share of African urban dwellers was projected to rise from about 11 % in 2010 to about 20 % by 2050, and 64 % of all Africans are projected to be living in cities by 2050. The eastern part of Africa is the least urbanized region of the continent and the urban areas provide economic opportunities and means to escape poverty for millions of people (Zhang 2016).

Urbanization presents numerous of challenges, many of which are closely tangled with the development of informal settlements. Rapid urbanization has led to significant population growth in cities worldwide, intensifying housing shortages and the emergence of informal settlements (Trask and Bahira S 2022). These unplanned and often illegal settlements typically lack essential infrastructure and services, resulting in issues like inadequate sanitation, overcrowding, and limited access to clean water (UN-Habitat 2020). Additionally, the urbanization-related problems of traffic congestion, pollution, social inequality, and inadequate housing often intersect with the challenges faced by residents of informal settlements, intensifying the overall impact on vulnerable communities (UN-Habitat 2020, Agyabeng, Peprah et al. 2022).

Informal settlements are commonly seen in almost world's centers and cities, and they contribute to unsafe conditions generated by informality, which exacerbates the challenges and problems that people, organizations and government face every day. Particularly in developing countries, where the economy and planning technology are limited; the problem becomes vast (Sarmiento, Polak et al. 2019). Some challenges like disasters, insecurity, and poor social service provision become a serious problem in the informal settlements. Therefore, the need for strategic planning and suitability analysis are needed in order to live in safe place (Sarmiento, Polak et al. 2019).

United Nations conducted a study that examined the prevalence of informal settlements in 140 countries. The study revealed that the proportion of the urban population living in informal settlements ranged from less than 1% in high-income countries to over 80% in some low-income countries. The study also found that informal settlements were more prevalent in sub-Saharan Africa, South Asia, and Latin America. In Africa, informal settlements are particularly widespread, according to a report by the United Nations Human Settlements Program (UN-Habitat), an estimated 60% of the urban population are living in these settlement, which is about 200 million people (UN-Habitat 2020). Residing in informal settlements results in limited access to improved water sources, deficient stormwater drainage systems, inadequate sanitation facilities, worse structural quality and durability of housing, and an absence of secure land tenure (Pätsch 2017).

The number of people living in informal settlements in Africa is projected to increase to about 350 million by 2050 due to rapid urbanization, high levels of poverty, and limited access to affordable housing (Chipao and Probert 2019). Some of the countries with the highest proportions of informal settlements in Africa include Nigeria, Kenya, South Africa, and Egypt. For instance, in Nigeria, over 69 million people are estimated to be living in informal settlement, which represents about 35% of the country's urban population (UN-Habitat 2020).

Rwanda, like numerous other nations, confronts similar issues concerning informal settlements. Rapid urbanization, population expansion, and a scarcity of affordable housing contribute to the rise and spread of informal settlements, particularly in Kigali, the country's primary urban hub. These areas frequently exhibit insufficient access to essential amenities like water, sanitation, electricity, and substandard housing conditions that lead to informal settlement formation (Nikuze, Sliuzas et al. 2019).

The informal settlement upgrading program emerged as a critical step in addressing the challenges posed by such settlements. This effort involves providing a variety of crucial services, such as ensuring access to clean water and establishing efficient sewage disposal systems, with the goal of improving the overall quality of life in these communities. However, at the core of this program consists of the crucial task of legalizing and regularizing properties in situations where land tenure is insecure or uncertain. This legal dimension is fundamental to ensuring that residents have secure rights to their homes, paving the way for more stable and sustainable living conditions in informal settlements (El Menshawy, Aly et al. 2011).

I.2. Problem statement

Urbanization in Rwanda is marked by significant demographic growth and a notable influx of people into urban areas, including displaced individuals and returnees following the 1994 genocide against the Tutsi. The urban population has undergone substantial growth, surging from a mere 4.6% in 1978 to 16.5% by 2012. The Vision 2020 initiative set an ambitious target of reaching 35% urbanization by 2020 (RHA 2013, MININFRA 2015). However, this rapid urbanization brought about substantial challenges, particularly in the formation of informal settlements. These settlements are associated with substandard housing, limited access to essential services, sanitation issues, inadequate infrastructure, and environmental degradation within these urban areas (MININFRA 2012).

In a bid to tackle the challenges of urban areas in Rwanda, Government aims to improve urban management and infrastructure access in selected urban centers across the country. The plan to improve urban management and infrastructure accessibility emphasizes on increasing settlement densities and affordable housing options for vulnerable populations and reducing displacement. Infrastructure enhancements are proposed to foster socioeconomic development and mitigate regional segregation trends (CoK 2013, MININFRA 2015). This is backed up by a legal framework that encourages upgrading of informal settlements in accordance with the national strategy, with the intention of laying the groundwork for both short and long-term upgrading and preventative measures (Habiyambere, Diang'a et al. 2019).

The attempt to mitigate the challenges posed by informal settlements started in Kigali, the primary urban center of the country, which comprises a large part of such settlements compared to other cities of the country (RHA 2014, Benken 2017). The process of taking over Ubumwe cell in Muhima Sector began in 2005, initiated by the Kigali City to undertake urban revitalization efforts by clearing informal settlements within the central area designated for the Central Business District (CBD). Families that had initially settled in the area reserved for development were relocated and resettled in the peripheries of the city, specifically at the Batsinda site, following a compensation arrangement (Bizimana, Mugiraneza et al. 2012). Apart from demolition of informal settlement, the approach of informal settlement upgrading were also initiated in Kigali where, in 2018, the first project started to improve social, economy and environment of the Agatare neighborhood (GISTech 2015). The implementation of Agatare project was supported by the World Bank aimed for road upgrading, electricity, and transportation systems of Biryogo, Agatare, Kiyovu, and Rwampara in Nyarugenge District. These include construction of 6.6km access roads and 6.2km footpaths; 2.512km drainage, 1.5km of street lights and relocation of 220m^3 water tank reservoir (KTPress 2021).

All activities related to the project implementation was coordinated by the Rwanda Housing Authority under the Ministry of Infrastructure, it addresses the lack of essential infrastructure like roads, pedestrian ways, drainage, streetlights, electricity, water, and wastes management in informal settlements. The project, primarily benefiting the local residents, seeks to provide these vital infrastructures after a pilot phase revealed the pressing need for such improvements, thereby contributing to improved daily life and living conditions (MININFRA 2021).

However, it is worth noting that various report Like; infrastructure upgrading of informal settlements in Kigali City have predominantly focused on aspects related to social and economic development in Kigali, emphasizing the provision of critical infrastructure such as roads, electricity, and water within upgraded informal settlements. Surprisingly, the environmental dimension including waste management, water drainage and stormwater control, despite being an important component of residents' overall well-being, has been somewhat overlooked in these reports.

I.3. **Research Objectives**

I.3.1. General Objectives

The main aim of the study was to assess to which extent the processes of informal settlement upgrading promote the quality of environment in Kigali city, using Agatare as the study area.

I.3.2. Specific objectives

1. To assess the extent to which the upgrading of Agatare informal settlement promote the sustainable residential neighborhoods in Kigali city,
2. To identify the challenges that might have hindered improvement of environmental quality in Agatare residential settlement.
3. To propose strategies and methods for addressing identified challenges for improving environmental quality during the informal settlement upgrading project.

I.3.3. Research Questions

1) Has the process of upgrading informal settlement in Agatare promoted the sustainable residential neighborhoods in the area?
2)
   a) What are the aspects of the environmental quality resulting from the upgrading of Agatare informal settlements?
   b) What are the challenges that might have hindered the improvement of environmental quality in those settlements?
3) What are the best strategies that can be adopted in order to promote environmental quality alongside the process of informal settlement upgrading projects?

I.4. The motivation of the study

The discussion highlights a critical oversight in previous research on informal settlement upgrading where they did not highlight on environmental sustainability aspects. While researchers have acknowledged the importance of infrastructure development, they have not address how such upgrades contribute to the overall environmental well-being (Mutisya and Masaru 2011, Njeri, Munala et al. 2023). In response, the project in Agatare conducted a SWOT analysis, which revealed environmental weaknesses, including inadequate waste disposal, a lack of stormwater management, and insufficient strategies to address environmental challenges (GISTech 2015).

Furthermore, this topic underscores the significance of assessing the sustainability and equitable development of informal settlement upgrading. By prioritizing environmentally sustainable and equitable approaches, the project contributes to the broader objective of sustainable and equitable urban development in Agatare and Kigali. Such efforts enhance the well-being of informal settlement residents who are often vulnerable to environmental hazards like floods and landslides. Through improvements in environmental quality, the resilience of these settlements to such hazards is significantly reinforced, promoting a safer and more sustainable living environment.

I.5. Analytical framework

An informal settlement is defined as an area with insufficient affordable housing and limited access to essential infrastructure such as roads, water drainage systems, and proper waste disposal facilities. These conditions contribute to a lower quality of life for the residents and poor environmental quality in these areas (UN-Habitat 2020). Environmental sustainability issues experienced in informal settlements include inadequate waste management systems, limited access to clean water and proper sanitation facilities, air and water pollution, deforestation, soil erosion, flooding, biodiversity loss, and land degradation. To address the challenges inherent in informal settlements, two distinct approaches can be considered: one involves the demolition of such settlements, while the other entails the upgrading and improvement of informal settlements (RHA 2014, Benken 2017).

The process of demolishing informal settlements involves the clearance of entire settlements by relocating existing residents to alternative areas for habitation. Following the expropriation of land, a redevelopment effort arises, featuring the construction of new housing that aligns with the specifications outlined in the master plan. Simultaneously, essential infrastructure is established within the area to ensure the well-being and functionality of the community. This comprehensive approach not only addresses the immediate housing concerns but also aims to create a more sustainable and organized urban environment in line with urban planning objectives (Wu, Zhang et al. 2013).

Conversely, the concept of informal settlement upgrading takes a different approach by focusing on the improvement and development of existing settlements. This strategy entails the provision of critical infrastructure such as roads, electricity, water supply, drainage systems, and effective

stormwater management. Additionally, it encompasses the establishment of a well-maintained waste management system (RHA 2014, Benken 2017, Smit 2017).

Focusing on informal settlement upgrading, this approach provides significant benefits for environmental sustainability by improving water drainage systems, which help prevent flooding by efficiently channeling excess water away from residential areas. It also helps maintain the structural integrity of buildings and roads by reducing water accumulation and soil erosion. This approach develops green and open spaces that improve air quality, support biodiversity, and mitigate urban heat effects. Through the creation and improvement of various infrastructures, waste management is enhanced by implementing organized collection and disposal systems, reducing garbage accumulation and related health hazards in the upgraded area. Additionally, it promotes sustainable practices such as recycling and composting, which enhance environmental quality and community health. Informal settlement upgrading conserves natural resources by implementing sustainable practices, such as proper waste management and eco-friendly construction methods, which reduce environmental degradation. The improvement of infrastructure and securing of land tenure also prevent deforestation and promote the preservation of natural habitats. (Smit 2017).

In this context, this study is particularly interested in examining the effectiveness of these infrastructure developments within Agatare, an informal settlement that has undergone upgrading. The specific focus is on those infrastructure elements that play an important role in environmental management, as they have the potential to not only enhance the living conditions of residents but also contribute significantly to the overall sustainability and wellbeing of the community.

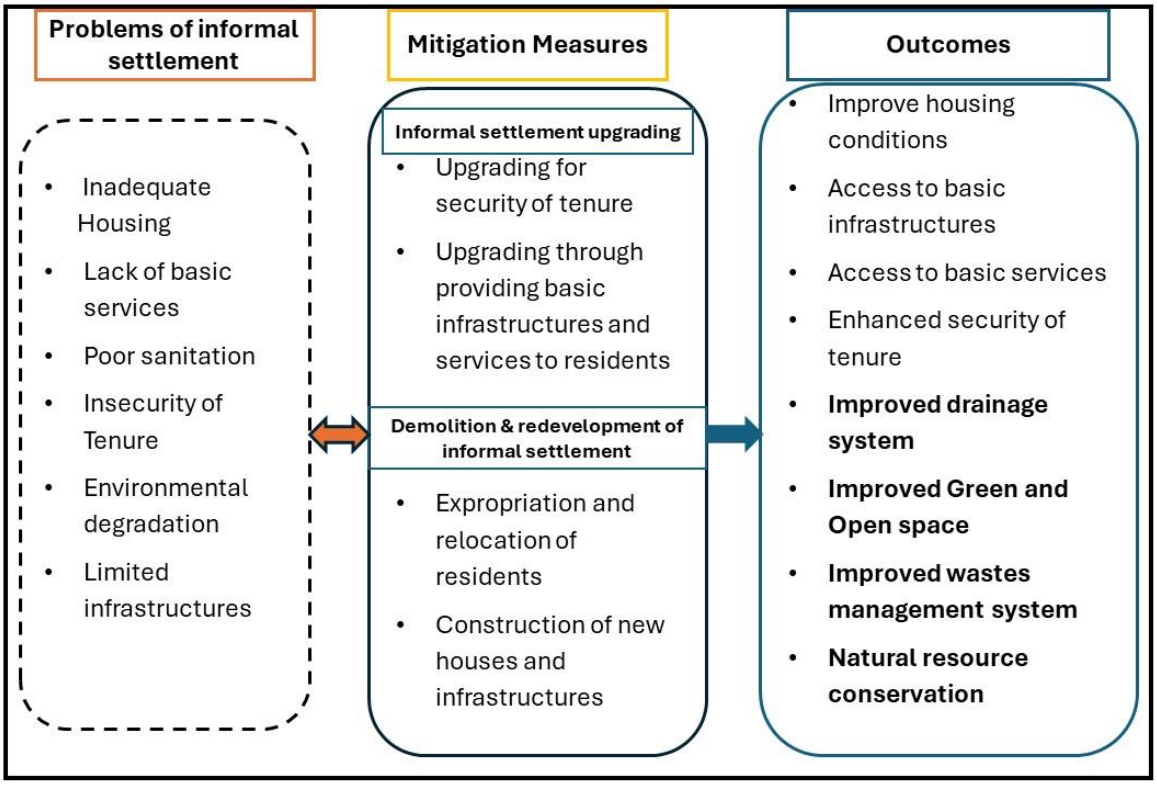

Figure 1. Analytical Framework (Source: Literature review)

I.6. Research matrix

The research matrix serves as a structured framework, comprising rows and columns, where each component of a research project finds its designated place. This comprehensive framework includes elements such as the research goal, objectives, definitions, variables, methods of analysis, and anticipated conclusions (Choguill 2005). As part of this research endeavor, the following table illustrates the research matrix that will guide the organization and alignment of these critical components, ensuring a systematic and cohesive approach to the study.

Table 1. The research matrix of Agatare settlement upgrading project

Specific objective	**Research question**	**Methods and data source**	**Expected results**
To assess the extent to which the upgrading of Agatare informal settlement promote the sustainable residential neighborhoods in Kigali city.	Has the process of upgrading informal settlement of Agatare promoted the sustainable residential neighborhoods in the area?	1. Review on existing literature on informal settlement upgrading in general context. 2. Review of the literature about informal settlement upgrading in Agatare 3. Field survey and Observation.	1. Overview of informal settlement upgrading. 2. overview on the improvement of sustainable neighborhoods after settlement upgrading in Agatare. 3. first sight on developed infrastructures that improve life standard of Agatare residents.
To identify the challenges that might have hindered improvement of environmental quality in Agatare residential settlement.	-What are the aspects of the environmental quality resulting from the upgrading of Agatare informal settlements? -What are the challenges that might have hindered the improvement of environmental quality in Agatare residential settlement?	1. Interview question and field survey. 2. Review on existing literature on aspect and challenges of informal settlement upgrading.	Overview of the challenges that hinder environmental sustainability in Agatare and first-hand insight on those challenges from Agatare residents.
To propose strategies and methods for addressing identified challenges and improving environmental quality during the informal settlement upgrading project.	What are the best strategies that can be adopted in order to promoting environmental quality alongside the process of informal settlement upgrading projects?	Review of literature based on best practice of informal settlement upgrading.	Summary on the approaches that can be adopted in informal settlement upgrading basing on the best practice of settlement upgrading.

