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An Analysis of Economic, Social and Environmental Dimensions of Sustainable Development in Rwanda

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Preface

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An Analysis of Economic, Social and Environmental Dimensions of Sustainable Development in Rwanda

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Abstract

Sustainability in the agriculture sector implies successfully managing the available resources to satisfy farmers' wants without damaging the environment. This is significant today as the world is facing climate change, desertification and chronic food insecurity. This study compares the progress made in sustainable development in Rwanda's districts and identifies the areas that require more attention for them to achieve the highest level of development. Instead of using the household income levels alone, this study uses the sustainability livelihood security index (SLSI) as an analytically rigorous tool to assess the ability and preparedness of the rural poor. The results show that the sustainability range is between 0.27 and 0.64 which indicates that performance in terms of sustainability varies across districts. The Government of Rwanda needs to enhance environmental management by promoting economic activities that are environmentally friendly so that it can sustain the socioeconomic welfare of its citizens.

Keywords: Resource management; sustainable development; sustainable livelihood; sustainability index; development performance; Rwanda;

JEL Classification Codes: D60; D90; I31; I38; O13; O18

1. Introduction

Sustainable development is seen as the allocation and protection of natural resources and setting and giving direction to technological and institutional dynamics with a focus on achieving and sustaining human wants for both present and future generations (Chittor and Mishra, 2012). Specifically, sustainability in the agriculture sector implies successful management of available resources to satisfy farmers' wants without damaging the environment (FAO, 1991). The term 'sustainable development' was first used by the United Nations in its document 'Our Common Future' (Brundtland et al., 1987). It entails the interdependence and interaction between the environmental, economic and social dimensions of development (Murphy, 2012). This interaction originated in the key theme of the United Nations Conference on the Human Environment held in Stockholm in 1972 that claimed explicitly that "it was possible to achieve economic growth and industrialization without environmental damage" (Mustaq and Azeem, 2012). According to Brundtland et al. (1987), making development sustainable means ensuring that it provides enough goods and services to not only current but also future generations to satisfy their wants. This implies that sustainable development requires meeting the basic needs of all and includes providing opportunities to fulfill their aspirations for a better life. The 2030 Agenda for Sustainable Development acknowledges the importance of healthy lives and the well-being of people built on sustained, inclusive and sustainable economic growth through protection, restoration and sustainable use of natural resources (UN General Assembly, 2015).

In Ballara's (1991) view, sustainable development is humanity's ability to survive by rationally using renewable resources and refraining from disrupting the ecosystem or overexploiting natural resources and by refraining from activities that destroy cultures or societies and instead allowing them to reach their potential. Hence, sustainable development has to do with participatory development, human development and environmental protection. In this line of thinking, Mustaq and Azeem (2012) emphasize that sustainable development ensures human well-being by integrating social development, economic development and environmental conservation and protection. Social development implies that human beings' basic needs are met through the implementation and realization of human rights. Basic needs include access to education, health services, food, housing, employment and a fair distribution of income. Social development promotes democracy to bring about public participation in determining policy, as well as creating an environment for accountable governance. Social development works to empower the poor to expand their use of available resources to meet their needs and change their lives.

According to Mustaq and Azeem (2012), sustainable global development requires the more affluent to adopt lifestyles which are within the planet's ecological means, for example, their use of energy. Further, rapidly growing populations can increase the pressure on resources and slow any improvements in living standards. Thus, sustainable development can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem. The authors also point out that sustainable development is the process of harmonizing satisfying needs and wants for both present and future generations through environmental friendly use of natural resources, appropriate orientation of investments, giving the right direction to technological changes and bringing about an institutional revolution. Therefore, sustainable development must rest on political will (Brundtland et al., 1987).

In recent decades, there has been global concern about the non-renewability of natural resources as a factor limiting production and the threat to long-term economic growth caused by environmental destabilization and pollution (Bassiago, 1999).

An important challenge to sustainable development arises from unsustainable consumption and production patterns that evolved in developed countries and are now being increasingly followed by developing countries. For example, per capita greenhouse gas emission levels in developed countries are 20-40 times higher than those needed for stabilizing atmospheric greenhouse gas concentration. The per capita ecological footprints in developed countries are 4-9 times higher than their bio-capacity. The high degree of inequality that accompanies and promotes these patterns makes them socially unsustainable and constrains achievement of human development goals. Without an effective global agenda, high-income households in both developed and developing countries are likely to continue to adopt unsustainable consumption practices (United Nations, 2013).

The most important environmental and developmental risks hindering sustainable development in African countries include climate change, water scarcity, desertification and land degradation, energy, lack of access to water and sanitation, loss of forest cover, extension of erosion, chronic food insecurity and vulnerability to extreme weather conditions (Klein et al., 2013). Dalal-Clayton and Bass (2002) highlight that sustainable development is committed to simultaneously integrating the economic, social and environmental aspirations of development. In case this integration is not feasible, there may be trade-offs between these three objectives.

