

Extent of Resilience to Climate Change in Secondary Cities of Rwanda (Energy Land Use and Natural Environment): Case Study of Rusizi District

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Abstract: This paper titled Extent of resilience to climate change in secondary cities of Rwanda: Case study of Rusizi District. The author Evaluated the current climate related hazards and their impacts on urban livelihoods in Rusizi secondary city community. The author adopted a mixed method approach. The location quotient formula allows researcher to calculate whether a region is employing enough workers in each sector as put up against a national economy. LQ is augmented by two other pieces of information. Size of industry/cluster/occupation in terms of job and percentage of changes in LQ over period of time. A high LQ industry with a small number of jobs may be an export oriented industry otherwise, a large high LQ-industry with declining LQ over time is endangering the regional economy. The result findings revealed that Location Quotient for total employment is below 1 for manufacturing (0.99), accommodation food (0.92), public sector (0.65) primary (0.21) as well as other activities (0.87). The findings also revealed that there is a limited attention in infrastructure development and inadequate commitment in building resilience of vulnerable community to natural shocks. Recommendations include addressing infrastructure development that are resilient to climate change effects in formal and informal settlements and supporting livelihood improvement program in secondary cities and to put in place Formalized collection and recycling systems, and sanitary landfills, requiring investment in equipment, landfill development and skills of US\$4-8 million by 2030 by also adopting new planning process to incorporate Green growth climate resilience principles as adopted by the GoR in 2018, by mainstreaming climate change resilience and preparedness to disaster risk management into the planning process.

Keywords: Climate Change, Energy Land Use, Natural Environment Resilience, Secondary Cities

1. Introduction

Cities play a prominent role in our economic development as more than 80% of the gross world product (GWP) comes from cities. Only 600 urban areas with just 20% of the world population generate 60% of the GWP. Rapid urbanization, climate change, inadequate maintenance of water and wastewater infrastructures and poor solid waste management may lead to flooding, water scarcity, water pollution, adverse health effects and rehabilitation costs that may overwhelm the resilience of cities. These megatrends pose urgent challenges [1].

International organizations and policy agendas present resilience as a key goal, for instance in the UNFCCC COP21

Paris Agreement, Sendai Framework for Disaster Risk Reduction, Habitat III New Urban Agenda, World Bank City Resilience Program, EU Urban Agenda, Sustainable Development Goals and city networks such as ICLEI, C40 Cities, 100 Resilient Cities, and ACCCRN.

These initiatives are “helping cities around the world become more resilient to the physical, social, and economic challenges that are a growing part of the 21st century”.

Rapidly expanding urban settlements in the developing world face severe climatic risks in light of climate change. Urban populations will increasingly be forced to cope with increased incidents of flooding, air and water pollution, heat stress and vector-borne diseases [4].

Meerow et al. (2016) explain “urban resilience” as an urban

system that can maintain or rapidly return to desired functions in the face of a disturbance, adapt to change, and quickly transform socio ecological systems that limit current or future adaptive capacity. We are going to the government of Rwanda effort in developing secondary cities in the so-called Green cities project.

With the Rwandan Vision 2050, National Land Use Master plan 2019 and the Urbanisation and Rural Settlement SSP, six secondary cities were selected for the promotion of urban development outside of the capital city: Rubavu, Musanze, Huye, Rusizi, Nyagatare, and Muhanga. The secondary cities were identified not only to transform the economic geography of the country, but also to avoid pressure on peri-urban land of the Capital city Kigali and urban sprawl, including sprawl of urban functions into rural areas and provide socio-economic opportunities. [2]

The eastern part of Rusizi urban area appears to have a low slope percentage, mostly not exceeding 20% slope, while the highest points of the area are in the western portion closer to Lake Kivu with areas above 40% slope category. Slope category will be essential in determining habitable areas in preparation of an updated master plan, to avoid flood prone zones.

Rusizi District is located in Eastern province of Rwanda with the population estimation of 404,712 people and about 55% of the population in Rusizi district is identified above the poverty rate, 20.5% as poor (excluding extreme-poor) and 24.5% as extreme-poor. The poverty indicators for Rusizi district are lower than the Western Province average, which is that 48.4% of the population is poor. Overall, 89.3% of households own less than 2 ha in Rusizi District of land constitutes a big challenge to the agriculture and agro-production development not only in Rusizi District. However, as proposed earlier, land irrigation will help to address the challenge and exploiting marchland will also help boosting agricultural productivity in Rusizi. Despite the small share of land owned per household, various crops are grown in Rusizi, per ha. [3]

With the urban population growing at 4.5 percent a year, more than double the global average, Rwandan officials are now emphasizing the need to develop secondary cities as poles of growth as the country has set a target to achieve a 35 percent urban population by 2034.