Chap II. Literature Review

II.1. Introduction

The aim of this chapter is to provide a comprehensive overview and relevance of the existing research on this topic, highlighting the key findings, theories, and debates within the field. It delves into various aspects of informal settlements, encompassing their definitions, developmental factors, and upgrading strategies. It discusses the diverse actors involved in informal settlement upgrading and examines the resultant outcomes. Additionally, it addresses the crucial aspect of environmental sustainability within upgraded settlements. This provided insights into various approaches for managing informal settlements and highlighted how environmental considerations can be integrated into their upgrading.

II.2. Key definitions

Informal settlements: are areas where groups of housing units have been constructed on land that the occupants have no legal claim to or occupy illegally. They can also be called unplanned settlements as areas and housing is not in compliance with current planning and building regulations (Huchzermeyer, Karam et al. 2014, UN-Habitat 2019).

Planned settlement: A formal/ planned settlement is a site or settlement that is recognized by the government which in turn provides administration and management facilities to the settlement dwellers by giving all social and personal services (Srejović 1974, MININFRA 2012).

Slums: are generally defined as areas in cities where the poor are concentrated in deplorable conditions. Slums are characterized by a lack of basic services, awful housing, overcrowding, insecure tenure, and poverty (Sheuya 2008). Similarly, the UN-Habitat defines a slum household in operational terms, as lacking one or more of the following indicators: a durable housing structure; access to clean water; access to improved sanitation; sufficient living space; and secure tenure (Nuissl and Heinrichs 2013, Agyabeng, Peprah et al. 2022).

According to Weerdt (2011), slums are the homes of the urban poor and those in search of a better life. without a better life or a better place to go Slums are not new; they have existed for as long as cities have existed, and slum problems are not new either. Poverty, overcrowding, poor hygiene,

social unrest, and violence. Drawing from the above conceptual definitions, slums are residential places in cities or towns where houses are so concentrated, poor living conditions and characterized by high crime rates.

Informal settlement upgrading: refers to the process of improving the physical and social infrastructure of informal settlements, also known as slums or shantytowns. This can include providing access to basic services such as water, sanitation, and electricity, as well as upgrading housing and improving community facilities. The goal of informal settlement upgrading is to improve the living conditions and overall well-being of residents, while also reducing poverty and promoting sustainable urban development (Abbott 2004, Huchzermeyer, Karam et al. 2014).

II.3. Factors for informal settlement development

Understanding the deep-rooted factors driving informal settlement development requires a nuanced analysis that acknowledges the interconnectedness of socio-economic, political, environmental, and cultural dimensions. Addressing the challenges posed by informal settlements necessitates comprehensive strategies that address land tenure insecurity, socio-economic inequalities, inadequate infrastructure, and exclusionary governance practices while empowering residents to participate in decision-making processes and fostering inclusive urban development policies. This section provides an overview of some key factors contributing to the development of informal settlements development.

II.3.1. Policy and Legal Frameworks

Government policies and regulatory frameworks play a crucial role in the development and persistence of informal settlements. Historical neglect and inadequate urban planning, compounded by exclusionary zoning policies, have marginalized certain communities, forcing them to form informal settlements. The absence of supportive policies for affordable housing, land tenure regularization, and informal settlement upgrading exacerbates the problem, impeding efforts to address and improve these settlements. Without comprehensive policies and effective regulations, informal settlements continue to proliferate, resulting in inadequate living conditions and perpetuating socio-economic inequalities. To effectively tackle the issue, it is essential for governments to implement inclusive and supportive frameworks that promote affordable housing,

regularize land tenure, and facilitate sustainable upgrading of informal settlement initiatives. (UN-Habitat 2018).

II.3.2. Poverty and Inequality

Poverty and inequality are both a cause and consequence of informal settlements. Low-income households often cannot afford formal housing due to high costs associated with rent, mortgages, or property ownership. As a result, they are forced to seek shelter in informal settlements where housing may be cheaper or even free. Moreover, limited access to education and employment opportunities perpetuates the cycle of poverty, further entrenching residents in informal settlements. Poverty-stricken individuals and families often lack the means to access formal housing options and are forced to settle in informal settlements due to limited resources (Alene 2022, Hosseini, Finn et al. 2023).

II.3.3. Inadequate Urban Planning and Housing Policies

Weak urban planning and governance contribute to the growth of informal settlements. As noted by Gilbert and Gugler (1992), "Zoning regulations in many cities often favor commercial or high-income residential development, leaving little space for affordable housing for low-income residents. This exclusionary approach to urban planning contributes to the proliferation of informal settlements as marginalized populations seek alternative housing options. The lack of comprehensive urban planning, ineffective land management, and inadequate provision of services create an environment conducive to the formation and expansion of informal settlements (Bonaiuto, Fornara et al. 2015). In summary, Inadequate urban planning and governance contribute significantly to the formation and persistence of informal settlements by neglecting the housing needs of marginalized populations, enforcing exclusionary zoning policies, failing to provide basic infrastructure, excluding residents from decision-making processes, and facilitating corrupt land transactions. Addressing these systemic issues requires inclusive and participatory urban planning approaches that prioritize the needs of all residents and promote equitable access to housing, land, and services (Nyambura 2012, Ghasempour 2015, UN-Habitat 2019).

II.3.4 Land Tenure Insecurity

Land tenure insecurity is a critical factor driving the development of informal settlements. These settlements often emerge on land with unclear or informal tenure arrangements, where residents lack formal property rights. This lack of legal recognition exposes them to the constant risk of eviction or displacement. Frequently, settlers occupy land without legal permission, resulting in conflicts over land ownership among residents, private landowners, and government authorities. These disputes hinder the provision of basic services and infrastructure, as authorities are reluctant to invest in areas where land rights are contested (Bizimana, Mugiraneza et al. 2012, Gwaleba and Masum 2018).

II.3.5. Lack of Affordable Housing Options

Formal housing in urban areas often comes with a high price tag, making it inaccessible to low-income earners. Factors such as rising land prices, construction costs, and property taxes contribute to the unaffordability of formal housing options. As a result, many individuals and families are unable to secure adequate housing within the formal sector, leading them to seek shelter in informal settlements.

The lack of affordable housing options forces marginalized populations to seek alternative housing solutions in informal settlements. High costs of formal housing, limited availability of social housing, housing discrimination, and inadequate government intervention contribute to the affordability gap, driving individuals and families towards informal settlement development. Addressing the affordable housing crisis requires comprehensive policies that prioritize equitable access to housing and promote inclusive urban development strategies. Formal housing often comes at high costs, leaving low-income populations with no viable alternatives but to settle in informal settlements (El Menshawy and Shafik 2016, Nzau and Trillo 2020).

II.3.6. Lack of Basic Services and Infrastructure

Informal settlements often lack access to essential infrastructure and services, including clean water, sanitation, electricity, healthcare, and education. Municipal governments may struggle to provide these services due to financial constraints, logistical challenges, or political marginalization of informal settlements. As a result, residents' resort to self-help strategies, such as informal connections to utilities or makeshift solutions, further perpetuating substandard living

conditions. The inadequate provision of these essential services contributes to the growth and persistence of informal settlements (GISTech 2015, Aerni 2016).

II.3.7. Lack of Access to Education and Employment Opportunities

Limited access to quality education and employment opportunities can lead to the concentration of poverty and informal settlements. the lack of access to education and employment opportunities exacerbates poverty, economic insecurity, and socio-economic inequalities, driving marginalized populations towards informal settlements in search of affordable housing and livelihood opportunities. Addressing the root causes of informal settlement development requires comprehensive strategies that prioritize equitable access to education, skills development, and formal employment opportunities, alongside efforts to improve housing affordability and promote inclusive urban development (Ghasempour 2015, Lerch and Buckner 2018).

II.4. Strategies of informal Settlement upgrading

Several strategies are being employed in informal settlement upgrading to raise the standard of living in the upgraded area. These strategies include Land tenure regularization, provision of basic infrastructures, housing improvement, community participation and empowerment, economic development initiative, environmental sustainability, integration into formal urban planning, partnership and corroboration, and incremental approach.

II.4.1. Land Tenure Regularization

Land tenure rights to residents is an important step towards fostering sustainable development within informal settlements. Whether achieved through formalizing land ownership or establishing long-term lease arrangements, this measure serves as a catalyst for stimulating investment in housing and infrastructure. By providing residents with a sense of security and ownership over their land, they are motivated to invest in improving their dwellings and surroundings. Moreover, secure land tenure can unlock access to credit and financial resources, enabling residents to undertake larger-scale development projects and initiatives. Ultimately, this approach not only enhances the physical infrastructure of informal settlements but also strengthens social cohesion and economic resilience within these communities (Bizimana, Mugiraneza et al. 2012, Smit 2017, Hafsi and Chabi 2019).

II.4.2. Basic Infrastructure Provision

The provision of basic infrastructure stands as a fundamental strategy in the upgrading of informal settlements, essential for enhancing living standards and promoting sustainable urban development. By addressing critical needs such as water supply, sanitation facilities, electricity, and waste management systems, this strategy lays the groundwork for improved public health, safety, and overall well-being within these communities. Access to clean water and sanitation facilities mitigates the spread of diseases and improves hygiene practices, while reliable electricity supports livelihoods and enables access to education and communication technologies. Furthermore, effective waste management reduces environmental pollution and enhances the aesthetic appeal of the settlement. Investing in basic infrastructure not only addresses immediate challenges but also paves the way for long-term resilience and inclusivity within informal settlements, ensuring that residents have the necessary foundation to thrive and contribute to the broader urban landscape (Brown-Luthango, Reyes et al. 2017, Ahmed S, Anwar F et al. 2019).

II.4.3. Housing Improvement

Renovating or replacing substandard housing structures with more durable and safer housing options represents an important aspect of informal settlement upgrading initiatives. This approach not only addresses immediate housing deficiencies but also lays the foundation for long-term resilience and stability within communities. Importantly, these efforts frequently entail active involvement from community members in the design and construction processes, empowering them to shape the development of their own living spaces (El Menshawy and Shafik 2016, Hegazy 2016).

II.4.4. Community Participation and Empowerment

Participatory planning processes serve as a cornerstone of informal settlement upgrading efforts, facilitating meaningful engagement with residents to shape the direction of interventions and ensure their long-term viability. By involving community members in decision-making, these processes not only prioritize interventions based on local needs and aspirations but also foster a sense of ownership and responsibility for the development and maintenance of infrastructure and

services. This collaborative approach not only strengthens the social fabric of communities but also enhances the effectiveness and sustainability of upgrading initiatives (Fuentes 2019, Nikuze, Sliuzas et al. 2020, Gonzalez Sanchez 2022).

II.4.5. Integration of Formal Urban Planning

Integrating informal settlements into the broader urban planning framework is a multifaceted effort for inclusive and sustainable urban development. This integration often entails formalizing informal settlements through regularization processes, providing affordable housing options, and facilitating the transition of informal economies into the formal sector. By acknowledging the presence and contributions of these settlements, cities can address housing shortages, enhance access to essential services, and promote economic inclusion. Furthermore, such integration fosters social cohesion and empowers residents, laying the groundwork for more equitable and resilient urban landscapes (Jones 2017, Torabi Moghadam, Lombardi et al. 2024).

II.4.6. Partnerships and Collaboration

Partnership and collaboration are key strategies of managing informal settlements, which come in to combine resources, skills, and support from a wide array of stakeholders. Collaboration with government agencies, NGOs, community-based organizations, and other appropriate bodies enhance skills and resources to tackle the intensive and complex challenges of informal settlement management. These partnerships create knowledge-sharing opportunities, promote best practices, and innovative solutions, thus improving the impact and sustainability of upgrading efforts. Moreover, it promotes and harnesses such partnerships with the active engagement of a wide range of stakeholders both at the community and national levels to train the values of inclusivity, ownership, and collective responsibility toward the laying of firm bases and the adoption of more holistic and participatory approaches in urban development (Mgele 2014, Fieuw and Mwau 2016, Fuentes 2019).

II.4.7. Incremental Approaches

Informal settlement upgrading is inherently a gradual journey, characterized by incremental improvements implemented over time. This approach recognizes the constraints of available

resources and the evolving needs of communities, emphasizing flexibility and adaptability in the upgrading process. By taking small, manageable steps and prioritizing interventions based on the immediate needs and resources at hand, informal settlement upgrading initiatives can make tangible progress while remaining responsive to changing circumstances (Swilling, Tavener-Smith et al. 2013, Maina 2016).

II.5. Actors of informal settlement upgrading

Informal settlement upgrading involves various actors working together to improve living conditions and infrastructure in informal settlements. These actors include governments, non-governmental organizations (NGOs), community-based organizations (CBOs), international agencies, private sector entities, and residents themselves. Each actor plays a unique role in the upgrading process, contributing resources, expertise, and support to achieve sustainable and inclusive development in informal settlements.

II.5.1. Government Institutions

Government agencies at the local, regional, and national levels are key actors in informal settlement upgrading. They provide policy direction, regulatory frameworks, and financial support for upgrading initiatives. Government agencies are responsible for land tenure regularization, infrastructure development, service provision, and ensuring compliance with building codes and standards. They also coordinate with other stakeholders and oversee the implementation of upgrading projects (UN-Habitat 2010, Wainaina, Truffer et al. 2022).

II.5.2. Community-Based Organizations (CBOs)

Community-based organizations (CBOs) play a crucial role in the upgrading of informal settlements. These resident-formed groups work directly with the community to identify needs, mobilize resources, and ensure active participation in decision-making processes. By fostering a sense of ownership and responsibility, CBOs empower residents to contribute to and sustain improvements. They serve as vital advocates for the rights and interests of informal settlement dwellers, ensuring that their voices are heard in discussions with authorities and stakeholders. Additionally, CBOs help bridge gaps between the community and external entities, facilitating access to funding, technical assistance, and other resources essential for successful upgrading projects. Through their grassroots efforts, CBOs enhance the effectiveness, sustainability, and

inclusivity of informal settlement improvements. (M'ithai 2012, Makinde and Ilesanmi 2012, Nassar and Elsayed 2018).

II.5.3. Non-Governmental Organizations (NGOs)

NGOs play an important role in informal settlement upgrading by providing technical assistance, capacity-building support, and community mobilization efforts. NGOs often work closely with communities to identify needs, priorities, and solutions for upgrading interventions. They facilitate participatory planning processes, advocate for pro-poor policies, and implement pilot projects to demonstrate innovative approaches to upgrading. NGOs also collaborate with government agencies, donors, and other stakeholders to leverage resources and expertise for sustainable development in informal settlements. They work in partnership with government agencies, community organizations, and other stakeholders to ensure the success of upgrading projects. NGOs also play a role in advocating for policy changes and promoting the rights of informal settlement residents (Makinde and Ilesanmi 2012, Aira 2016).

II.5.4. International Development Agencies

International development agencies, such as UN-Habitat, the World Bank, and various bilateral aid agencies, play an important role in upgrading informal settlements by providing financial support, technical expertise, and policy guidance. These agencies often collaborate with governments, NGOs, and community organizations to promote sustainable and inclusive urban development. Their involvement ensures that projects are well-funded, scientifically sound, and strategically planned. By leveraging their global experience and resources, these agencies help design and implement effective solutions that address the unique challenges of informal settlements. Their efforts contribute to improved living conditions, enhanced infrastructure, and better access to essential services for marginalized communities, fostering long-term socio-economic development and environmental sustainability. (Abbott 2002, Ehebrecht 2014, Smit 2016).