For countries to pursue and achieve sustainable development, their governments are expected to come up with policies that aim at improving citizens' socioeconomic conditions on three pillars of sustainable development – economic, social and environmental. Documents on how governments in sub-Saharan Africa (SSA) have focused on the interaction between these dimensions of development are not available for all SSA countries.

Wide inequalities, improper management of natural resources and increasing population in SSA are also threatening the ecological balance and economic as well as social conditions leading to a big threat to successful sustainable development in different countries. My study analyzes sustainable development in Rwanda from the economical angle. The study aims specifically to: (1) compare development performance in terms of sustainable development in Rwandan districts, and (2) identifying the areas that require more attention for different districts to achieve the highest levels of development.

2. Literature review

2.1 Theoretical Literature Review: Definitions of Sustainable Development

The first and most common definition of sustainable development (SD) took its roots in the famous report 'Our Common Future' written by a team of researchers led by Brundtland for the United Nations World Commission on Environment and Development (Brundtland et al., 1987). The Brundtland Report defines SD as development that brings together social, environmental and economic objectives. According to Elliot (2006), human development's targets and the kind of environmental policies required to achieve these targets -- challenges in surmounting poverty, meeting

the basic needs and integrating the environment into economic decisions -- deserve the attention of public leaders and policymakers. In this context a common definition used by Brundtland et al. (1987) and Elliot (2006) states that sustainable development is committed to satisfying the needs of the current generation without negative effects on its ability to satisfy the needs of future generations. They point out that sustainable development is fundamentally about reconciling development and the environmental resources on which society depends.

There are other definitions of SD as well but all of them have interactions between social equity, economic efficiency and environment protection as their common denominators (see Ciegis et al., 2009; European Council, 2006; Roosa, 2010) over a long period of time (UNECE, 2009). Hanf (1995) emphasizes that environmental protection should not be seen as being in competition with economic growth and development, but instead as an essential precondition for such growth and development. Expressing the same meaning, FAO (1989) defined sustainable development as the management and conservation of the natural capital stock and the quantitative and qualitative changes in technological and institutional sectors to ensure the sustained attainment and dynamic satisfaction of human needs for all generations. As per FAO (1989), there should be no negative effects on the environment and the techniques used should be appropriate with high economic viability and social acceptability.

2.2 Theoretical Literature Review: Principles of Sustainable Development

Harris et al., (2001) and Harris (2000, 2003) identified the principles which emerge from a discussion of the three dimensions of sustainable development. These include: (1) conservation of natural capital, (2) limiting the scale of the population and total resource demand, (3) practices consistent with sustainable development, and (4) social equity focusing on the fulfillment of basic health and educational needs as well as participatory democracy. This list was extended to include more principles underlying sustainable development: (5) a stable population level (Arrow et al., 1995) or slowing rates of population growth, (6) harmful practices to the world soil and water settings (Harris and Kennedy, 1999; Pinstrup-Andersen and Pandya-Lorch, 1998; Pretty and Chambers, 2000), (7) adapting non-fuel energy systems to local conditions (IPCC, 2001a, 2001b; Johansson and Goldemberg, 2002; MacKenzie, 1996), (8) “industrial ecology” that implies lowering pollution and recycling raw materials at all levels of the production process; this is also referred to as corporate reform and greening (Ayres and Ayres, 1996; Frosch, 1992; Frosch and Gallopoulos, 1989; Socolow, 1994), and (9) conservation of natural resources, sustainable harvesting and strong involvement of local communities in conservation (Ene et al., n.d.; UNEP, 2000, 2002; UNDP et al., 2000).

These principles are applied to the three dimensions of sustainable development -- economic equity, social equity and environmental equity. This means that it is now accepted that the global challenge to sustainability lies in the complex interdependencies of environmental, social and economic development (Briassoulis, 2001; Pinter et al., 2013; Potter et al., 2004).

2.3 Theoretical Literature Review: Measurement of Sustainable Development

Different institutions have developed measures and indicators of sustainable development. UNECA (n.d.) underlines that the quest for achieving sustainable

development has led to the development of various tools and measures for structuring and conducting sustainable development policy analyses. Most of these tools and measures emphasize the importance of frameworks that synchronize the principles and dimensions of sustainable development. A summary of some of these indicators is given by Sea (1997) and includes the poverty headcount (HC) index, the human development index (HDI), the physical quality of life index (PQLI), per capita income, poverty gap indices and Gini coefficient (G) (also see, the World Bank, 2005).

Indicators were developed in the 1970s for measuring progress in development and ranking countries as per a commonly defined scale. A pioneer in this field was the Social Indicators Program of the Organization of Economic Cooperation and Development (OECD), which integrated environment in urban development systems (OECD, 1978, 1982, 2004). In social sciences, Bauer (1966), Biderman (1966) and Sheldon and Moore's (1968) pioneering work focused on frameworks for social development indicators. Their main purpose was defining and measuring social progress and establishing national goals and priorities.