While the initiative appears to be a strategic tool for the National Strategy for Climate Change and Low Carbon Development that was adopted by the country in 2011, experts suggest that it is also important for local administrative entities to understand the mechanisms of green urbanization and secondary city development. [5]

The National Urbanization Policy was adopted in December 2015 and sets the framework for the governmental, non-governmental and private interaction in the country's urbanisation process in support of sustainable development. It sets the principles for coordinated strategies and actions supported by urban planning documents, development of urban areas at high density, inclusive urban areas providing quality of life and conditions for economic growth. [6]

This concept of climate resilience is key to preparing cities

for the impacts of gradual climate change and associated extreme climate events. United nations stated that increasing populations within urban ecosystems are putting heavier demands on the supporting biophysical and socioeconomic systems. [7], while the Intergovernmental Panel of Climate Change stated that urban population's activities are influencing natural systems, serving as forces for environmental change at local, regional, national, and global scales [8]. Climate change represents yet another source of vulnerability for both our natural and human systems. Urban climate resilience is a city's ability to reduce exposure and sensitivity to, and recover and learn from gradual climatic changes or extreme climate events. This ability comes from a city's risk reduction and response capacity, and includes retaining or improving physical, social, institutional, environmental, and governance structures within a city. The components of urban climate resilience reflected in the conceptual framework include three measures of vulnerability (exposure, sensitivity, and response capacity), as well as the process of initiating responsive action, learning from mistakes or ineffective responses, and building risk reduction capacity (reducing exposure and sensitivity, and increasing response capacity). [9]

In cities, surface transportation networks (roads, railways, sidewalks, parking lots, alleys, and port infrastructure on land) account for a significant amount of imperviousness, which increases surface runoff, which in turn increases vulnerability to floods. Green infrastructure can be a suitable approach to increasing resilience because large amounts of funding are available from both local transportation departments and private system operators for both capital projects and repair, maintenance, and upgrading. Thus green infrastructure resilience measures can be incorporated into both new projects and retrofits of large impervious areas. [10]

On the other hand, Kumar (2015) and Friend et al. (2013) argue that improving understanding of existing urban vulnerabilities enables key stakeholders to formulate efficient and effective responses to catastrophes. It is obvious that government of Rwanda has elaborated social development policy and mobilized funds to ensure that vulnerable community are supported and periodically graduated from poverty level. However, the development of secondary cities should go hand in hand with those initiatives.

Rwanda ranks 131 out of 178 countries in the ND-GAIN index3 (2013), which is slightly better than in 2010 (rank 135). It ranks 13th on vulnerability and 95th on readiness – meaning that it is highly vulnerable to climate change effects, yet its readiness to combat these effects is moderate. Vulnerability measures the exposure, sensitivity, and ability to cope with climate related hazards by accounting for the overall status of food, water, environment, health, and infrastructure within a country. Readiness targets those portions of the economy, governance and society that affect the speed and efficiency of adaptation.

On the other hand, "Urban Resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter

what kinds of chronic stresses and acute shocks they experience." Rockefeller Foundation, 100 Resilient Cities.

Urban climate change resilience checklist: Rockefeller foundation through the city resilience index has developed drivers that contribute to city resilience. These drivers are normally recognized as factors, which enhance city climate change resilience. These factors are organized into the four core dimensions of the urban resilience framework:

Leadership and strategy: Encourage capable leadership and effective urban management within government and civil society, particularly during an emergency. This involves strong leadership, cross-sector communication, and evidenced-based decision-making. Ensure everybody is well informed, capable, and involved in their city. This includes access to information and education, communication between the government and public, knowledge transfer, and timely and appropriate monitoring.

Align sectoral plans and individual projects with the city's vision to be coordinated and appropriate to address the city's needs. This includes city strategies and plans.

Health and well-being: Everyone living and working in the city has access to what they need to survive and thrive.

Particularly in times of crisis, ensure that people have access the basic resources necessary to survive – food, water and sanitation, energy, and shelter.

Assist individuals to access diverse livelihood and employment opportunities, including access to business investment and social welfare. This includes skills and training, fair labor policy, and development and innovation.

Provide access to effective public healthcare and emergency services to safeguard physical and mental health. This includes medical practitioners and plans, as well as clinics and ambulances.

Economy and society: The social & financial systems that enable urban populations to live peacefully, and act collectively.