II.5.5. Academic and Research Institutions

Academic and research institutions play a critical role in informal settlement upgrading by generating knowledge, conducting research, and providing evidence-based recommendations. Their expertise extents urban planning, architecture, environmental sustainability, and social development, contributing to the development of holistic and sustainable solutions. These

institutions collaborate with government agencies, NGOs, and communities to design and implement effective upgrading strategies. By leveraging their research capabilities, they identify best practices, assess the impact of interventions, and develop innovative approaches tailored to the specific needs of informal settlements. Additionally, academic institutions provide training and capacity-building programs for local stakeholders, ensuring the successful execution and long-term sustainability of upgrading projects. Through these efforts, they help bridge the gap between theory and practice, ultimately enhancing the quality of life for residents in informal settlements. (Makinde and Ilesanmi 2012, Van Breda and Swilling 2019).

II.5.6. Residents

Local communities play an important role in the success and sustainability of informal settlement upgrading initiatives. They actively participate in decision-making, contribute local knowledge, labor, and resources, and hold stakeholders accountable to ensure that interventions meet their needs. Their involvement enhances social inclusion, strengthens community resilience, and promotes sustainable development. By engaging in needs assessments, participatory planning, knowledge sharing, and maintenance, communities ensure that upgrading efforts are contextually relevant and impactful. Empowering residents not only improves their living conditions but also fosters social cohesion and long-term sustainability (Chitekwe-Biti, Mudimu et al. 2012, Makinde and Ilesanmi 2012, , M'ithai 2012, Hegazy 2016, Smit 2017, Parikh, Bisaga et al. 2020).

II.6. Social and Economic outcomes of informal settlements upgrading

Beside environmental benefits Informal settlement upgrading provide as benefit, it contributes much to social and economic development for improving lifestyle of the community. Here are some socio-economic benefits of the informal settlements upgrading:

II.6.1. Infrastructures development

In the spatial planning of settlement upgrading, the integration of transport networks, health services, clean water availability, electric power, schools, and markets is essential. By strategically incorporating these elements, the upgraded settlement ensures that local residents, whether they are pedestrians, cyclists, motor vehicle users, or car owners, have easy access to these critical services. This proximity is achieved by establishing decentralized growth nodes, which are hubs of infrastructure and social services. These nodes not only enhance convenience for the residents

but also promote sustainable urban development by reducing the need for long commutes. Consequently, the improved access to comprehensive amenities such as healthcare, education, and reliable utilities fosters a higher quality of life and supports the overall well-being of the community (Te Lintelo, Gupte et al. 2018, Ahmed S, Anwar F et al. 2019).

II.6.2. Improvement of hygiene and sanitation

Settlement sanitation is a critical factor in promoting people's health, productivity, and well-being, especially in urban areas. Effective sanitation systems prevent the spread of diseases, reduce healthcare costs, and enhance overall quality of life. Health and human development are closely linked to environmental protection and better management of human settlements. Proper sanitation contributes to a cleaner environment, which in turn supports healthier communities. Additionally, by preventing contamination of water sources and reducing waste accumulation, sanitation systems play an important role in sustaining natural resources and mitigating environmental degradation. To support both rural and urban development, investing in settlement sanitation is essential for ensuring good health, enhancing productivity, and improving the efficiency of people's well-being. Sanitation infrastructure is also foster economic growth by creating a more livable and sustainable environment (Winchester 2005, Amoah, Kumari et al. 2020).

II.6.3. Land value addition and economic development

A significant benefit of settlement upgrading is the comprehensive enhancement of infrastructure and facilities, which greatly contributes to the well-being of residents. When settlements underwent upgrades, new infrastructures were built and essential amenities installed, improving the quality of life for the community. This process not only boosted the overall living standards but also added value to the land. During the infrastructure installation, land acquisition becomes necessary, leading to expropriation and the purchasing of land where new facilities will be constructed. This acquisition process benefits landowners by providing them with fair compensation, as professional valuers ensure that land prices are accurately assessed. Consequently, the upgrading of settlements brings substantial economic benefits to the local community while enhancing the overall urban environment (Ehebrecht 2014, Magina, Kyessi et al. 2020).

II.6.4. Livelihood Opportunities and Economic Development

Upgrading projects often focus on creating or enhancing livelihood opportunities for residents of informal settlements. This can involve providing skills training, supporting small businesses, and developing local economic initiatives. By equipping residents with the skills and resources they need to pursue sustainable livelihoods within or near their settlements, these projects help reduce commuting distances and the associated environmental impacts. The reduction in travel lowers carbon emissions and pollution but also improves the quality of life for residents by giving them more time and energy to invest in their communities. Additionally, fostering local economic growth can lead to increased economic stability and self-sufficiency, further enhancing the overall resilience and sustainability of the settlement. (El Menshawy, Aly et al. 2011, UN-Habitat 2013).

II.6.5. Increased Security and Safety

Upgrading infrastructure, such as lighting, pathways, and housing, significantly enhances safety and security within informal settlements. Improved street lighting deters criminal activities by increasing visibility at night, making residents feel safer when walking in their neighborhoods. Well-designed pathways not only facilitate easier and safer movement but also reduce the risk of accidents, especially in poorly lit or hazardous areas. Upgraded housing structures provide more secure living conditions, protecting residents from both natural elements and potential intrusions. These improvements collectively contribute to a reduction in crime rates and foster a heightened sense of security among the community. By creating a safer environment, these upgrades improve the quality of life for residents but also encourage community cohesion and stability, leading to more resilient and flourishing informal settlements. (Mutahi 2011, Satterthwaite 2012, Brown-Luthango, Reyes et al. 2017).

II.6.6. Increase of the economy of the settlement dwellers

Accessibility to transportation means significantly enhances economic development by improving connectivity. This connectivity allows people to access jobs and services more efficiently, enabling employers to reach broader labor markets and businesses to connect with their customers more effectively. The improved transport network fosters the initiation and growth of commercial activities along the roadways, boosting local economies. As businesses flourish due to increased customer access, the overall economic landscape of the area is transformed, leading to sustained

economic growth and development. This enhanced transportation infrastructure supports individual livelihoods but also stimulates broader economic progress and community development. (Satterthwaite 2012, Mohamed, Van Nes et al. 2015).

II.7. Environmental sustainability in residential settlement

Globally, more people now live in urban than in rural areas. Urban populations are also expected to continue to grow, so that by 2050 approximately two thirds of the world's population will be urban. With this increase and rapid urbanization, cities frequently face challenges with housing, water, sanitation, electricity, crime, pollution, and transportation. Space-based technologies have to be applied to provide unique tools for planning socially and environmentally sustainable human settlements (Williams, Máñez Costa et al. 2019).

Environmental sustainability in residential settlements refers to the practices, policies, and designs implemented to minimize negative environmental impacts while promoting the well-being of residents and ecosystems. Achieving environmental sustainability in residential areas involves addressing various aspects, including energy consumption, water usage, waste management, transportation, green spaces, and building materials (Williams, Máñez Costa et al. 2019, de Duren, Rivas et al. 2021).

Central government policymakers, mayors, city planners, engineers, landscape architects, urban and environmental planners should use their planning skills including remote sensing and GIS tools to measure and monitor existing patterns of land use with infrastructure development. This helps in decision making so that the current urban building projects considers the environmental benefits through infrastructure development and complex models' construction to hold large number of people on small land. Thus, reserving the remained land for environmental benefits. Informal settlements upgrading makes areas clean by enhancing the attractiveness of city centers and the health of the citizens and it reduces greenhouses gases emissions. A good, planned settlement has huge impacts on the quality of the urban realm, mostly significantly by reducing waste of space (UN-Habitat 2018, Citaristi 2022).

II.7.1. Social Cohesion and Environmental Stewardship

Informal settlement upgrading can significantly foster social cohesion and a sense of community responsibility. When residents actively participate in the upgrading process, they develop a stronger sense of collective ownership and accountability for their surroundings. This increased engagement often translates into community-led initiatives focused on environmental stewardship. For instance, residents may organize waste recycling programs, tree planting campaigns, and awareness drives promoting sustainable practices. Such initiatives not only improve the immediate environment but also build a more resilient and united community. By taking collective action, residents can address local issues more effectively and create a healthier, more sustainable living space for everyone. (Brown-Luthango, Reyes et al. 2017, Gibson, Movono et al. 2021).

II.7.2. Reduction of air pollution

As transport sector contributes to air pollution, through shortcuts roads that are made in informal settlement upgrading, the travel distances are minimized thus reduced emission of carbon dioxide in atmosphere. Again, as informal settlements suffer from insufficient social services like provision of electricity power, there is high chance of using firewood and charcoals as fuel thus fumes. This largely hinders the atmosphere directly and indirectly as they produce smokes. So, through settlement upgrading other means of power and fuel provision that are friendly to environment are provided like electricity power, cooking gas and others, hence reduction of air pollution (Parikh, Bisaga et al. 2020, West, Bowyer et al. 2021).

II.7.3. Green and Open Spaces

Upgrading projects frequently prioritize the creation and enhancement of green and open spaces within informal settlements. These spaces offer residents opportunities for recreation, social interaction, and improved mental well-being, fostering a sense of community and belonging. Moreover, they contribute significantly to environmental sustainability. Green spaces help mitigate the urban heat island effect, reducing local temperatures and energy consumption. They improve air quality by filtering pollutants and increasing oxygen levels. Furthermore, these areas preserve biodiversity by providing habitats for various plant and animal species, thereby maintaining ecological balance within urban environments. Overall, integrating green and open spaces into upgrading projects enhances the quality of life for residents but also promotes long-

term environmental health and resilience. (UN-Habitat 2010, Adegun 2017, Matamanda, Mafuku et al. 2020).

II.7.4. Conservation of Natural Resources

Informal settlement upgrading initiatives often prioritize the promotion of sustainable resource management practices as a means to improve the living conditions and resilience of communities. These initiatives encompass a range of strategies aimed at reducing reliance on finite resources and promoting environmental conservation. For instance, rainwater harvesting systems can be implemented to capture and store rainwater for domestic use, alleviating pressure on existing water supplies and mitigating the risk of water scarcity. Additionally, the adoption of renewable energy solutions, such as solar panels or biogas digesters, can provide residents with access to clean and affordable energy sources, reducing dependency on fossil fuels and mitigating environmental pollution. Furthermore, community gardening initiatives empower residents to cultivate their own food locally, promoting food security, nutrition, and community cohesion while reducing the carbon footprint associated with food production and transportation. (Güneralp, Lwasa et al. 2017, Matamanda, Mafuku et al. 2020).

II.7.5. Improved waste management system

Informal settlement upgrading plays a key role in establishing sustainable waste management systems. By formalizing waste collection and disposal processes, these upgrading projects significantly reduce environmental pollution and health hazards. Upgraded settlements often implement structured waste segregation at the source, encouraging residents to separate recyclables, organic waste, and non-recyclables. This not only facilitates more efficient recycling and composting efforts but also reduces the burden on landfills. Community education and engagement are key components, empowering residents with knowledge and practices that promote responsible waste management. Infrastructure improvements, such as the provision of waste bins, designated disposal sites, and regular collection services, ensure that waste is managed effectively. Additionally, upgrading projects often incorporate innovative solutions like composting facilities and waste-to-energy plants, further enhancing sustainability. Overall, these efforts lead to cleaner, healthier living environments and contribute to broader environmental goals by reducing waste-related carbon emissions and conserving natural resources (El Menshawy, Aly et al. 2011).

II.8. Environmental sustainability in upgraded Favelas of Rio de Janeiro

II.8.1. Overview of upgrading Favelas of Rio de Janeiro

The best practice of informal settlement upgrading in Brazil had an overview of myriad challenges facing informal settlement dwellers. Among these challenges include environmental degradation, waste accumulation and lack of green spaces exacerbating existing issues. In 1195 Favela-Bairro project appeared in the city of Rio de Janeiro, which was the best solution as it aimed at developing the informal areas. However, upgrading infrastructure is not the only activity directed towards environmental sustainability with the Favela-Bairro project (Ahmed S, Anwar F et al. 2019).

A high-tech waste management system was the highlight of the campaign. Community residents were bidden to take part in the recycling campaign to turn trash into cash. The recycling stations were evenly located within the favelas. The community was encouraged to recycle and fess up in their tasks to the betterment of the environment and be rewarded for their action through selling of the recyclables (Riley, Fiori et al. 2001, de Duren, Rivas et al. 2021).

It also took the highest priority in the creation of green spaces in the midst of that concrete jungle. Vacant lots and rooftops were turned into green community gardens and parks, allowing the inhabitants to take some respite from the daily grind of the city. This added aesthetic value enhanced not only the aesthetic value of the favelas but also acted as the lung of the city key in the improvement of air quality and biodiversity (Riley, Fiori et al. 2001, de Duren, Rivas et al. 2021).

There was great emphasis placed on the ownership and stewardship of these environmental initiatives within the community through the Favela-Bairro project. Planning, maintenance, and management of green spaces and waste recycling programs were carried out by residents. Workshops and grassroot campaigns have given a culture of environmental awareness and consciousness to the favelas, creating pride and responsibility for their surroundings (Riley, Fiori et al. 2001, de Duren, Rivas et al. 2021).

II.8.2. Approach used for Upgrading Favelas of Rio de Janeiro

During the upgrading of Rio de Janeiro, the Melendez pyramid strategy for slum improvement was adopted. This approach aims to meet all human needs through gradual, integrated, and multidisciplinary interventions. The pyramid emphasizes close cooperation among various stakeholders, with a special focus on fostering community participation at all stages. Successful

upgrading of urban precarious areas requires regularization tools, strong political will, good governance, and adequate credit. Additionally, to ensure transparency, a robust intermediary structure should be established to serve as a conduit between communities and authorities (Fuentes 2019). The formulation of the Melendez's pyramid on slum upgrading is therefore an association of the potential, the ideal, and the rational, regarding slum upgrading. It has ten blocks as shown on the figure 2 and some of them explained below:

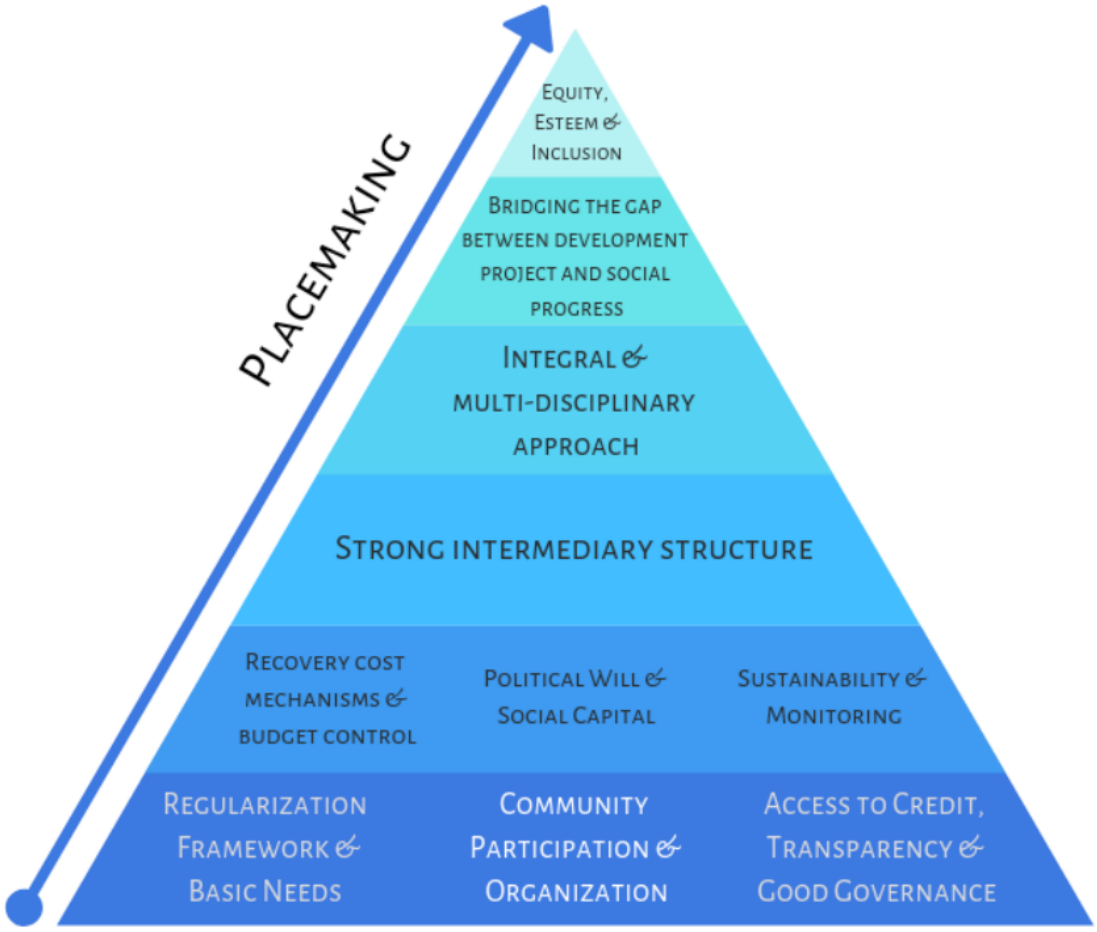

Figure 2.Meléndez Pyramid on Slum Upgrading (Fuentes 2019)

II.8.2.1. Regularization framework and coverage of basic needs

Regularizing human settlements by incorporating them into city limits and providing essential services and infrastructure benefits informal dwellers by legalizing land tenure and granting access to political participation. Without legal support, slum upgrading cannot be securely institutionalized, leaving squatters vulnerable to eviction. Regularized slums gain access to basic

city services, such as water, sanitation, electricity, and waste management, which improve living conditions and promote investment in infrastructure. This process also enhances tax recovery, integrates informal activities into the formal economy, and increases security and stability. Ultimately, regularization and service provision make slum upgrading more compatible with urban economic interests and strengthen the legal protections for communities (Fuentes 2018, Fuentes 2019).