Over the years, different measures have been used for analyzing sustainable development including the capability approach, the life cycle approach (LCA), the sustainable livelihood approach (SLA), the basic needs approach (BNA), the physical quality of life index (PQLI) and the human development index (HDI).

The capability approach is a broad normative framework for evaluating individual well-being and social arrangements and the design of policies and proposals on social change (Robeyns, 2003). It is used for evaluating a wide variety of aspects of people's well-being such as individual well-being, inequality and poverty. It can also be used as an alternative evaluation tool for a social cost-benefit analysis, or for designing and evaluating policies ranging from the design for a welfare state in affluent societies to development policies by governments and non-governmental organizations (NGOs) in developing countries (Fukuda-Parr, 2003; Fukuda-Parr, 2003). Some aspects of the capability approach can be traced back to, among others, Aristotle, Adam Smith, John Stuart Mill and Karl Marx (see Nussbaum, 1988, 2003; Sen 1993, 1999), but this approach in its present form has been pioneered by economist and philosopher Amartya Sen (1980, 1984, 1985b, 1985a, 1987, 1992, 1993, 1995) (Drèze and Sen, 2002). More recently it has also been significantly developed by Nussbaum (1988, 1992, 1995, 2000, 2002a, 2003a).

The life cycle approach (LCA) is another measure of SD. De Haes and Van Rooijen (2005) report that living organisms and products have life cycles like living organisms. According to where living organisms originate, reproduce and eventually die, products are produced from raw materials, that are used by consumers and eventually disposed of. They add that products can interact with the environmental (extraction or addition of substances and land use), economic (the cost of producing a product, implementing technologies and profit) and social domains (employment and workers' rights). The relations between the environmental, economic and social domains are quite dynamic. The implementation of cleaner technologies decreases environment pollution but may increase the cost of making the product at least in the short term.

The sustainable livelihoods approach (SLA) is one of the methods used for assessing livelihoods of poor households (Kamaruddin and Samsudin, 2014; Krantz, 2001). In contrast to other measures of SD, SLA is a multidimensional, integrated and rational

approach to poverty eradication. This concept was first introduced by the Brundtland Commission on Environment and Development in 1987 and later elaborated upon at the United Nations Conference on Environment and Development in 1992 (IISD, 2013). As a concept, the sustainable livelihoods approach provides a more rounded picture of the complexities of living and surviving in poor communities than on an understanding based on measures of income, consumption and employment (Brocklesby and Fisher, 2003). A livelihood comprises of the capabilities, assets and activities required for generating a means of livelihood. This is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets while not undermining the natural resource base (Chambers and Conway, 1992; Scoones, 1998). A fundamental feature of the sustainable livelihoods framework is an analysis of five different types of assets owned by individuals for their livelihoods -- natural, social, human, physical and financial capital (Ashley and Carney, 1999; Bebbington, 1999; Carney, 1998).

According to Morse et al., (2009), the sustainable livelihoods analysis (SLA) became a dominant approach in implementing development interventions by a number of major international agencies in the 1990s. SLA first sought to identify important assets in a livelihood, their trends over time and space as well as the nature and impact of shocks and stresses (environmental, economic and social) on these assets. Hence, this approach can be said to be a practical framework for evidence-based interventions; it has much logic behind it, especially in a world undergoing rapid changes where resources for supporting development interventions are limited. According to Serrat (2008), the sustainable livelihoods approach improves our understanding about livelihood options for the poor. He underlines that this approach enhances livelihood opportunities and explains the relationships among them. He adds that SLA can help plan development activities and assess the contribution that existing activities have made to sustaining livelihoods.

The basic needs approach (BNA) was a response to the idea that monetary growth – economic and income – alone would promote human well-being through a trickle-down effect. Developed in the 1970s, BNA promoted the construction of selective policies to target basic needs of the whole population directly rather than focusing on an indirect approach to satisfying basic human needs. At a basic level, BNA includes satisfying minimum levels of material needs such as consumption of food, shelter and clothing and access to such essential public services as pure water, sanitation, public transport, health and education. Under this approach a direct attack on the basic needs of a population is considered cost effective and speedy as well as a mechanism for redistributing social products by aiming at direct satisfaction of the most urgent needs of the poor (Streeten, 1982). When it was introduced the implications of BNA for public finances and inequality meant that in an era of a debt crisis, the imposition of structural adjustment programs (SAPs) overtook BNA and became the prominent method of development particularly in developing countries (Stewart, 2006).