Create a sense of collective identity and mutual support. This includes building a sense of local identity, social networks, and safe space; promoting features of an inclusive local cultural heritage; and encouraging cultural diversity while promoting tolerance and a willingness to accept other cultures.

Ensure a comprehensive and inclusive approach to law enforcement and justice that fosters a stable, secure, and just society. This includes fair and transparent policing and deterrents to crime – specifically in times of crisis, as well as enforcement of laws such as codes and regulations.

Ensure the availability of funding and a vibrant economy because of diverse revenue streams, the ability to attract business investment, and contingency plans. This involves good governance, integration with the regional and global economy and measures to attract investment.

Infrastructure and environment: The man-made and natural systems that provide critical services, protect, and connect urban assets enabling the flow of goods, services, and knowledge.

Maintain protective natural and man-made assets that

reduce the physical vulnerability of city systems. This includes natural systems like wetlands, mangroves and sand dunes or built infrastructure like sea walls or levees.

Actively manage and enhance natural and man-made resources. This includes designing physical infrastructure such as roads and bridges to withstand floods so that people can evacuate, as well as ecosystem management for flood risk management. It also includes emergency response plans and contingency plans that may coordinate airports to function so that relief can be lifted in and out during a crisis.

Provide a free flow of people, information, and goods. This includes information and communication networks as well as physical movement through a multimodal transport system.

Transformational in Urban sanitation

Future wastewater management is common challenge in most Rwanda's secondary cities, especially in collection Transport and disposal. The world bank group report on Profiling Secondary Cities in Rwanda (2017) states that With increasing wealth and development in Rwanda's urban areas will come higher levels of water use and wastewater generation, eventually exceeding the ability of the on - site systems to accommodate the wastewater volumes. Therefore, Sewerage and associated wastewater treatment systems will need to be developed to accommodate future wastewater flows, but the cost of such systems increases dramatically with lower - density development, placing further pressure on already constrained affordability. Furthermore, consideration in providing urban sanitation is that many of the secondary cities and fast growing towns are located in areas with relatively steep slopes. While moderate slopes can be beneficial for minimizing the costs of sewerage systems, high slopes can add to costs and flat land is required for wastewater treatment plants.

Although Rwanda is amongst the least urbanized countries in the world, it is also one of the fastest urbanizing ones, with an annual urban growth rate of 4.5 %. In 1990, it was the least urbanized country in the east African Community countries. But by 2030 it will be one of the region's most urbanized, with an estimated urbanization rate of 30%. About half of the country's urban population resides in Kigali. The secondary cities of Huye, Muhanga, Musanze, Nagatare, Rubavu and Rusizi together house about a quarter of the country's urban population. This will put substantial challenges on adequate environmental management, reduce urban pollution and take pressure off natural resources at risk due to this development [11].

However based on National Institute of statistics data for 2012, Planned urban housing in Rusizi District is at 9.5% while 63.5% are classified as Spontaneous / Squatter housing, on the other hand three main sources of energy for lighting are electricity (51.7%), kerosene lamp (29.3%) and candle (8.2%). In the same City private households use mostly firewood (57.6%) and charcoal (38.3%) in cooking. The same data revealed that Improved source of water supply was at (78.7%).

Urban households evacuate their waste mainly in the compost dumping (55.4%), in the private dust bins (20.5%) or on the Farms (10.7%).

World Health organization states that Improved drinking water sources include protected springs, public standpipes, water piped into dwelling/yard, boreholes, protected wells and rainwater collection, as defined by the World Health Organization. Considering the above definition, Rusizi District is covered with water supply at 73% [12].

2.4% of the total active population aged 16 years and above in Rusizi District were unemployed during the 7 days preceding the census. In the same District, unemployment rate (UR) is higher in urban (3.9%) than in rural areas (2.1%).

Population characteristics:

The District of Rusizi is one of the seven Districts of Western Province of Rwanda. It borders Nyamasheke District in the North, Nyamagabe and Nyaruguru Districts in the East, Burundi in the South and the Democratic Republic of Congo in the West. Its area is 940.95km² and is populated by

404,714 inhabitants, with a population density of 399 inhabitants/Km². [13]

2. Methodology

2.1. Data Collection

Economic Development

According to world bank Group report secondary cities, notably Rusizi, which has the potential to significantly expand cross - border trade with DR Congo but scores the lowest for access to domestic markets, improved access to domestic markets, especially Kigali, can further increase its potential to serve as hub for transport logistics and a conduit for regional trade. Below is summary of findings of spatial development of Rusizi compared to other secondary cities.

Table 1. Summary of findings of spatial development analysis.