II.8.2.2. Community Participation and Organization

When community members participate in upgrading projects, they gain ownership over their own development. Dwellers should be involved at all stages according to their needs and skills, with funders and planners acting as advisors. This self-help approach fosters equitable interactions and combats paternalistic attitudes. Participatory budgeting, where funds allocation follows grassroots decisions, empowers communities politically and ensures their voices are heard. Community participation also improves needs assessment, optimizes public spending, reduces costs, and revitalizes the local economy. It aligns projects with local culture and traditions, enhancing sustainability and community integration. Despite the challenges of coordinating participation, effective representative systems and inclusive methods are essential. Engaging residents is crucial for creating a sense of ownership and achieving successful slum upgrading, as these efforts must be informed and driven by the residents themselves (Murray and Clapham 2015, Fuentes 2018, Fuentes 2019).

II.8.2.3. Sustainability and Monitoring

Despite significant progress in slum upgrading globally, sustainability remains a key challenge, often leading to decay of improvements over time. For programs to be sustainable, they must result in lasting benefits and spark long-term development. This involves considering five dimensions: preserving physical benefits, training communities for durable social development, fostering local economic growth towards self-sufficiency, enhancing budgets, and ensuring environmental compatibility. Effective programs require community agreement on priorities, training in maintenance, and focusing on initiatives that communities can sustain. Social development should transform communities into catalysts for progress, through education and building support networks. Economic sustainability involves ensuring residents can access market opportunities,

investing program funds wisely, and empowering people through professional development. Financial sustainability requires affordable upgrading options and planning for future maintenance costs, with community involvement reducing costs and raising awareness. Environmental sustainability includes reforestation, waste management, and addressing erosion risks, enhancing both the local environment and overall city attractiveness. Ultimately, sustainability is the most accurate measure of a slum upgrading program's success, driving urban growth, investment, job creation, and improved quality of life (Murray and Clapham 2015, Fuentes 2019).

II.8.2.4. Equity, Self-Esteem and Inclusion

Effective slum upgrading must go beyond merely providing infrastructure; it must also address the emotional and social needs of residents to achieve sustainable development. This comprehensive approach, as illustrated by Melendez's pyramid strategy, emphasizes equity, self-esteem, and inclusion. Current practices often neglect these emotional elements, focusing instead on quantitative measures that perpetuate segregation. To truly transform slum areas, upgrading initiatives should incorporate culture, education, and public transportation, enhancing residents' quality of life and fostering community pride. Public spaces, such as squares and community centers, promote unbiased social interactions and reduce stigma, while quality education empowers future generations. Additionally, connecting slum areas to formal cities through public transportation improves access to opportunities and services, further integrating these communities. By prioritizing these elements, slum upgrading can effectively address the root causes of urban poverty and provide a lasting solution (Murray and Clapham 2015, Fuentes 2019).

The informal settlement upgrading in Rio de Janeiro has underscored the critical importance of integrating environmental sustainability into urban development projects. A key lesson learned is that addressing environmental issues such as proper waste management, effective water drainage, and the preservation of green spaces not only enhances the living conditions for residents but also promotes long-term ecological balance. The initiative demonstrated that sustainable practices, like eco-friendly construction and the inclusion of community green spaces, significantly mitigate environmental degradation and improve overall urban health. Furthermore, fostering community participation in these sustainability efforts has proven essential for maintaining these improvements, as it cultivates a sense of ownership and responsibility among residents. This

holistic approach ensures that urban upgrades are resilient and beneficial for both people and the environment (Murray and Clapham 2015, Fuentes 2019).

II.9. Policies and Legal Framework of informal settlement management in Rwanda

Addressing the effects of informal settlements requires comprehensive and integrated approaches that prioritize the rights and well-being of residents. This includes policies and interventions aimed at improving access to basic services, formalizing land tenure, promoting economic opportunities, enhancing social cohesion, and empowering residents to participate in decision-making processes. By addressing the root causes of informal settlements and investing in sustainable urban development, societies can work towards creating more inclusive, equitable, and resilient cities for all residents. Here are some commonly employed policies and strategies for managing informal settlements:

II.9.1. Upgrading and regularization programs

These programs aim to improve the living conditions in informal settlements by providing basic infrastructure such as water supply, sanitation, electricity, and paved roads. They also involve the regularization of land tenure, which grants legal recognition and security of land rights to the residents. Upgrading and regularization programs help integrate informal settlements into the formal urban fabric and provide a foundation for further development (UN-Habitat 2004).

II.9.2. Affordable housing and rental schemes

Providing access to affordable housing options is crucial for addressing the housing needs of residents in informal settlements. Governments can implement various measures such as subsidized housing programs, microfinance initiatives, and rental schemes to offer secure and affordable housing alternatives. These initiatives prevent the expansion of informal settlements but also significantly enhance the living conditions of current residents. By ensuring that affordable housing is available, governments can promote stability, reduce overcrowding, and support the overall well-being of communities. These efforts are vibrant for fostering sustainable urban

development and ensuring that all citizens have access to safe and dignified living environments. (Bonaiuto, Fornara et al. 2015).

II.9.3. Slum prevention and eviction alternatives

Rather than resorting to forced evictions, which can exacerbate the problems faced by informal settlement residents, it is important to focus on slum prevention strategies. These strategies include measures such as land-use planning, inclusive urban development policies, and targeted poverty reduction programs. When evictions are necessary, alternatives such as resettlement plans, compensation, or providing alternative housing options should be considered to minimize the negative impacts on affected communities (Tanaka 2009).

II.9.4. National Urbanization Policy (2015)

The National Urbanization Policy in Rwanda prioritizes the promotion of sustainable urban development as a cornerstone of its vision for the future. Central to this agenda is the commitment to upgrading and regularizing informal settlements, recognizing them as integral components of the urban landscape. By focusing on the provision of basic services, infrastructure, and social amenities within these settlements, the policy endeavors to improve the quality of life for residents while fostering inclusivity and integration within the broader urban environment. Through targeted interventions and community engagement, the policy seeks to transform informal settlements into vibrant, thriving communities that contribute positively to Rwanda's urban fabric (MININFRA 2015).

II.9.5. Integrated Human Settlements Development Policy (2018)

This policy is dedicated to tackling the challenges of unplanned settlements and urban poverty by promoting comprehensive solutions. It advocates for the provision of affordable housing to ensure that all residents have access to safe and secure living conditions. Additionally, the policy emphasizes the upgrading of informal settlements, transforming them into well-structured and sustainable communities. A key component of this initiative is enhancing access to essential services such as water, sanitation, and electricity, which are fundamental to improving the quality

of life for urban dwellers. By addressing these critical issues, the policy aims to create more equitable and livable urban environments, fostering social and economic development for all residents.

II.9.6. Kigali Master Plan 2050

The Kigali Master Plan is a visionary long-term development strategy for Rwanda's capital city, aimed at transforming it into a modern, inclusive, and sustainable urban center. A key component of the plan is the upgrading of informal settlements, ensuring that their residents are seamlessly integrated into well-planned urban areas. This approach emphasizes the importance of inclusive development, prioritizing the improvement of infrastructure, housing, and access to essential services for all citizens. By focusing on sustainable urban growth, the Kigali Master Plan seeks to enhance the quality of life for residents, reduce inequalities, and create a resilient city that can adapt to future challenges. Through this comprehensive strategy, Kigali aims to set a benchmark for urban development in the region, showcasing a model of progress that balances economic growth with social equity and environmental stewardship (Burns 2021).

II.9.7. Land Tenure Regularization Program

Land tenure regularization in Rwanda is an important element of the country's development strategy, aimed at ensuring secure land ownership and fostering economic stability. This process involved systematically registering land parcels and issuing land titles to individuals and communities, thereby providing legal recognition and protection of land rights. By formalizing land ownership, Rwanda enhances security for landholders, reduces land-related conflicts, and promotes investment in land and property. This initiative is especially crucial for informal settlements, where residents often lack formal land rights. Through land tenure regularization, Rwanda empowers its citizens by granting them legal ownership but also stimulates economic growth by encouraging land development and improving access to credit. The success of this program is a testament to the country's commitment to inclusive development and social equity, ensuring that all Rwandans have a stake in their nation's progress (Fosudo 2014, Ngoga 2019).

II.9.8. Participatory Planning and Community Engagement

Rwanda recognizes the crucial role of community participation in managing informal settlements. By utilizing participatory planning processes, the country engages residents in decision-making, allowing them to prioritize interventions and ensure the sustainability of upgrading initiatives. This inclusive approach empowers communities but also fosters a sense of ownership and responsibility for the development and maintenance of infrastructure and services. As residents actively contribute to the planning and execution of projects, they become invested in their success, leading to more resilient and well-maintained urban environments. This collaborative method strengthens community bonds and enhances the overall effectiveness of informal settlement upgrading efforts (Nikuze, Sliuzas et al. 2020).

II.9.9. National Urban Housing Policy for Rwanda (2008)

The process of upgrading and providing services for urban areas will be conducted with consideration of household income levels and the necessary infrastructure and services to be established. Upgrading does not mean demolishing entire neighborhoods; rather, it involves rational redevelopment to improve residents' living conditions. However, if rebuilding an entire area is necessary, those relocated must be assisted in finding alternative accommodation and facilities. The upgrading process must also consider the income levels of nearby households. Sanitation should be carefully planned and adapted to existing site conditions, including stormwater drainage, and the construction of bulk sanitation systems is recommended where possible. Allotment plans will prioritize integrating existing buildings into single grouped plots to minimize the need for compensation and demolition. Pilot schemes will be developed and tested to determine the best approach, with successful models being replicated while incorporating lessons learned from the pilot projects (MININFRA 2008).

II.9.10. Ministerial Order determining urban planning and building regulations

This order N° 03/CAB.M/019 of 15/04/2019 provide first annex which is Rwanda Urban Planning Code where it provided principles for the sustainable development and management of land used for human settlement. It is binding for all categories of land within urban areas for any development and investment project, public institutional, tourist, public spaces, urban renewal and infrastructure servicing. Urban neighbourhoods should be upgraded to meet agreed service provision standards for residents, provided the area is suitable and free from health hazards such as flooding, weak soil, or slopes steeper than 20%. Such initiatives require adequate primary infrastructure, particularly water distribution, to ensure that upgraded neighbourhood infrastructure functions effectively. If a residential area must be cleared due to any of these hazards, it should not be redeveloped. Additionally, areas needing environmental protection should be cleared of polluting industrial activities and safeguarded from new constructions, while preserving and restoring trees, green spaces, and natural areas. Planning and development must adhere to specific Land Development Plans and applicable urban planning procedures as determined by the relevant authorities (GoR 2019).

Chap III. RESEARCH METHODOLOGY

III.1. Introduction

This chapter presents the research methodology employed to investigate the informal settlement upgrading process through the Agatare Project. The aim of this research is to gain a comprehensive understanding of the strategies, challenges, and outcomes of informal settlement upgrading initiatives, with a specific focus on the Agatare Project. Through employing a systematic and rigorous approach, this research seeks to contribute to the existing knowledge base on effective methods for improving the living conditions of informal settlement residents. By utilizing a mixed-methods approach and employing various data collection and analysis techniques.

This study drew upon two distinct types of data sources to provide a comprehensive analysis. The primary data source obtained through a multifaceted approach that includes direct Observation, guided interviews, and household surveys. These methods allowed gathering a wealth of both qualitative and quantitative data directly from the field. This diverse set of primary data served as a foundational pillar in research, enabling to gain deep insights into the subject matter. In conjunction with primary data, Geospatial analysis and literature utilized to enrich understanding and ensure a well-rounded analysis. The data collection focused on assessing residents' living conditions in the upgraded area, the significance of the developed infrastructures for the community, the environmental benefits accrued, and the challenges experienced following the Agatare project's implementation if any.

III.2. Research design

The research design is thoughtfully structured, employing a mixed-methods approach that combines qualitative and quantitative methods. This approach facilitates a deeper examination of the intricate dynamics involved in informal settlement upgrading. By integrating both data types, the study sought to provide a comprehensive understanding of the process, going beyond mere descriptions to uncover the underlying reasons and mechanisms.

This comprehensive approach enhances the study's ability to inform more effective policy recommendations and interventions in the realm of informal settlement upgrading.