The physical quality life index (PQLI) was developed by David M. Morris in 1979 (Sen, 1997). It combined information on life expectancy, infant mortality and literacy and was a precursor to HDI (which has different dimensions as discussed later). Like HDI, PQLI gives equal weight to the attributes of the composite index under the assumption that they are equally important in capturing the defined aspects of the concept. The human development index (HDI) is a composite index of four indicators -- income index, adult literacy index, gross enrolment index and education index (Todaro and Smith, 2009). Its

components reflect three major dimensions of human development: longevity, knowledge and access to resources. These represent three essential choices for human beings to attain high levels of welfare status to gain the knowledge and means required for improved welfare conditions. These dimensions are derived from the notion of human capabilities as proposed by Sen (1985a) and are regarded as being essential requirements for enhancing human capabilities. HDI has scored various attempts at development since its introduction in 1990 (Sea, 1997; Stanton, 2007; UNDP, 1992). HDI marks further development of the indicators for measuring human development and ranking countries on a commonly defined scale. HDI is a composite tool that measures the average achievement of a country in three dimensions: (a) longevity, (b) educational attainment, and (c) the standard of living. Since 1990, the Human Development Report has been ranking countries according to their achievements in human development (UNDP, 2000).

2.4 Empirical Literature Review

Different scholars have researched sustainability using the sustainable livelihoods approach (LCA). In Malaysia, Kamaruddin and Samsudin (2014) comprehensively measured all the livelihood elements of the rural poor households by developing a sustainable livelihood index (SLI) based on the sustainable livelihoods approach (SLA) framework. They first identified 22 livelihood asset and outcome indicators from the dataset and broadly grouped these into five asset groups -- human, physical, natural, social and financial -- and two groups of livelihood outcomes -- food security and health status. Then, an aggregate SLI for each household was constructed by averaging all the seven groups of livelihood asset and outcome indices with an equal weight. With reference to household incomes that it considered as a poverty indicator, the study found that SLI moved in tandem with total household income. The hardcore poor group had 90.91 percent of the households with SLI below 0.5 indicating that households with low incomes also had low SLI. The authors recommended the use of SLI as a more analytically rigorous tool as compared to the use of household income levels alone to assess the ability and preparedness of the rural poor. In addition, local authorities broadened their scope in manageable ways to ensure the sustainability of a specific project.

In India, Sajjad et al., (2014) analyzed spatio-temporal variations in agricultural sustainability in Vaishali district in Bihar by creating a sustainable livelihood security index (SLSI). Their results showed that persistently increasing inequalities, improper management of resources, natural calamities and exponential population growth had created a significant threat to the successful development of sustainable agriculture in the study area. A SLSI-based spatio-temporal analysis showed that there were wide variations in agricultural sustainability and its three aspects (ESI, EEI and SEI) within blocks during 2000-03 and 2007–10. SLSI also proved to be an effective planning instrument for analyzing the performance and changing status of three aspects of sustainable agricultural development in different blocks in the district. SLSI identified blocks which required immediate attention for sustainable development of agriculture (SDA) and helped focus on priorities for attaining livelihood security. Therefore, the SLSI approach can best be used for assessing sustainable agricultural development and creating a holistic perspective on environment and socioeconomic development in a region. Further, in India Sajjad and Nasreen (2016) examined agricultural sustainability

among farming communities in Vaishali following the SLSI approach which is characterized by three interacting component indices (ecological security, economic efficiency and social equity). Their analysis showed that the SLSI approach helped identify priorities for attaining farmers' agricultural sustainability.

Other research has also been conducted using SLA, for example, Arnamath and Saranya (2014), Hatai and Sen (2008), Lindenberg (2012) and Singh and Hiremath (2010).

3. Materials and Methods

3.1 Sources of data and selection of variables

The Republic of Rwanda is located in east-central Africa. It is the 149th largest country in the world and is ranked at the fourth position among the smallest countries in Africa. It is composed of five provinces, 30 districts and 416 administrative sectors. With a size of 26,338 square kilometers, it has the Democratic Republic of the Congo on its west, Uganda on the north, Tanzania on the east and Burundi on the south. It is a country with many hills and mountains located at a high altitude where the lowest point is 950 meters above sea level. Rwanda's population was estimated at 11,689,696 in 2012 with a density of 415; 83.5 percent of the population lived in rural areas and 28.6 percent households were female headed (NISR, 2012). The projected life expectancy at birth was 66.6 years. With a labor force participation of 73.6 percent, a majority of the employed population in Rwanda was self-employed in the agriculture sector (62 percent), followed by employees (19 percent). Among the non-agricultural sectors, those with the highest employment rates were wholesale and retail trade (22 percent), construction (15 percent), manufacturing (12 percent) and households (11 percent) (NISR, 2012).

With the intent of assessing agricultural sustainable development in Rwanda, my study used district level data collected from the National Institute of Statistics of Rwanda (NISR) on selected variables (depending on availability). The selected variables are described in Table 1.