Type	city	Spatial growth (%)	Average per year (%)	Pace of expansion	Prevalent modality of growth
Intermediate urban centers	Huye	34	2.2	Slow	Densification
	Rubavu	23	1.4	Slow	Densification and sprawling
	Musanze	120	6.0	Average	Densification and sprawling
	Rusizi	109	6.4	Above average	Densification and sprawling
Total					

Source: Authors' analysis of USGS Landsat satellite imagery.

Table 2. Status of urban master plans.

City	Urban master plan	Local plan	Comments
Secondary city			
RUSIZI	It was developed in 2015 and covers greater area of the District but focus on existing urban core.	Area plans for Central Business District in the Master Plan	Contains detailed housing and servicing concepts and costs

Table 3. Total employment (formal and informal) location quotients of broad sectors, secondary cities.

Secondary city	Wholesale retail trade	Manufacturing	Accommodation and food	Public sector	Primary	Other activities
Huye	1.05	0.84	1.03	1.18	0.40	0.99
Nyagatare	1.56	1.14	1.12	0.63	0.09	1.10
Muhanga	1.61	1.34	0.72	0.82	0.20	0.95
Rusizi	1.82	0.99	0.92	0.65	0.21	0.87
Rubavu	1.35	0.76	1.26	0.76	0.79	0.83
Musanze	1.38	1.39	1.26	0.76	0.02	0.90

Source: Establishment Census 2014

Note: Color scale of green-red indicates specialization, with green high specialization and red low.

2.2. Urban Jurisdiction and Institutional Capacity

The jurisdiction of secondary cities within districts' institutional and legal frameworks is currently unclear. The lack of dedicated provisions for urban areas in districts risks rendering the attention to such urban areas insufficient in terms of district planning, supervision and management. While this is a difficult area for reform, mechanisms to improve collaboration across sector jurisdictions should be considered, possibly leading to formation of dedicated urban management and/or governance structures in the longer-term.

Capacity constraints and staffing shortages of One Stop Centers (OSCs) 11 should be addressed to increase their ability to support urban infrastructure and service growth and development.

Location Quotient (LQ)

The location quotient formula allows researcher to calculate whether a region is employing enough workers in each sector as put up against a national economy.

LQ is augmented by two other pieces of information. Size of industry/cluster/occupation in terms of job and percentage of changes in LQ over period of time. A high LQ industry with a small number of jobs may be an export oriented industry otherwise, a large high LQ-industry with declining LQ over time is endangering the regional economy. [14]

The result revealed that with spatial development analysis, Rusizi district ranked 6.4% per year. (Above average mean) this means, with resilient infrastructure development, there is an increase of workforces in the period of analysis [15].

When the Location quotient = 1 that means the employment

is equal in the sector for the national and regional economy. Therefore the sector is non-basic and supply is just equal to demand.

If $LQ < 1$, The output is not sufficient to meet the local demand and imports are needed. It is also non-basic.

If $LQ > 1$ the output is more than sufficient to meet the local demand and exporting the surplus is an option. It is basic.

The formula is as follows, and an example is in the excel file: LQ tutorial.

How to Calculate a Location Quotient?

$$LQ_i = (e_i/e) / (E_i/E)$$

where,

LQ_i = location quotient for sector in the regional economy;

e_i = employment in sector i in the regional economy;

e = total employment in the local region;

E_i = employment in industry i in the national economy;

E = total employment in the national economy.

3. Conclusion

Based on the findings above, it is revealed that Location Quotient for total employment is below 1 for manufacturing (0.99), accommodation food (0.92), public sector (0.65) primary (0.21) as well as other activities (0.87) Even though it is among secondary cities, there is a need to develop infrastructure that will accommodate all business activities considering that Rusizi District is a Hub of Democratic Republic of Congo. Considering its high population density, There is a need of adequate commitment in building resilience of vulnerable community to natural shocks.

A further consideration which may impact growth prospects is the likely influence of physical constraints, particularly in the case of Rusizi, this city is located on land which is characterized by steeply varying topography—ridges, steep ravines and fertile valley floors. This makes land for development hard to find and/or expensive to develop and service. In contrast, development opportunities are likely to be greater in cities with easily developable flat land.

4. Recommendations

To adapt to the climate change as a growing secondary city Rusizi Town should put in place Formalized collection and recycling systems, and sanitary landfills, requiring investment in equipment, landfill development and skills of US\$4-8 million by 2030.

New planning process should incorporate Green growth

climate resilience principles as adopted by the GoR in 2018. by mainstreaming climate change resilience and preparedness to disaster risk management into the planning process.

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