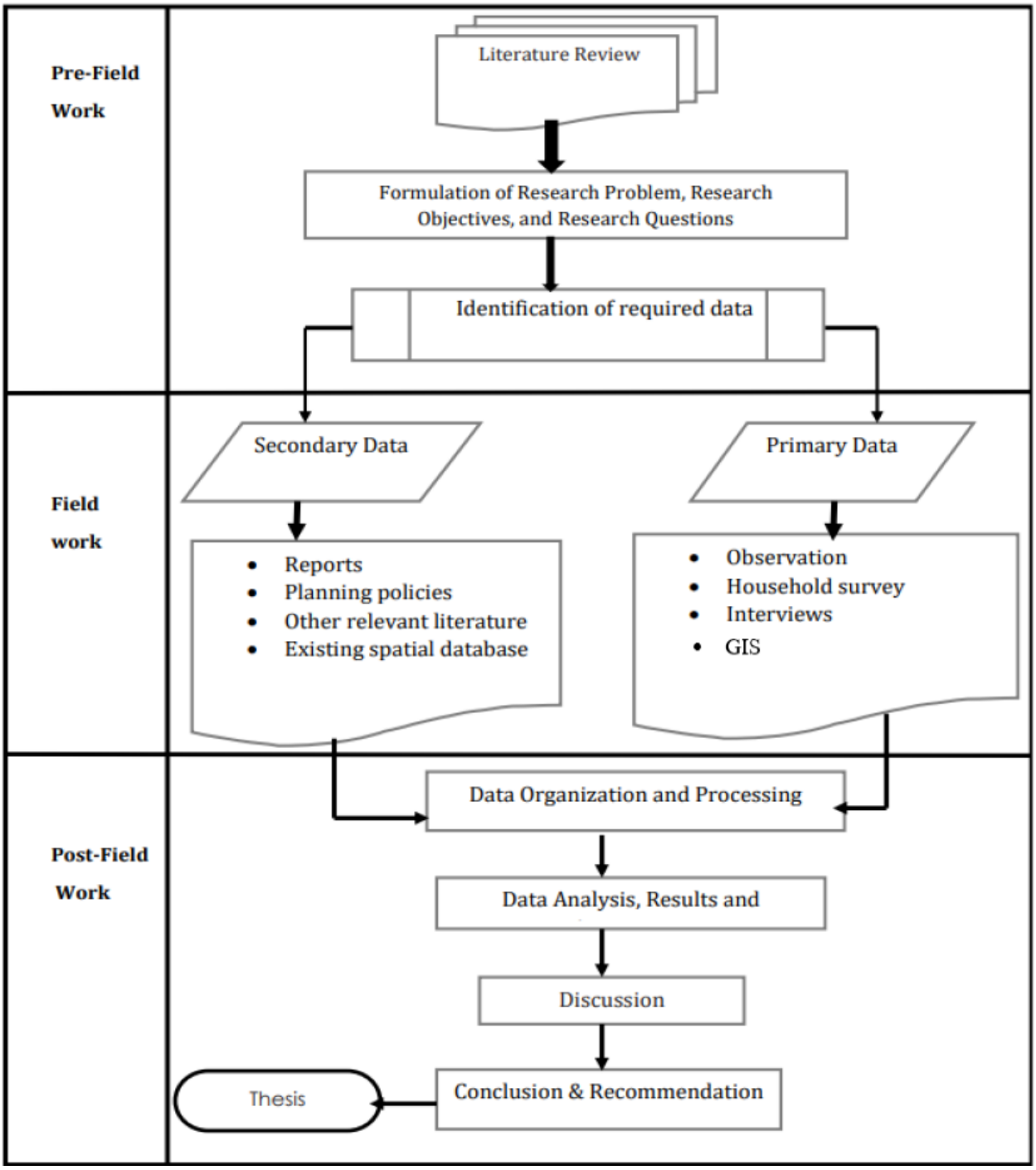

Figure 3. Research Design

III.3. Study area description

Agatare cell is in the Nyarugenge sector and bordered by Kiyovu cell in the East, Biryogo in the North, Rwampara cell of Nyamirambo sector in the West, Bwerankori and Rwampara cells of Gikondo sector in the South. Agatare cell is further divided into seven villages, which are Umucyo, Umurava, Meraneza, Agatare, Uburezi, Amajyambere, and Inyambo. It is an urban cell, which was mostly characterized by an informal settlement.

The project of upgrading informal settlements in this area covered Agatare and Rwampara cells and the southern portions of the Kiyovu and Biryogo cells (MININFRA 2016). The land use in the Agatare cell is dominated by settlement in most of its villages from the central to northern parts of the whole matrix. Thus, a large area of Agatare cell is dominated by residential use in Umucyo, Umurava, Meraneza, Agatare, Uburezi, and Amajyambere villages. Inyambo village in the South part of the cell is mostly for agricultural activity due to the nature of its land dominated by wetland. The topography of the Agatare cell encourages the development of informal settlements due to its natural slope. As the land in an urban area is dominated by housing, this becomes similar in the Agatare cell where the big part of the matrix is covered and shielded by settlement.

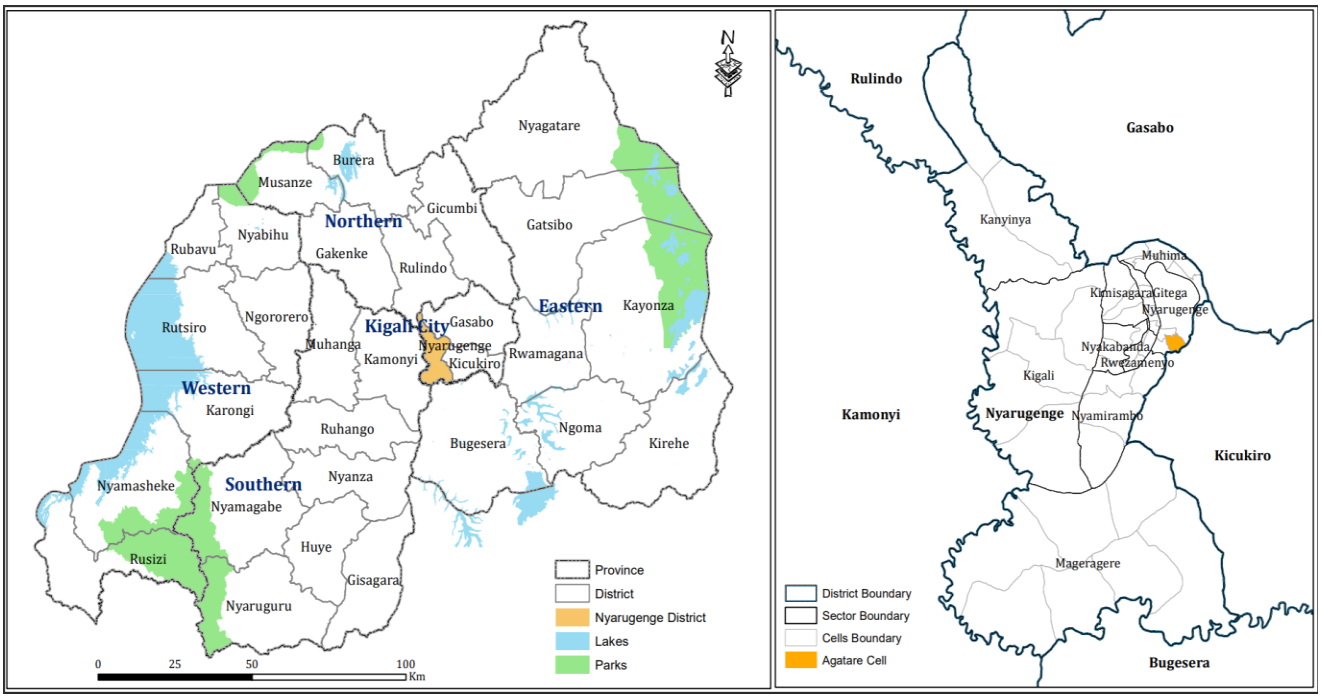

Figure 4. Spatial location of study area (Source: NISR 2012)

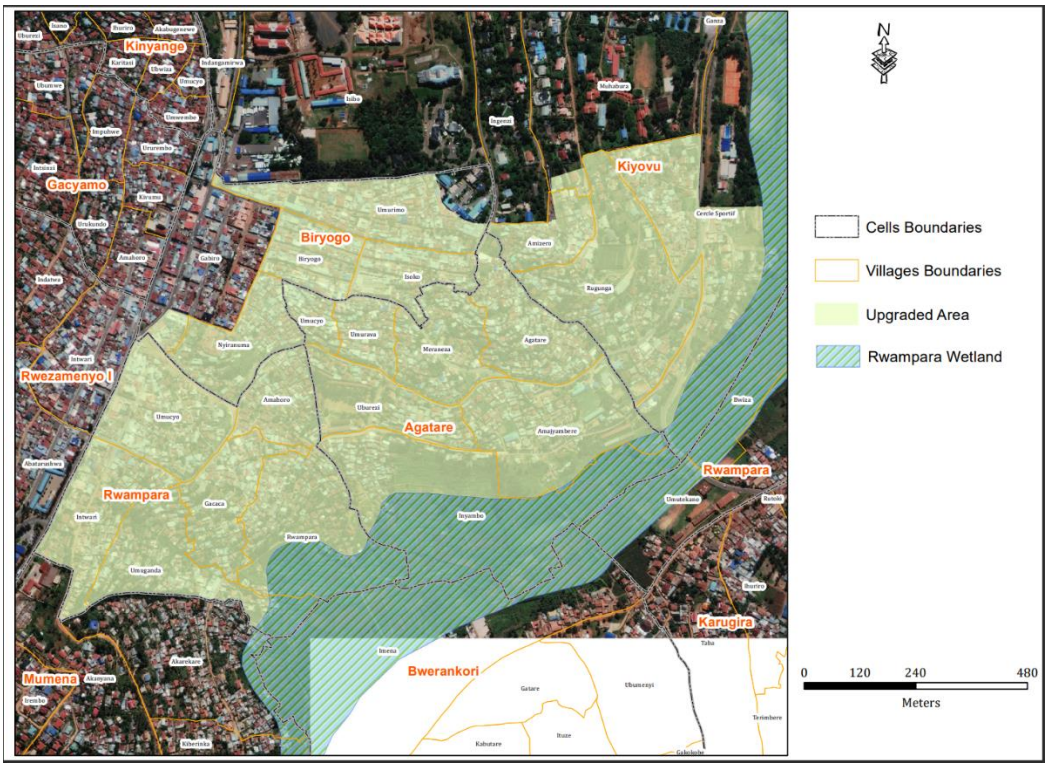

Figure 5. Spatial location of Study area at Cell level (Source: NISR 2012)

III.4. Data Source and Methodology

This section provides a detailed description of the data collection methods employed in this research. Primary data gathered through several techniques, including Interview, Household survey, and observations. Interviews conducted with key stakeholders involved in the Agatare Project, such as community leaders, and government officials. Surveys were administered to a sample of residents from the informal settlements targeted by the project. Additionally, direct observations made to gather valuable insights into the physical changes occurring in the settlements because of the upgrading interventions.

III.4.1. Sampling techniques

This section explains the sampling strategy adopted for the study. A purposive sampling technique was utilized to select participants who possess relevant knowledge and experience related to the Agatare Project and informal settlement upgrading. The sample included household representatives from the targeted informal settlements.

Based on information provided by local leaders of Agatare Cell, Agatare has 1292 households. The formula developed by Javeau (1985) used by Nsengiyumva E (2014) in his study has been used to determine the sample size where in the equation **n** represents the sample size, **N** stands for the total target population within the study area, and $\mathbf{n_o}$ is the computed constant derived from the probabilities of two complementary events, **p** and **q.**

Where $p=q=0.5 \leftrightarrow p+q=1$; $n = \frac{N*no}{N+no}$

The value of $\mathbf{n_o}$ determined by Cochran (1963), where he developed the following equation:

$\mathbf{n_o = (Z^2 * p * q)/e^2}$

Where **Z** is the threshold of confidence which is estimated to be equal to **2** and **e** is the stroke of errors that is estimated to **10%** or **0.1**.

Therefore, $\mathbf{n_0 = (2^2 * 0.5 * 0.5)/0.1^2}$ Then**,** $\mathbf{n_0 = 100}$

By applying the above-mentioned formula using the total population of 1292 households the sample (**n**) will be **n = 1292*100/1292+100** = **92.8**; Means that Sample size is **93** households.

III.4.2. Literature Review

The literature review offered a thorough examination of existing research on this topic, emphasizing key findings, theories, and debates in the field. It explored multiple facets of informal settlements, including their definitions, developmental factors, and strategies for upgrading. The review also discussed the diverse stakeholders involved in the upgrading process and evaluated the outcomes. Furthermore, it covered the essential aspect of environmental sustainability in upgraded settlements, providing insights into different approaches for managing informal settlements and illustrating how environmental considerations can be incorporated into their upgrading.

III.4.3. Household Survey

The household survey served as necessary component of this study, offering valuable insights into the direct beneficiaries of the Agatare upgrading project. During this survey, residents asked to provide information about the tangible impact of the project on their lives, encompassing both social, economic, and environmental dimensions. Additionally, the study sought their perspectives

on how the project has elevated their overall standard of living. This includes an examination of improvements in sanitation and environmental quality, with a focus on the management of solid and liquid waste in comparison to conditions before the project's implementation. Residents also provided insights into their rainwater harvesting practices and articulate how the newly established water drainage systems have positively influenced their local environment. Through this survey, I aimed to gather firsthand accounts that illuminate the transformative effects of the Agatare project on the lives of the community members. As mentioned above, the sample size in this study is 93 households' representative.

The distribution of the sample based on the nature of the Agatare Cell. Observing the landscape of Agatare after the upgrading of its settlement, residents of Agatare settled into blocks due to the established infrastructure including footpaths, roads, and water drainage systems. Agatare now consists of 31 blocks, with Amajyambere Village comprising 4 blocks, meaning 12 respondents were surveyed. Agatare Village, with 8 blocks, was represented by 24 respondents. Meraneza, with 7 blocks, was represented by 21 respondents. Villages such as Umurava, Umucyo, Uburezi, and Inyambo, each with 3 blocks, were represented by 9 respondents from each village.

No	Village	Number of Blocks	Number of Surveyed households
1	Amajyambere	4	12
2	Agatare	8	24
3	Meraneza	7	21
4	Umurava	3	9
5	Umucyo	3	9
6	Uburezi	3	9
7	Inyambo	3	9
Total		**31**	**93**

Table 2. Distribution of Respondents within study area

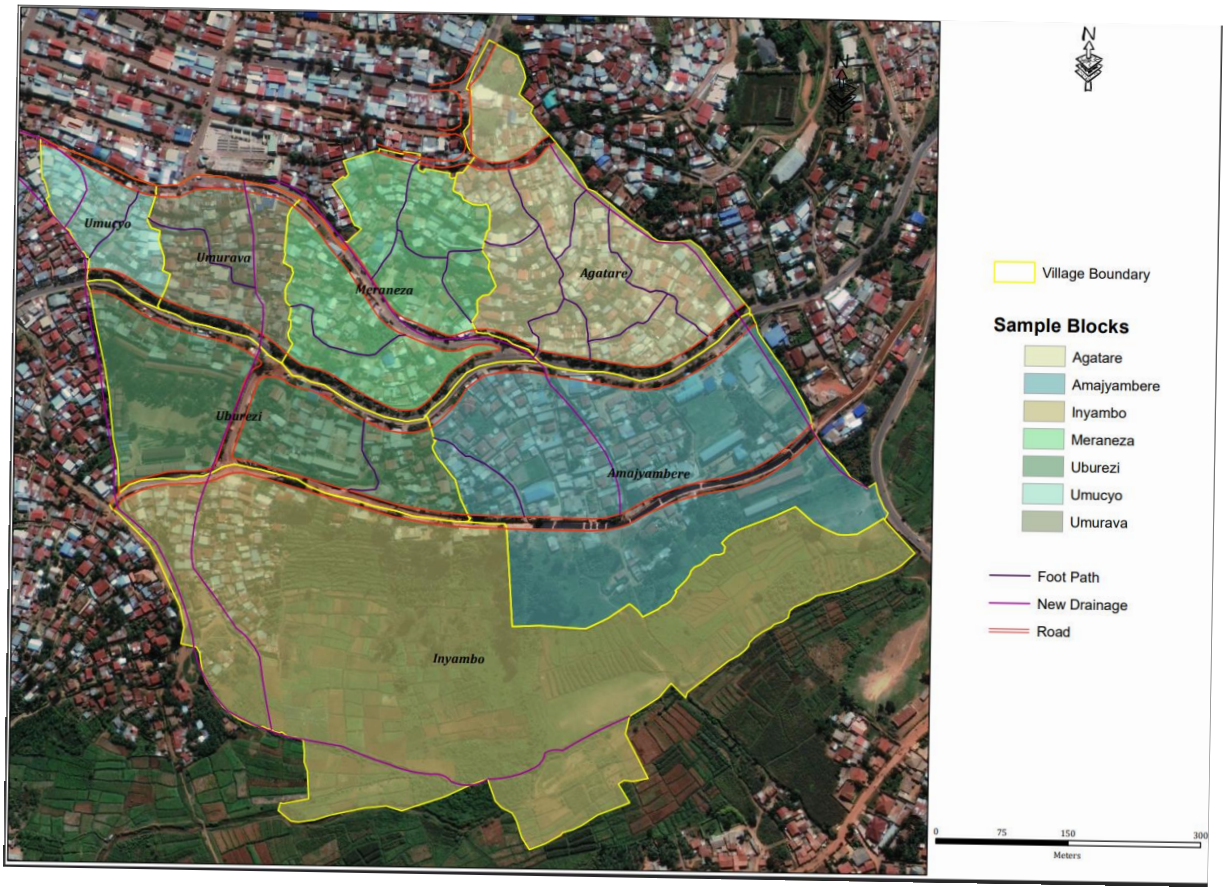

Figure 6. Sample Distribution with study area (Source: NISR 2012 & CoK)

III.4.4. Interview

The interview conducted to local leaders, ranging from the Cell level to the City of Kigali, and Government Officials (Rwanda Housing Authority and Ministry of Infrastructure) who actively participated in the implementation of the Agatare project. The selection of interviewees was based on those who were engaged in the Agatare upgrading project and could provide information from their daily involvement in the activities.