Table 1. Selection of variables for measuring agricultural sustainability

Ecological variables	Economic variables	Social variables
Population density (Pop/km^2)	Crop (cereals) yield (Qtty/ha)	Literacy rate (%)
Forest cover (%)	Chemical fertilizer use (%)	Health insurance rate (%)
Livestock size (Cattle)	Organic fertilizer use (%)	Electrification (%)
		Primary s. enrolment (%)

3.2 *Method of data analysis*

SLSI was introduced as a methodology in 1991. It is consistent with the three-dimensional conception of sustainability as it has the three interacting components of ecological security, economic efficiency and social equity (Swaminathan, 1991). SLSI was developed as an approach by UNDP as a generalization method for measuring HDI

(UNDP, 1992). It is a cross-sectional measure to evaluate the relative sustainability status of a given set of entities. SLSI serves as an educational and policymaking instrument for assessing the potentiality of sustainable development (Swaminathan, 1991). It explains livelihood aspects that ensure environmental protection, economic efficiency and social equity. The intimate conceptual, casual and operational linkages between SLSI and other welfare goals like poverty alleviation, meeting basic needs for human development and quality of life (Saleth and Swaminathan, 1993) justify its use in studying sustainable development.

In line with the operationalization of sustainable development, SLA in the form of SLSI is identified by three propositions (Becker, 1997; Hatai and Sen, 2008; Swaminathan, 1991). First, SD's three-dimensional conceptions are ecological security, economic efficiency and social equity in both intra and inter-regional contexts. Second, SD's dynamic and contextual nature implies that any sustainability evaluation needs to be relative rather than absolute in both time and space. Lastly, in an operational context, the multidimensional conception of SD requires SLSI to be a composite of three indices – the ecological security index (ESI), the economic efficiency index (EEI) and the social equity index (SEI) so that it can take stock of both the conflicts and the synergies among SD's ecological security, economic efficiency and social equity aspects (Hatai and Sen, 2008; Swaminathan, 1991).

SLSI is computed through three steps. The first step concerns each variable in the three dimensions of sustainable development: Let X_{ijk} be the variable we are required to calculate in the sustainability index. Two formulae are used depending on whether the concerned variable has positive or negative implications for SLS. In case of positive implications, the SLSI formula is (Hatai and Sen, 2008):

$$(1)\quad SLSI_{ijk} = \frac{X_{ijk} - \min_k X_{ijk}}{\max_k X_{ijk} - \min_k X_{ijk}}$$

In case of negative implications, SLSI is calculated by the formula (Hatai and Sen, 2008):

$$(2)\quad SLSI_{ijk} = \frac{\max_k X_{ijk} - X_{ijk}}{\max_k X_{ijk} - \min_k X_{ijk}}$$

In Eqns. (1) and (2), *i* is a variable (for example, GDP) in a dimension *j* (like economic efficiency) and *k* is a district in Rwanda.

The second step is computing sustainability at the level of each component or dimension of SD. The means that the economic efficiency index (EEI), the social equity index (SEI) and the environmental security index (ESI) are estimated separately starting from the sustainability indices estimated at the individual variable level.

The calculation of $SLSI_{ijk}$ for all variables serves as a precedent to the computation of different constituents of SLSI using a formula of a simple mean of their respective variables. For this, the following formula is used (Hatai and Sen, 2008):

$$(3)\quad SLSI_{jk} = \frac{\sum_{i=1}^{I} SLSI_{ijk}}{I}$$

where j=1, 2, 3, ……, J (representing the dimensions of sustainable development) and k=1, 2, 3, ….., K (representing the districts).

Then the composite indicator for each district is calculated (see Eqn. 4) as a weighted mean of the component indices obtain from Eqn. 3 (see Hatai and Sen, 2008):

$$(4)\quad SLSI_{jk} = \frac{\sum_{i=1}^{j} W_{jk} SLSI_{ijk}}{J}$$

Finally, the relative SLSI is computed at the country level where EEI, SEI and ESI are weighted while calculating the sustainability of each district in Rwanda. The procedure of weighting can be summarized as: computing the inverse of the proportional shares of ESI, EEI and SEI in SLSI. Therefore, the coefficients used to weight the constituents of each index will be the ratio of its inverse contribution to the sum of all the three inverse proportions.

4. Results and Discussion

For the environmental dimension my study shows that ESI ranged from 0.19 to 0.77, implying that districts in Rwanda have large disparities in aspects that impact environmental sustainability. Districts with a high index have better environmental performance (or less negative impacts on the environment) whereas those with a low index have poor environmental performance (or high negative impacts on the environment). The top five districts with the highest ESI were Kayonza, Nyaruguru, Gicumbi, Nyagatare and Nyamagabe; and the five with the lowest ESI were Kicukiro, Rubavu, Nyarugenge, Ngoma and Musanze. It was also seen that rural districts were more environmentally sustainable as compared to urban districts and only 14 districts had ESI equal to or above 0.50.