The selected interviewees were expected to provide valuable insights into several key aspects, including the extent of infrastructure improvements achieved in Agatare as a direct result of the project and the environmental challenges encountered during its execution. Additionally, they would share lessons learned from the Agatare project, which can potentially contribute to enhancing environmental quality in future informal settlement upgrading initiatives.

III.4.5. Observation

The observation in this study served as a crucial tool for discerning the status of livelihood within the context of the Agatare informal settlement-upgrading project. Through this observation process, I aimed to identify and document the range of infrastructure improvements facilitating the environmental sustainability that emerged during the project's implementation. These included but were not limited to water drainage systems, rainwater harvesting initiatives, and waste collection systems. I sought to gain valuable insights into the tangible environmental benefits brought about the upgrading efforts in Agatare.

III.4.6. Geo-Spatial Analysis and Mapping

Spatial data analysis through GIS played an important role in this research endeavor, as it enables to harness a wealth data from various institutions, notably the City of Kigali (CoK) and the National Land Authority (NLA). These datasets were instrumental in analyzing the diverse transformation that unfolded in the Agatare area. From the City of Kigali's masterplan data, I aimed to construct comprehensive maps that delineate the environmental infrastructures introduced in Agatare because of the informal settlement upgrading project. This spatial mapping was invaluable in assessing and understanding the substantial changes that have occurred, offering a plain comparison to the pre-existing infrastructure landscape in Agatare.

III.5. Ethical Considerations

This section addresses the ethical considerations involved in the research. To protect participants, stringent measures were implemented to ensure confidentiality and anonymity. Informed consent was obtained from all participants, ensuring they were fully aware of the study's purpose and their rights. Ethical guidelines and protocols were strictly adhered to throughout the data collection and analysis process, safeguarding the integrity of the research and the well-being of the participants. These measures ensured that the research was conducted with the highest ethical standards, respecting the dignity and privacy of all individuals involved.

Chap. IV. RESULTS AND DISCUSSION

IV. 1. Introduction

The study centers on enhancing environmental quality through the upgrading of informal settlements within Agatare Cell, located in the Nyarugenge Sector of Nyarugenge District. The primary objective of this chapter is to understand the findings derived from field data collection, analysis, and interpretation. This was primarily accomplished through the utilization of a questionnaire and field observations, aimed at gauging the perspectives of the local community and assessing the role of governing authorities in improving the environmental quality through that project. It is crucial to gain insights into the current environmental conditions within Agatare Cell and the socioeconomic status of residents in the upgraded area.

IV.2. Informal Settlements upgrading in Agatare

The Agatare project, launched in 2018, was a concerted effort to revitalize informal settlements in the Biryogo, Agatare, Kiyovu, and Rwampara areas, which collectively accommodate more than 83% of the residents in Nyarugenge Sector, Nyarugenge District. This ambitious initiative sought to address longstanding infrastructure deficiencies and enhance the overall living conditions of the residents. Through the development and implementation of various basic infrastructures such as roads, footpaths, electricity, water supply systems, street lights, green spaces, and water drainage systems, the project succeeded in significantly improving both the socio-economic and environmental landscapes of the upgraded areas.

Agatare, as the pioneering upgrading project in Kigali, involved collaboration among diverse stakeholders, including the local community, the City of Kigali (CoK), the Rwanda Housing Authority (RHA), and international organizations like the World Bank (WB). This collaborative approach facilitated the mobilization of technical expertise and financial resources essential for the successful implementation of the project, setting a precedent for future urban renewal endeavors in the region.

IV.3. Outcomes of Agatare Informal Settlement Upgrading

IV.3.1. Environmental Aspects

Informal settlements often developed in environmentally fragile areas, such as floodplains or steep hillsides, where formal housing is impractical or prohibited. The lack of proper waste management infrastructure and sanitation facilities leads to environmental pollution, including contamination of water sources and soil. Moreover, deforestation and land degradation may occur as residents clear land for housing and firewood. Unplanned urbanization and inadequate waste management systems lead to environmental degradation, including pollution, deforestation, and soil erosion (Patel, Lotia et al. 2021). In this section, the study focusing on looking the improvement of different aspect of environmental sustainability that should be looked at during the implementation of Agatare informal settlement upgrading.

IV.3.1.1. Waste Management in Agatare

Waste management, also known as waste disposal, encompasses the procedures and measures necessary for handling waste from its source to its ultimate elimination. This encompasses activities such as gathering, transporting, treating, and disposing of waste, as well as overseeing and regulating the waste management process. Additionally, it involves adherence to waste-related laws, utilization of various technologies, and implementation of economic mechanisms (Wilson, Rodic et al. 2015).

Before the implementation of the upgrading project in Agatare, wastes collection faced numerous challenges. The informal settlement lacked formal waste management systems, leading to haphazard disposal practices and accumulation of waste in streets, alleys, and open spaces. Residents often resorted to burning or dumping waste indiscriminately due to the absence of designated collection points or proper disposal facilities. This unregulated waste management contributed to environmental pollution, health hazards, and aesthetic degradation within the community. Moreover, the irregular collection of waste by informal waste pickers or occasional municipal services further exacerbated the problem, resulting in inefficient and inadequate waste removal. Overall, the pre-upgrading scenario underscored the urgent need for comprehensive interventions to address waste management challenges and improve environmental sanitation in Agatare.

The wastes collection in Agatare has now significant schedule where every Village has a day in a week that the company (COPED) in charge of wastes collection and management come to pick the wastes from households to the disposal site. Waste collection in Agatare is carried out using a door-to-door system, where vehicles arrive, and manpower collect waste directly from households, placing them into the vehicle. Every household has to pay a service fee ranging from one thousand Rwandan Francs to five thousand Rwandan Francs, based on the quantity of waste generated and the economic status of the household. Prior to the upgrading of the Agatare settlement, there were limited roads available, hindering access to many households. The inadequate road infrastructure resulted in ineffective waste collection and transportation methods. The Agatare project addresses this issue by maintaining existing roads and constructing new accessible roads to facilitate the collection and transportation of waste.

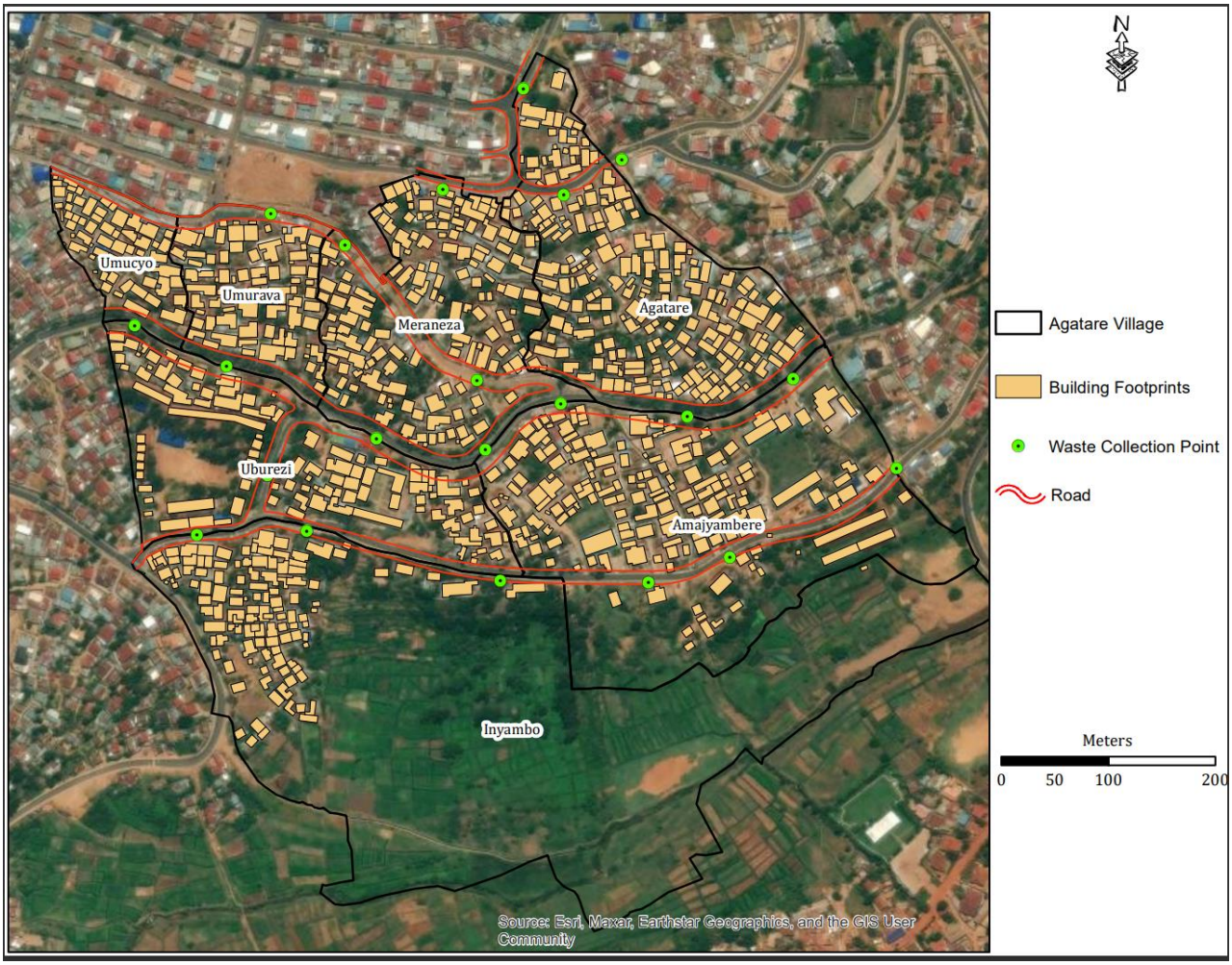

Figure 7. Wastes collection truck stop point (Source: NISR 2012 & Field survey)

Despite the presence of infrastructure to support the waste collection system in Agatare, some households fail to adhere to the established procedures due to insufficient income, which may prevent them from affording the cost of waste collection, and others lack a clear understanding for the role of waste collection. Instead of utilizing designated collection points, waste from these households is often improperly disposed of, being deposited in water drainages, and various open spaces. This disregard for proper waste disposal not only undermines the effectiveness of the collection system but also poses environmental and health hazards to the community. Efforts to address this issue include raising awareness about responsible waste management practices and enhancing enforcement measures to ensure compliance with wastes disposal regulations.

Figure 8. Improper wastes disposal (Source: Field survey)

IV.3.1.2. Stormwater management in Agatare

Stormwater within a residential community originates from various sources such as rooftops, paved surfaces, and roads during rainfall. The volume of stormwater is directly influenced by both the intensity of rainfall and the characteristics of the surface it falls upon. Surfaces covered with vegetation help to reduce the flow of runoff and enable rainwater to infiltrate the soil, whereas impermeable surfaces hinder infiltration, resulting in increased runoff.

Agatare, a densely populated cell in Nyarugenge Sector characterized by its steep slope, faced the challenge of managing high volumes of stormwater runoff originating from house rooftops. As

part of the upgrading initiative in Agatare, solutions were implemented to address this issue. One significant aspect of this initiative involved the creation of several water drainage systems and the enhancement of existing ones prior to project implementation. Additionally, footpaths were constructed, which also serve the dual purpose of functioning as small drainage channels within Agatare.

These drainage systems play a crucial role in managing stormwater runoff by redirecting excess water away from susceptible areas. By doing so, they help mitigate the risks associated with soil erosion and landslides that are prevalent in Agatare due to its steep terrain. Furthermore, these drains contribute to maintaining water quality by effectively filtering out pollutants and sediments from the runoff where some water drains have catch basin for trapping large debris before it reaches downstream ecosystems, such as the Rwampara wetland. Overall, the implementation of these drainage solutions has been instrumental in improving environmental sustainability and resilience within the Agatare settlement.

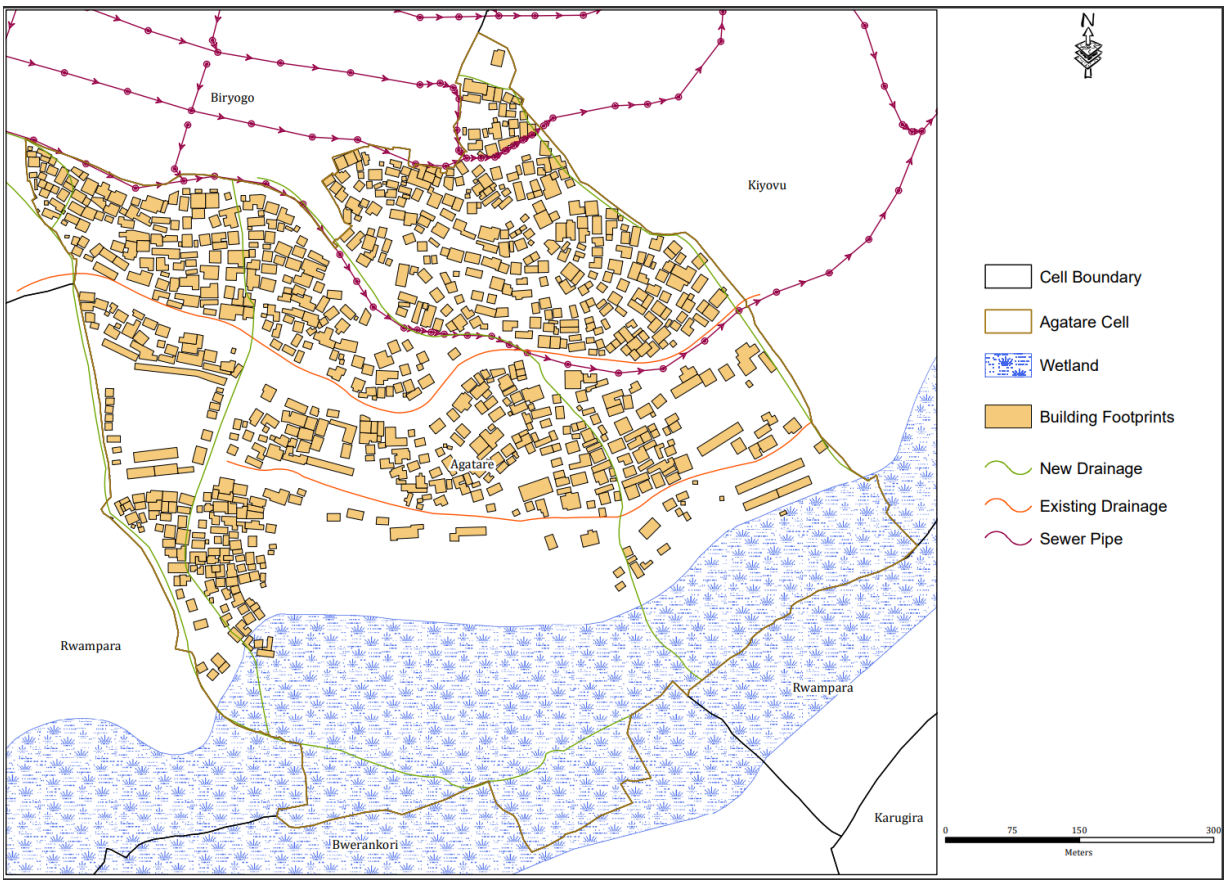

Figure 9. Drainage & Sewer system in Agatare (Source: CoK 2018 & NISR 2020)

Figure 10. Footpaths serve as small drains (Source: Field survey)

The images above depict the drainage system currently in place in Agatare. Figure 9 illustrates the primary water drains that existed in Agatare cell prior to the commencement of the Agatare upgrading project, along with the new main drains created during the project implementation. Meanwhile, Figure 10 showcases the enhanced footpaths that have been repurposed to serve as water drainage channels.

As noted by the respondents, the installation of water drainage systems has significantly improved their quality of life by enhancing hygiene and sanitation standards. They expressed that prior to the project's implementation, they lived in fear of rainwater flooding their homes due to the inadequacy of the existing drainage system. The project addressed this issue by maintaining and constructing multiple water channels designed to effectively divert water from the roofs of houses without causing widespread flooding. This improvement in drainage infrastructure has not only alleviated concerns about water damage but has also contributed to a cleaner and safer living environment for residents.

The drainage system in Agatare faces several challenges. One issue is that some drains are not adequately maintained, leading to the accumulation of debris that obstructs the flow of water.

Consequently, during heavy rain seasons, water overflows onto the roads, causing various problems that could have been avoided with proper maintenance.

Additionally, there are some open drainages posing risks of accidents, especially for children, and serving as potential sites for waste accumulation, impeding the intended flow of water. Both open and closed drains share a common problem where water they carry eventually ends up deposited in the Rwampara wetlands. Unfortunately, there are no proper mechanisms in place to capture this water without also depositing the carried materials into the wetlands, exacerbating environmental concerns.

Figure 11. Open drainage & Drainage that flows toward wetland (Source: Field survey)

The issue of liquid waste being poured into the drainage systems has also emerged, leading to poor sanitation in Agatare. This situation exacerbates public health concerns, as the contamination of water sources and the environment creates breeding grounds for disease-causing organisms. The inadequate management of liquid waste disrupts the community's daily life, contributing to unpleasant odors, unsightly conditions, and increased health risks. This requires immediate

intervention, including improved waste management practices and public awareness campaigns to promote sanitary habits and environmental conservation in Agatare.

IV.3.1.3. Recreation area, Green and Open Spaces in Agatare

Green and open spaces play a great role in enhancing the quality of life and sustainability of settlements. These areas provide numerous benefits to residents, the environment, and the community. Green spaces, such as parks, gardens, and urban forests, offer opportunities for recreation, exercise, and relaxation, promoting physical and mental well-being among residents. These spaces serve as valuable gathering places for social interaction, community events, and cultural activities, fostering a sense of belonging and cohesion within neighborhoods.

Moreover, green spaces contribute to environmental sustainability by mitigating urban heat island effects, improving air quality, and reducing noise pollution. They provide habitats for biodiversity, support pollinators, and enhance ecosystem resilience, thereby promoting ecological balance and enhancing urban biodiversity. Additionally, green spaces act as natural stormwater management systems, helping to reduce flooding, control erosion, and improve water quality by filtering pollutants and slowing runoff.

The Agatare project has focused on enhancing greening within the neighborhood by taking proactive steps to sustain the environment through planting trees along the roads and preserving existing green spaces. Furthermore, it actively encouraged citizens to cultivate gardens at their homes, promoting a culture of green living and community beautification. By integrating these initiatives, the project aimed to create a sustainable urban environment where residents could enjoy improved infrastructure while fostering a deeper connection with nature. Through these efforts, the project not only enhanced the physical landscape of the neighborhood but also contributed to the overall well-being and quality of life of its inhabitants.

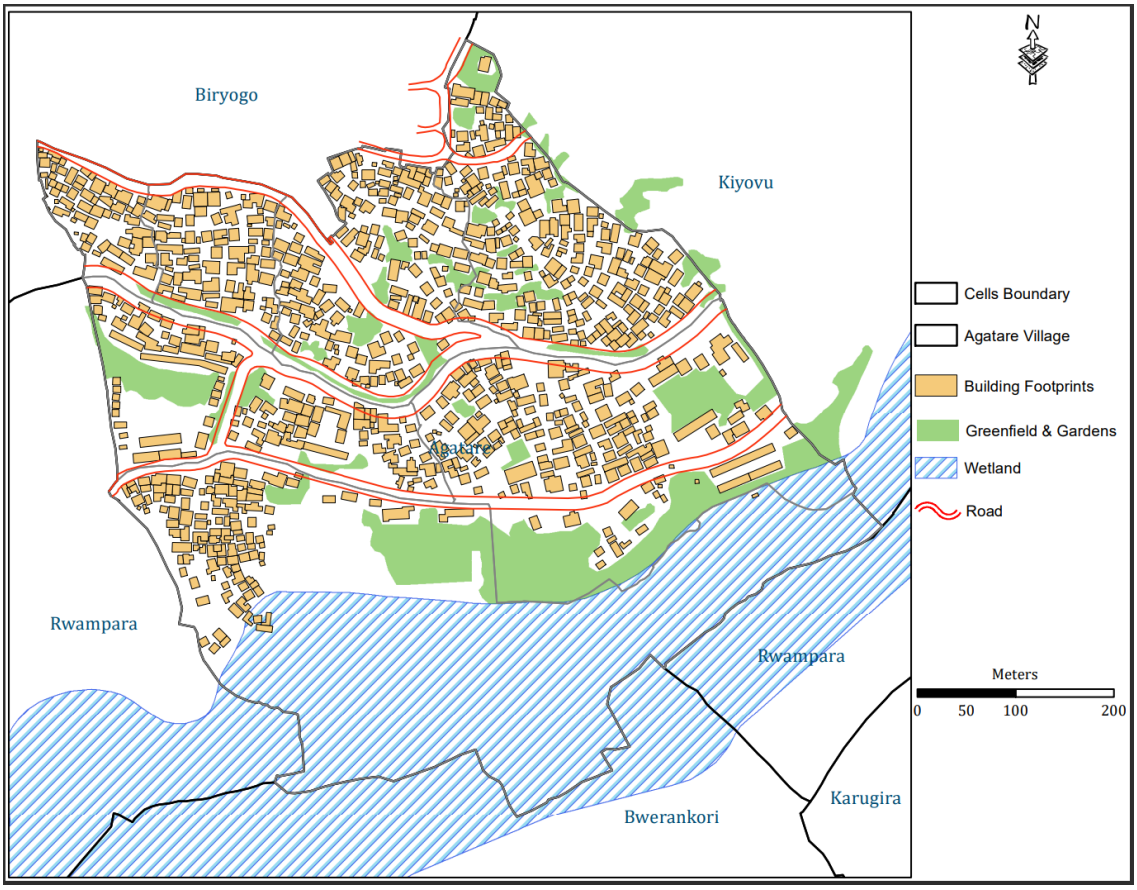

Figure 12. Provided and created greenfield in Agatare (Source: NISR 2010, 2020)

Figure 13.Trees planted along roads (Source: Field survey)

The project also introduced a designated recreation area for children called Kumarangi y'Abana, offering them a space to engage in various games of their preference. A notable environmental benefit of this initiative is the restriction of vehicle access to the area, effectively reducing emissions of harmful gases from vehicles. This restriction not only ensures the safety of children but also contributes to improving air quality within the Agatare settlement. By providing a safe and pollution-free environment for recreational activities, the Kumarangi y'Abana area demonstrates the project's commitment to fostering both the well-being of residents and the health of the local ecosystem.

Figure 14. Recreation zone for Children (Source: Field survey)

IV.3.1.4. Protection of Degradable area in Agatare

The upgrading project in Agatare aimed to enhance and provide essential infrastructure within the neighborhood. However, during the initiation of new infrastructure such as roads, certain areas posed safety concerns, particularly due to steep slopes and exposed drainages, which posed risks, especially for children. To address these challenges, the project took proactive measures to ensure

safety and stability. It initiated the construction of retaining walls to protect areas steepened by roads construction from landslides, mitigating the risk of soil erosion and potential accidents. Additionally, guardrails were installed along the drainages to prevent accidents and ensure the safety of residents, particularly children who might be playing nearby.

Figure 15. Retaining wall and guardrails for protection (Source: Field survey)

IV.3.1.5. Wetland Protection in Agatare

In undertaking informal settlement upgrading projects, it is imperative to prioritize the protection of natural resources, including wetlands. This involves establishing wetland buffer zones to safeguard these delicate ecosystems from encroachment and degradation. Additionally, implementing erosion control measures and effective stormwater management techniques is essential to preserve the integrity of wetland habitats and prevent sedimentation and pollution. Equally important is the need to educate residents about the numerous benefits of protecting wetlands, not only for the environment but also for their own well-being.

The Agatare project implemented various measures that help to protect the Rwampara wetland, focusing on erosion control and stormwater management. Through initiatives such as installation

of retaining walls, helped to prevent sedimentation and nutrient runoff into the wetlands, and preserving their ecological integrity. Additionally, the construction of water drainage systems helped regulate stormwater flow, reducing the risk of flooding and safeguarding wetland habitats from damage. Furthermore, the Kigali City masterplan for 2020-2050 designated buffer zones around wetlands, including Rwampara, as protected areas where construction and development activities are restricted. This strategic approach ensures the preservation of wetland ecosystems by minimizing human encroachment and maintaining their dynamic ecological functions for the benefit of both the environment and local communities. However, the establishment of buffer zones has not yet been implemented, as human encroachment continues to be a pressing issue.

The project aimed to transform the Rwampara wetland into an ecological park by introducing ecologically compatible species to rejuvenate and restore its natural conditions, while also serving recreational and educational purposes to attract both local and international tourists. However, the project can currently be considered a failure, as the wetland has not been properly maintained and is being used ambiguously. This lack of clear management and preservation efforts has hindered the achievement of the project's goals, preventing the wetland from becoming a thriving ecological and recreational area as initially envisioned.

Despite the failure of not making the wetland an ecological park as aimed by the project, there are other significant challenges that threaten the well-being of the Rwampara wetland including the deposition of materials carried by certain water drainages into the wetlands, which contributes to sedimentation and pollution, compromising the ecosystem's health. The presence of residential houses within the wetland contradicts land use regulations outlined in the Land Use Plans Zoning Regulations. According to these regulations, all forms of residential use are prohibited in wetlands to preserve their ecological integrity. Addressing these challenges requires a multifaceted approach, including improved enforcement of regulations, community education on wetland conservation, and the implementation of additional measures to mitigate pollution and encroachment.

Figure 16. Residential houses in wetland & Drainages discharged in wetland (Source: Field survey)

IV.3.2. Social and Economic aspects

The Agatare informal settlement upgrading project aimed to enhance the infrastructure standards within the Agatare area, encompassing the development and improvement of roads, electricity lines, drainage systems, street lighting, and water provisions. By addressing these fundamental infrastructure needs, the project sought to uplift the quality of life for residents, both socially and economically. Access to well-maintained roads facilitates transportation and connectivity, while reliable electricity and water supplies enhance daily living conditions and support economic activities. Additionally, the implementation of proper drainage systems and street lighting enhances safety and resilience within the community. Overall, the provision and enhancement of infrastructure play a crucial role in fostering community development and improving the overall well-being of residents in the Agatare settlement. This has been confirmed by 83% of respondents when asked about the comparison between Agatare before and after the upgrading project.

They unanimously highlighted the inadequacy of infrastructure, which significantly impacted their living standards. Some participants shared their experiences, stating that, "Before this project, we used to fear for our security while commuting to or from our homes at night due to the darkness in the area. We would rush home early, affecting our economic activities as we could only utilize limited daylight hours. Well-lit streets now enable us to walk safely at any time, enhancing our mobility and sense of security".

Several private owners particularly retailers in Agatare faced challenges in efficiently transporting merchandise directly to their shops. The provision of roads has alleviated this issue by facilitating easier access for suppliers to deliver goods directly to their shops, eliminating the need for manual labor to transport goods from the road to the shop. This not only saves time but also reduces costs. Additionally, the availability of roads benefits waste collection companies operating in the area. Prior to the project implementation, waste collection involved laboriously transporting sacks of waste over long distances to the collection vehicles. However, with the introduction of roads, collection vehicles can now park near household gates, allowing waste to be easily loaded directly into the vehicles. This streamlines the waste collection process, saving time and enabling waste collection companies to serve a larger number of households more efficiently.

Figure 17. Some provided infrastructures (Source: Field survey)

IV.4. Challenges of environmental sustainability in Agatare Cell

The responses obtained from provided questionnaires, residents of Agatare reveal persistent challenges in meeting environmental sustainability despite several developments brought about by the settlement upgrading project.

IV.4.1. Lack of Proper waste management system

Despite the improvements made by the Agatare project in waste management, residents of Agatare still face significant challenges in controlling waste within their cell. A notable concern highlighted by 37% of respondents pertains to the inefficiencies in waste collection methods, particularly for households situated away from main roads. The lack of public dustbins for pedestrians exacerbates the problem, leading to littering along roads and in drains. Additionally, some residents dispose of solid waste in drains, causing health problems, unpleasant odors, and environmental pollution. This situation not only poses health risks, especially to children due to poor hygiene practices, but also contributes to environmental degradation. Addressing these issues requires more effective waste collection systems, increased availability of public dustbins, and community education on proper waste disposal practices to protect both public health and the environment.

IV.4.2. Insufficient green space

The Agatare project introduced green spaces along roads by planting trees, which help bring fresh air and protect the steep terrain against erosion. However, residents of Agatare claim these efforts are insufficient for their well-being and the sustainability of the environment. According to 18% of respondents, the project maintained existing green spaces and promoted the creation of home gardens, yet there is a lack of new public green spaces. Residents view this shortfall as a missed opportunity to enhance environmental well-being and foster community cohesion, highlighting the need for more comprehensive green space initiatives to fully support the community's environmental and social needs.

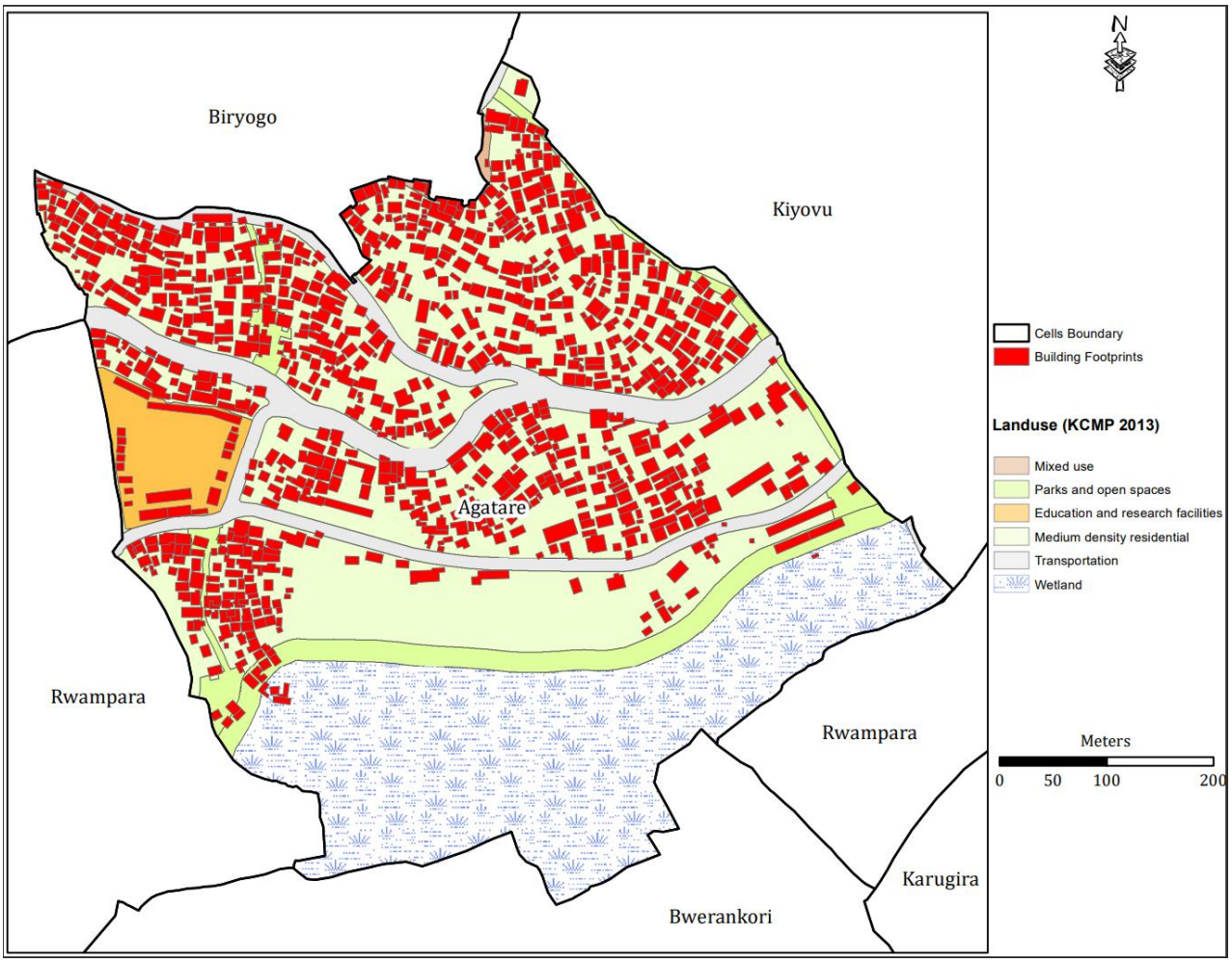

Figure 18.Land use proposed by KCMP 2013 (Source: CoK & NISR 2020)

The Kigali City Master Plan 2013 delineates several green and open spaces slated for creation in Agatare Cell by 2020. Rwampara wetland, like other wetlands, is mandated to be protected under Land Use Plan Zoning regulations, which stipulate that no building should be erected in the wetland except under conditional permits. Despite the Agatare informal settlement upgrading project aligning with the objectives of the Kigali City Master Plan 2013, it failed to realize certain features outlined in the plan, including the proposed green and open spaces in Agatare Cell, as well as the presence of some houses still situated within the wetland. These elements represent critical components that could greatly enhance environmental quality if properly implemented and maintained.