Results on the economic dimension indicate that EEI varied from 0.33 to 0.69 which implies relatively diverse economic performance among the districts. Districts with high EEI scores had better economic performance, that is, the resources were used for satisfying the maximum needs of the people, whereas districts with low EEI were not optimizing the use of available resources. The top five districts with the highest EEI were Gatsibo, Nyaruguru, Kicukiro, Rulindo and Gicumbi and the five districts with the lowest EEI were Rubavu, Kirehe, Muhanga, Rusizi and Bugesera. The results show that only 10 districts had EEI equal to or above 0.50; rural districts performed better than urban ones.

Results on the social dimension showed that SEI ranged from 0.15 to 0.88, implying varied social performance among the districts. Districts with high SEI had high levels of social welfare whereas districts with low SEI had low social welfare. The top five districts with the highest SEI were Kicukiro, Nyarugenge, Gasabo, Gakenke and Musanze; and the bottom five districts with the lowest SEI were Nyaruguru, Ngoma, Rubavu, Gisagara and Nyanza. The study shows that urban districts performed better on the social dimension as compared to the rural districts, and only 12 districts had SEI equal to or above 0.50.

Overall, SLSI ranged from 0.27 to 0.64 which shows that all the districts had large disparities in developmental sustainability. This implies that human activities and the use of resources impacted the environment differently and contributed at different rates to

the socioeconomic welfare of the people. The results also indicate that performance in terms of sustainability was different in the districts. Districts with high SLSI were more committed to environmental protection and conservation than districts with low SLSI as districts with high SLSI adopted sustainable practices of environmental management. The top five districts with the highest SLSI were Gasabo, Gatsibo, Gicumbi, Gakenke and Rulindo, and the lowest five were Rubavu, Ngoma, Gisagara, Kirehe and Bugesera. Only 10 districts (33 percent) had SLSI equal to or greater than 0.50, which implies that Rwanda needs to enhance environment management by adopting economic activities that promote the socioeconomic welfare of people; these activities also need to be environmental friendly.

5. Conclusions and Recommendations

This paper investigated sustainable development in different districts in Rwanda. Based on the theoretical framework it considered three dimensions -- environmental, economic and social -- to elaborate on policies for improving citizens' welfare. In the first dimension (environmental), the results show that this ranged from 0.19 to 0.77, indicating that there were disparities in the districts in terms of impacting environmental sustainability. Districts with high EEI had better economic performance, meaning that the resources were allocated for maximizing the needs of the people, while the ones with low EEI were not optimizing the use of available resources. This conclusion is drawn on the basis of EEI as it varied between 0.33 to 0.69. Further, rural districts performed better than urban ones. My study also shows that urban districts performed better socially as compared to rural districts as SEI ranged from 0.15 to 0.88. This implies that districts with high SEI recorded higher levels of social welfare whereas districts with low SEI had low levels of social welfare.

Finally, large disparities were seen in dimensions of development sustainability in SLSI which ranged from 0.27 to 0.64 showing that human activities and the use of resources impacted the environment differently and contributed at different rates to the socioeconomic welfare of the people. Hence, I recommend strengthening sustainability development, particularly its environmental, economic and social dimensions by following activities which are environmentally friendly.

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Table 1. Ecological, economic and social sustainability variables selected for sustainable development in Rwanda

No	District	Pop./km^2 Census2012	Forest cover (%)	Livestock size (Cattle)	Crop yield (kgs/ha) of Maize A 2017	Chemical fertil. use (%)	Organic fertil. use (%)	Literacy rate (%)	Villages electrified (%)	Health insurance (%)	Primary school enrolment (%)
1	Nyarugenge	2,124	18.7	47,470	661	10.70	6.10	88.40	75.70	63.90	94.60
2	Gasabo	1,234	16.0	121,006	754	19.10	14.80	88.50	68.30	71.20	92.90
3	Kicukiro	1,911	5.3	68,559	1,624	12.80	6.80	90.50	80.60	76.90	95.10
4	Nyanza	482	9.8	67,647	899	19.20	8.70	70.00	10.90	56.80	91.60
5	Gisagara	475	10.1	44,037	1,215	39.80	12.40	64.80	0.90	68.80	87.50
6	Nyaruguru	291	26.2	69,936	2,177	56.10	15.60	63.30	2.90	55.60	89.10
7	Huye	565	16.4	57,885	457	37.40	17.70	72.40	17.20	78.90	92.40
8	Nyamagabe	313	21.4	65,487	1,219	51.90	14.00	69.30	5.90	64.40	91.00
9	Ruhango	510	7.8	61,894	514	19.20	10.00	70.70	8.90	67.10	93.00
10	Muhanga	493	18.3	72,623	850	31.90	8.00	74.20	17.50	63.90	97.20
11	Kamonyi	519	9.6	71,674	876	29.50	9.10	67.00	8.90	84.90	95.10
12	Karongi	334	13.7	65,655	1,626	50.70	11.40	70.00	9.30	67.20	94.30
13	Rutsiro	281	7.3	60,868	1,451	41.00	14.10	65.80	7.30	68.90	90.60
14	Rubavu	1,039	6.8	41,206	1,280	46.50	4.50	72.60	27.70	54.30	86.10
15	Nyabihu	555	10.5	45,880	1,460	66.80	16.40	70.90	10.40	78.00	92.90
16	Ngororero	491	14.0	79,557	1,228	46.70	16.50	61.00	5.20	81.90	92.00
17	Rusizi	418	9.9	43,152	1,041	46.50	11.50	73.00	28.60	71.90	91.40
18	Nyamasheke	325	11.7	54,760	1,097	50.20	16.20	69.90	9.40	64.80	94.70
19	Rulindo	507	19.5	70,400	1,259	38.40	19.30	70.70	9.00	68.50	96.20
20	Gakenke	480	17.3	88,996	1,409	71.80	20.60	74.30	4.60	86.80	96.80
21	Musanze	694	7.6	52,934	1,505	58.00	22.20	73.70	23.60	78.80	95.40
22	Burera	522	7.0	60,892	1,432	55.10	14.50	66.20	10.00	81.30	93.90
23	Gicumbi	477	17.2	103,783	1,401	22.20	12.20	70.40	4.00	75.60	95.80
24	Rwamagana	460	5.4	63,024	1,182	36.00	10.10	77.70	26.70	75.70	93.70
25	Nyagatare	242	3.1	136,016	1,977	14.20	2.60	69.10	19.80	72.90	90.20
26	Gatsibo	274	21.4	93,562	1,666	22.20	13.30	71.30	13.40	72.80	91.40
27	Kayonza	178	1.0	65,958	810	18.00	6.50	72.20	17.10	75.20	93.30
28	Kirehe	287	7.9	59,588	543	28.10	9.90	68.90	8.40	65.80	90.40
29	Ngoma	388	1.2	58,481	1,213	30.20	6.60	54.10	6.80	68.60	91.20
30	Bugesera	280	6.1	59,341	804	13.20	4.00	73.50	13.70	72.70	89.60
	Max	2,124	26.2	136,016	2,177	71.80	22.20	90.50	80.60	86.80	97.20
	Min	178	1.0	41,206	457	10.70	2.60	54.10	0.90	54.30	86.10
	Max-Min	1946	25.2	94,810	1,720	61.10	19.60	36.40	79.70	32.50	11.10

Table 2. Ecological sustainability indices, economic sustainability indices, and social sustainability indices in Rwanda

No	District	Ecology Security Index (ESI)			Economic Efficiency Index (EEI)			Social Equity Index (SEI)			
		Pop index	Forest index	Livestock index	Yield index	Chemical fertilizer index	Organic fertilizer index	Literacy index	Electrification index	Health insurance index	Prim. school enrolment index
1	Nyarugenge	0.00	0.70	0.07	0.12	1.00	0.18	0.94	0.94	0.30	0.77
2	Gasabo	0.46	0.60	0.84	0.17	0.86	0.62	0.95	0.85	0.52	0.61
3	Kicukiro	0.11	0.17	0.29	0.68	0.97	0.21	1.00	1.00	0.70	0.81
4	Nyanza	0.84	0.35	0.28	0.26	0.86	0.31	0.44	0.13	0.08	0.50
5	Gisagara	0.85	0.36	0.03	0.44	0.52	0.50	0.29	0.00	0.45	0.13
6	Nyaruguru	0.94	1.00	0.30	1.00	0.26	0.66	0.25	0.03	0.04	0.27
7	Huye	0.80	0.61	0.18	0.00	0.56	0.77	0.50	0.20	0.76	0.57
8	Nyamagabe	0.93	0.81	0.26	0.44	0.33	0.58	0.42	0.06	0.31	0.44
9	Ruhango	0.83	0.27	0.22	0.03	0.86	0.38	0.46	0.10	0.39	0.62
10	Muhanga	0.84	0.69	0.33	0.23	0.65	0.28	0.55	0.21	0.30	1.00
11	Kamonyi	0.82	0.34	0.32	0.24	0.69	0.33	0.35	0.10	0.94	0.81
12	Karongi	0.92	0.50	0.26	0.68	0.35	0.45	0.44	0.11	0.40	0.71
13	Rutsiro	0.95	0.25	0.21	0.58	0.50	0.59	0.32	0.08	0.45	0.41
14	Rubavu	0.56	0.23	0.00	0.48	0.41	0.10	0.51	0.34	0.00	0.00
15	Nyabihu	0.81	0.38	0.05	0.58	0.08	0.70	0.46	0.12	0.73	0.61
16	Ngororero	0.84	0.52	0.40	0.45	0.41	0.71	0.19	0.05	0.85	0.53
17	Rusizi	0.88	0.35	0.02	0.34	0.41	0.45	0.52	0.35	0.54	0.48
18	Nyamasheke	0.92	0.42	0.14	0.37	0.35	0.69	0.43	0.11	0.32	0.77
19	Rulindo	0.83	0.73	0.31	0.47	0.55	0.85	0.46	0.10	0.44	0.91
20	Gakenke	0.84	0.65	0.50	0.55	0.00	0.92	0.55	0.05	1.00	0.96
21	Musanze	0.73	0.26	0.12	0.61	0.23	1.00	0.54	0.28	0.75	0.84
22	Burera	0.83	0.24	0.21	0.57	0.27	0.61	0.33	0.11	0.83	0.70
23	Gicumbi	0.85	0.64	0.66	0.55	0.81	0.49	0.45	0.04	0.66	0.87
24	Rwamagana	0.86	0.17	0.23	0.42	0.59	0.38	0.65	0.32	0.66	0.68
25	Nyagatare	0.97	0.08	1.00	0.88	0.94	0.00	0.41	0.24	0.57	0.37
26	Gatsibo	0.95	0.81	0.55	0.70	0.81	0.55	0.47	0.16	0.57	0.48
27	Kayonza	1.00	0.00	0.26	0.21	0.88	0.20	0.50	0.20	0.64	0.65
28	Kirehe	0.94	0.27	0.19	0.05	0.72	0.37	0.41	0.09	0.35	0.39
29	Ngoma	0.89	0.01	0.18	0.44	0.68	0.20	0.00	0.07	0.44	0.46
30	Bugesera	0.95	0.20	0.19	0.20	0.96	0.07	0.53	0.16	0.57	0.32