IV.4.3. Pollution

Various factors contribute to the unsustainable environment, including pollution and inadequate infrastructure. Among the respondents surveyed, 27% highlighted the issue of open drainage systems, which facilitate the indiscriminate disposal of waste into waterways, and pouring out liquid waste leading to water pollution when these contaminants are carried along with rainwater. Additionally, debris deposited in these open drains can decompose, emitting foul odors and contributing to air pollution. Respondents emphasized the importance of enclosed drainage systems to mitigate these adverse effects and prevent such circumstances from arising.

IV.4.4. Overcrowding

Agatare Cell, one of the most densely populated areas in the Nyarugenge Sector, faces significant environmental sustainability challenges due to overpopulation. According to 18% of respondents, overcrowding is a major obstacle, with the high density of houses leaving little space for water infiltration during the rainy season. This exacerbates water runoff from rooftops, causing water to flow over cemented surfaces and ultimately affecting the nearby Rwampara wetland, where accumulated water and debris are deposited. Furthermore, many households lack the capacity to harvest rainwater from their roofs, increasing the risk of erosion within Agatare. These issues highlight the urgent need for improved water management and sustainable practices to protect the local environment.

IV.5. Strategy for informal settlement upgrading for sustainable environment

For an informal settlement upgrading project to be successful and fruitful, it is crucial that residents are well-informed about the developments occurring in their area. Awareness fosters a sense of ownership among the community, encouraging active participation in maintaining and protecting the newly established infrastructures. To achieve this, Rwanda can adapt the Melendez Pyramid on Slum Upgrading approach, which has been successfully implemented in Latin America. This approach emphasizes community involvement, collaboration with local authorities, and sustainable development practices. By integrating these principles, Rwanda can ensure that its informal settlement upgrading projects not only improve living conditions but also promote long-term environmental and social sustainability.

The Melendez Pyramid on Slum Upgrading has ten key features but briefed below are those that can reflect to environmental sustainability:

- **Regularization framework and coverage of Basic needs:** A regularization framework and coverage of basic needs involve establishing legal and regulatory measures to formalize informal settlements while ensuring residents have access to essential services. This framework includes providing secure land tenure, improving infrastructure, and ensuring access to clean water, sanitation, healthcare, and education. By addressing these basic needs, the regularization framework promotes stability, improves living conditions, and fosters sustainable community development.
- **Community participation and Organization:** Community participation and organization are essential components of successful development projects. Involving residents in the planning, decision-making, and implementation processes ensures that their needs and perspectives are addressed, fostering a sense of ownership and responsibility. Effective community organization facilitates collaboration, enabling members to collectively address challenges, manage resources, and sustain improvements. When the community is actively engaged in upgrading their area, they value and protect every developed infrastructure by avoiding actions that could cause damage. They participate in maintenance activities such as removing waste from drainage systems, developing open spaces through community initiatives, and maintaining sanitation standards within their settlement. This collective effort ensures the sustainability and longevity of the improvements made.
- **Sustainability and monitoring:** focuses on ensuring that the improvements made to informal settlements are long-lasting and beneficial to the community. This involves establishing systems for regular assessment and maintenance of the upgraded infrastructure, engaging residents in sustainable practices, and continuously tracking the social, economic, and environmental impacts of the project. By implementing robust monitoring mechanisms and fostering community involvement, the approach ensures that the positive outcomes of informal settlement upgrading are maintained over time, contributing to the overall resilience and sustainability of the settlement. By addressing this aspect, the environmental challenges identified in Agatare, such as the deposition of solid waste and the pouring of liquid waste into drainage systems, can be effectively overcome. Sustainable and monitored waste management

practices will prevent these issues, and facilitating the efficient management of both liquid and solid waste and contributing to a cleaner and healthier environment.

- **Strong intermediary Structure:** Informal settlement upgrading programs should establish a strong intermediary structure that unites diverse stakeholders, including residents, authorities, companies, landowners, donors, and NGOs. This non-partisan body facilitates strategic partnerships, communication, and protects the interests of all parties, creating a more flexible and efficient negotiation environment. It strengthens community organization, participation, and capacity-building while managing information and knowledge effectively for monitoring and evaluation. Uniting diverse stakeholders will open opportunities for environmentally pioneering companies and NGOs to contribute their ideas and solutions, thereby enhancing environmental protection and sustainability in the upgraded area.
- **Equity, Self-Esteem and Inclusion:** Ensuring that all residents, regardless of socioeconomic status, have fair access to resources and opportunities is crucial. Equity addresses disparities and promotes justice in resource distribution, while self-esteem is enhanced by involving residents in decision-making, recognizing their dignity and worth. Inclusion ensures that all community members, especially marginalized groups, participate actively in the upgrading process. Together, these elements foster a more cohesive, empowered, and resilient community, essential for the long-term success of informal settlement improvements. Additionally, this approach will help manage all provided infrastructures by ensuring their maintenance and protection, preventing illegal waste deposition into drains and along roads, safeguarding existing natural resources, and maintaining green and open spaces. Engaging the community in these efforts inspires a sense of ownership and responsibility, promoting sustainable environmental practices and the preservation of developed infrastructure.

The Melendez Pyramid for slum upgrading has been successful in Latin America by prioritizing citizen and stakeholder engagement to meet the needs of all beneficiaries. This approach fosters community ownership, allowing residents to voice their priorities and ensuring the sustainability of environmental features introduced by the project. Environmentalists contribute by advocating for practices like proper waste management, which helps maintain long-term environmental sustainability.

Chap v: CONCLUSION AND RECOMMENDATION

v.1. Conclusion

The first objective of this research is to assess the extent to which the upgrading of Agatare informal settlement promote the sustainable residential neighborhoods in Kigali city. The findings related to this objective shows that the project improved the standard of living in Agatare and its neighborhood by providing several infrastructures including roads, electricity, water, water drainages, footpaths, and street lights. Those infrastructures improved the connectivity, security, sanitation and the economy of residents of Agatare and its neighborhoods.

The second objective is to identify the challenges that might have hindered improvement of environmental quality in Agatare residential settlement where the findings show that the Agatare settlement upgrading project has significantly transformed the environment of the area by implementing a stormwater drainage network which effectively manages water runoff from the rooftops of houses, facilitate the easy collection of solid waste through the creation and development of roads enabling transportation vehicles to collect waste door-to-door more efficiently and by planting the trees along roadsides and the cultivation of gardens that bring freshness in the Agatare.

Despite the environmental improvements brought about by the Agatare upgrading project, there are still challenges to environmental sustainability that were not adequately addressed during its implementation. The Rwampara wetland has not been well maintained, as water from some drainages accumulates in the wetland, leading to soil degradation due to transported materials that are harmful to the environment. There are also open drainages pose a challenge to the environment by allowing individuals to dispose solid waste into them, resulting in the obstruction of water flow during heavy rainfall and affecting the sanitation of households.

The last objective of this study is to propose effective strategies and approaches to address the challenges identified during the informal settlement upgrading project, thereby enhancing environmental quality. While the project in Agatare has yielded significant positive impacts on the environment and socio-economic aspects of the community, it is imperative to implement additional measures for sustainable environmental management. Education initiatives should be

prioritized within the community, emphasizing the ending of solid waste dumping along roads, drains, and open spaces. Instead, residents should be encouraged to utilize waste bins placed suitably in front of their homes and along roads and in public places. Furthermore, active participation in the Umuganda program, important for tasks such as drain clearing, grass cutting, and street sweeping, should be promoted vigorously. Additionally, all public facilities, including markets, open spaces, and recreational areas, must be equipped with fixed disposal points or strategically positioned disposal bins to facilitate proper waste management.

By conclusion, the Agatare upgrading project has brought about significant positive impacts on the social and economic standards of the community by providing essential infrastructure such as roads, electricity, water supply, drainage systems, footpaths, and street lighting. Moreover, it has contributed to enhancing the environmental sustainability of the area by facilitating waste collection processes, managing stormwater effectively, and promoting greenery through tree planting and gardening initiatives. Despite these improvements, there remains a pressing need to further boost environmental sustainability. Specifically, efforts should focus on mitigating issues related to waste disposal into drains and open spaces. Additionally, preserving the integrity of the Rwampara wetland is paramount, necessitating measures to prevent the deposition of waste and contaminated water transported by drains.

V.2. Recommendation

While the upgrading project in Agatare settlement has undeniably delivered substantial positive outcomes for the community in terms of socio-economic development and environmental enhancement, it has also brought to light various challenges impeding long-term environmental sustainability and community well-being. In response to these challenges, the study proposes a range of initiatives aimed at addressing key environmental concerns and fostering continued progress. These recommendations serve as vital steps toward ensuring the enduring success and resilience of the community. I recommend that:

- Community Involvement: Engage local residents in planning and decision-making processes to ensure they take ownership of environmental initiatives. This includes education on the importance of sustainability and training on maintaining new infrastructure.
- Green infrastructure development: I recommend that every project of informal settlement upgrading in Kigali should focus on infrastructure such as sewage system, permeable pavement, stormwater drainage network, create green and open space for helping in improving the environment quality in upgraded settlement.
- Umuganda programme must highlighted in order to engage the community in clearing open drains, cuttings grass and sweeping the streets in the Agatare for proper maintenance of the environment and sanitation.
- All public places like market, open space and recreational facilities should have a fixed disposal point for solid wastes or disposal bins strategically located for ease of use.
- Designate a well-structured strategy to maintain wetlands in good condition by implementing buffer zones to prevent human encroachment and ensuring water drainage systems do not deposit debris into the wetlands.

Chap VI. References

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7. Appendix

7.1. Questionnaire

Dear Respondent,

I am students from university of Rwanda (UR), College of Science and Technology, School of Architecture & Built Environment, Department of Geography and Urban Planning, MSc in Geo-Information Sciences for Environmental and Sustainable Development, I am carrying out my final research project on topic entitled "***Environmental Quality Improvement Through Informal Settlement Upgrading. A probe from Agatare Upgrading project, Nyarugenge District, Kigali City***". The main objective of this research is to assess if the processes of settlement upgrading in Kigali city promote the Quality of environment.

You have been selected as one of the respondents for this study and the information you will give, will be treated with utmost confidentiality and used purely for academic purposes. I hereby requesting you to help me by answering the questions that will guide me in responding to my research questions.

I. Identification of Respondents

1. **Age:**

Range of Respondent years	
20 to 30	
30 to 40	
40 to 50	
50 to 60	
60 and above	

2. **Gender:**

Male ☐

Female ☐

3. **Occupation:**

Student ☐ Private worker ☐

☐

Government worker ☐ Other

For other, please specify: ……

4. **Educational level:**

None ☐ Primary ☐ Secondary ☐ University ☐

Others ☐

For Others, then specify, ……

II. <u>Questions</u>

1. How long have you been residing in Agatare zone?

Less than 1 year ☐ 1- 5 years ☐ 6- 10 years ☐

More than 10years ☐

2. Were you aware of the project to upgrade Agatare that has been ongoing since 2018?

Yes ☐ No ☐

If yes,

3. What actions were undertaken during the implementation of that project?
4. How were these actions executed during the project implementation?
5. Who participated in the implementation of the project, and what were the outcomes?
6. How would you describe Agatare before the implementation of this project, from your perspective?

7. How would you rate the impact of the recent upgrading in Agatare on promoting life standard of Agatare neighborhoods?

   Very positive ☐ Positive ☐ Neutral ☐

   Negative ☐ Very negative ☐

8. In what specific ways do you think the Agatare upgrading has positively impacted the residential environment in Agatare?
9. What challenges do you think have hindered the improvement of environmental quality in Agatare residential settlement? (Select all that apply)

Lack of proper waste management systems ☐ Insufficient green spaces ☐

Pollution (air, water, noise) ☐ Poor infrastructure (roads, drainage) ☐

Overcrowding ☐ Other (please specify) ☐

10. Please elaborate on the challenges you've selected and how they specifically affect the environmental quality in Agatare.
11. What strategies or approaches do you think could effectively address the identified challenges and promote environmental quality in Agatare? (Open-ended)
12. Is there any additional information or suggestions you would like to provide regarding the improvement of environmental quality in Agatare?

Thank you for taking your time to answer this questionnaire!

7.2. Letter for data collection

UNIVERSITY of RWANDA

COLLEGE OF SCIENCE AND TECHNOLOGY (CST)

SCHOOL OF ARCHITECTURE AND BUILT ENVIRONMNE (SABE)

Office of the Dean

TO WHOM IT MAY CONCERN

Dear Sir,

Dear Madam,

Kigali, 05 February 2024

Data Collection for MSc Dissertation by Mr. UWIRAGIJIMANA Emmanuel

Through this letter, we would like to confirm that **Mr. UWIRAGIJIMANA Emmanuel** is a final year student in the MSc of Geo-Information Science for Environment and sustainable Development (GI-ESD) under the School of Architecture and Built Environment (SABE), College of Science and Technology (CST), at the University of Rwanda (UR). He is currently working on the MSc dissertation, with the topic "***Environmental Quality Improvement Through Informal Settlement Upgrading. A probe from Agatare Upgrading project, Nyarugenge District, Kigali City"***, under the supervision of Dr. UWAYEZU Ernest (+250 783022510).

From February up to April 2024, he will be collecting data which are relevant to that topic in the sectors of Nyarugenge of Nyarugenge District. Data collection will include the household surveys and interviews with local leaders, and various government officials. In addition, he will need access to various spatial datasets and documents that are held by both public and private organizations. We would therefore like to request for your support so that he can get access to those data and documents. For any question related to his research, do not hesitate to contact his supervisor (tel. above) or the dean of the school on the tel. or email below.

We do appreciate your support to that UR Student in his academic journey.

We do appreciate your support to that UR Student in her academic journey.

Sincerely yours.

Dr. Ernest Uwayezu
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MSc - GI-ESD program coordinator
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