Table 3. Ecological security, economic efficiency, social equity and sustainable livelihood security status in Rwanda

No	District	Ecological security status		Economic efficiency status		Social equity status		Sustainable livelihood security status			
		Ecological Security Index (ESI)	Ranks	Economic Efficiency Index (EEI)	Ranks	Social Equity Index (SEI)	Ranks	Sustainable Livelihood Security Index (SLSI)	Ranks	Relative Sustainable Livelihood Security Index (SLSI*)	Ranks
1	Nyarugenge	0.26	28	0.43	22	0.74	2	0.47	16	0.72	9
2	Gasabo	0.63	7	0.55	9	0.73	3	0.64	1	0.93	1
3	Kicukiro	0.19	30	0.62	3	0.88	1	0.56	6	0.85	5
4	Nyanza	0.49	15	0.48	14	0.28	26	0.42	24	0.58	26
5	Gisagara	0.41	24	0.49	11	0.22	27	0.37	28	0.51	28
6	Nyaruguru	0.75	2	0.64	2	0.15	30	0.51	9	0.68	16
7	Huye	0.53	12	0.44	20	0.51	8	0.49	12	0.71	11
8	Nyamagabe	0.67	5	0.45	19	0.31	23	0.47	17	0.65	18
9	Ruhango	0.44	19	0.42	24	0.39	21	0.42	25	0.59	24
10	Muhanga	0.62	8	0.39	28	0.51	9	0.51	10	0.72	10
11	Kamonyi	0.50	13	0.42	25	0.55	7	0.49	13	0.71	12
12	Karongi	0.56	11	0.49	12	0.42	16	0.49	14	0.69	15
13	Rutsiro	0.47	16	0.56	8	0.31	24	0.45	20	0.62	22
14	Rubavu	0.26	29	0.33	30	0.21	28	0.27	30	0.37	30
15	Nyabihu	0.41	25	0.46	17	0.48	13	0.45	21	0.65	19
16	Ngororero	0.59	10	0.52	10	0.41	18	0.51	11	0.71	13
17	Rusizi	0.42	20	0.40	27	0.47	15	0.43	23	0.62	23
18	Nyamasheke	0.50	14	0.47	16	0.41	19	0.46	19	0.65	20
19	Rulindo	0.62	9	0.62	4	0.48	14	0.57	5	0.81	6
20	Gakenke	0.67	6	0.49	13	0.64	4	0.60	4	0.86	2
21	Musanze	0.37	26	0.61	6	0.60	5	0.53	8	0.77	8
22	Burera	0.42	21	0.48	15	0.50	10	0.47	18	0.67	17
23	Gicumbi	0.72	3	0.62	5	0.50	11	0.61	3	0.86	3
24	Rwamagana	0.42	22	0.46	18	0.58	6	0.49	15	0.71	14
25	Nyagatare	0.68	4	0.61	7	0.40	20	0.56	7	0.78	7
26	Gatsibo	0.77	1	0.69	1	0.42	17	0.63	2	0.86	4
27	Kayonza	0.42	23	0.43	23	0.50	12	0.45	22	0.65	21
28	Kirehe	0.47	17	0.38	29	0.31	25	0.39	27	0.54	27
29	Ngoma	0.36	27	0.44	21	0.21	29	0.35	29	0.48	29
30	Bugesera	0.45	18	0.41	26	0.39	22	0.42	26	0.59	25