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The Impact of Population Growth on Land Degradation, Case of Rwamagana District (2000-2020)

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Abstract:- The main objectives of this study were to assess the impacts of the population growth on land degradation over a period of 20 years. Specific objectives of the study sought to assess the trend of population growth in the study area, to analyze the extent to which land is being degraded in Rwamagana district and to establish the relationship between population growth and land degradation. To achieve these objectives, the study utilized quantitative research approach and three land-sat satellite imageries (2000ETM, 2010 &2020 ETM+) that were processed and analyzed using ERDAS IMAGINE and GIS software to produce GIS maps to detect and quantify land cover changes in Rwamagana district during the years: from 2000 - 2010, and 2010 - 2020. The increase in human population has put tremendous pressure on natural resources. In Rwanda, the growing human population is associated with an increase in developmental needs thus posing a threat to the land resource. This problem has been noted in the high potential areas of the country which support a large population seeking to fully exploit the land resources for their livelihoods and welfare Increasing land use may lead to erosion if hills are farmed, or to a reduction in soil fertility if fallow periods are shortened to the point that the land has insufficient time to replace lost nutrients. For the study, both secondary and primary data were used. The secondary data were collected from population data of 2000, 2010 and 2020. The study result revealed that both population number and density was increased from 2000-2020, and Built up has been increasing from 30.6% t0 47.6%. Due to high population growth, agricultural practices have expanded into upland and marginal areas, and clearing of vegetated has become prevalent. Thus, the existing population growth puts pressure on land resources degradation in the study. However, the utilization of fertilizer and terracing can prevent such degradation. Land degradation can be the result of efficient depletion of land resources for production. In Rwamagana district, human population has been increasing over the years, people have changed land use, and land cover and thus it has been leading to the land degradation. An accuracy assessment of the satellite imageries classification was conducted with field assessment points as reference data and an overall accuracy was determined. The outcomes of the land use maps will be used to evaluate the impact of population growth and their human activities on the land and show that major changes in land use land cover that have occurred. Based on the research findings, the recommendations were provided.

***Keywords*:-** *Population, Growth, Land Use, Land Cover , Degradation*

I. INTRODUCTION

Population pressure on the environment primarily results in overuse and improper management of natural resources, as well as waste production that is directly linked to environmental stress, which causes biodiversity loss, air and water pollution, and increased pressure from people and animals on arable land (Phong, 2004; Tarawneh, 2014). In other studies Asfaw (2018) have stated that "land degradation is defined as the loss of the land's productivity and its capacity to produce goods or services, either quantitatively or qualitatively, as a result of natural or human-induced changes in physical, chemical, and biological processes." Land degradation is a persistent decrease in the rate at which a given area of land produces goods that can be used for local subsistence within an acceptable amount of time. (Barnieh et al., 2020). Degradation of the land's ability to generate in the present or the future is another term for it (Shalaby & Tateishi, 2007). Other academics have proposed that the basic biophysical reason for the declining per capita food production in Sub-Saharan Africa for the past two decades is land degradation, particularly because of declining soil fertility. About two thirds of African countries rely on agriculture for their livelihoods, and most economic developments in Sub-Saharan Africa are founded on it. Pender (2006) says that the majority of farmers in this area are small holders who have between 0.5 and 2 ha of land and make less than US $1 per day. Many of the farmers have big families, go without food for three to five months, and are undernourished. As a result, the future of the agricultural sector has a direct impact on Africa's economic development, efforts to end poverty, and societal welfare.

Most developing nations, including Rwanda, depend heavily on the exploitation and use of natural resources, particularly in the primary sector like agriculture. Consequently, the development of the economy and society depends on land and land use legislation (MINAGRI, 2018). If the objectives of improved nutrition, economic development, and poverty reduction are to be achieved, greater rapid increases in food production are required over and above past trends, according to analysis of future trends for food and agricultural inputs as well as trends in their supplies (J. Olson, 1994) .

The decline in soil fertility as an overall decline in necessary nutrients and organic matter is presently a serious threat to the productivity of agriculture and food security in Rwanda and Africa as a whole (Nicodemus Osoro et al., 2019).

It is well known that one of the biggest issues threatening global food supply is land degradation. Agricultural practices, changes in land use, the total removal of natural vegetation, the use of heavy equipment and agrochemicals, and changes in hydrological cycles are some of the main causes of land degradation. Wide-ranging effects of such behaviors have been observed both on- and off-site. Through its effects on soil and water quality, biodiversity, and other factors, land use change was shown to be the cause with the greatest environmental impact. As a result, land use practices significantly add to land degradation (Li et al., 2005; Wanyonyi & Ed, 2012). Some studies (Appiah Mensah et al., 2019; Kayiranga et al., 2016) have demonstrated that altering land use can cause soils' physical and chemical characteristics to worsen, as well as the general degradation of the land.

Land degradation has long been recognized as a major problem in Rwanda, especially impacting the country, but important everywhere. Researchers reported that soil losses is between 35 and 246 tons ha/yr., and farmers report declining productivity of their fields (Kayiranga et al., 2016; Nambajimana et al., 2020). An important root cause is the pressure on farm households as a result of a steadily increasing rural population and dramatic changes in farm size to average less than one hectare.

Farmers view the issue more as a reduction in the amount of available manure to fertilize the fields, despite government initiatives emphasizing terracing and other steps to reduce soil loss. A common reaction to declining fertility is to switch crops, producing less cereal and more tubers with lower nutrient contents. However, tuber yields per ha also indicate a sharp decline. (Owino & Ryan, 2014).

Although the costs of degradation of land are difficult to quantify, estimates of the effect of productivity declines point to a loss of at least 3.5% of the agricultural GDP. Changes in crops are causing a decline in the amount of nutrients accessible to rural families, which is a root cause of social unrest and civil conflict in the areas. (Olson, 2014).

II. PROBLEM STATEMENT

The area continues to face significant challenges due to the widespread land degradation, which is exemplified by soil erosion and declining soil fertility, which in turn causes falling output. (Nambajimana et al., 2019). Due to a variety of causes, there are unacceptably high levels of erosion and soil degradation in many small-farm zones (Mlotha, 2018). These include expanding cultivation too close to waterways and encroaching on wetlands, frequent cultivation for seedbed preparation without including conservation of soil measures, cultivation of steep slopes and hillsides, and conversion of important forests into farmland and settlements.

The growing demand for natural resources as a result of rising human population (Abebe et al., 2022). To meet the demands of a large population, more food manufacturing, more energy and water needs, better public facilities for an acceptable standard of living, and infrastructure development to withstand mounting pressure to maintain the standard of living are all necessary. (Bidogeza, 2011). The potential for natural regeneration has been greatly outpaced by the extensive use of traditional fuel, particularly wood, in rural areas of Rwamagana. The outcome has been rapid deforestation, soil erosion, and overall soil depletion. The livelihoods of millions of people around the globe, in both wealthy and poor countries, continue to be threatened by land degradation and desertification, according to the 5th International Conference on Land Degradation (Jitendra, 2016; UNEP, 2018).

As the human population in Rwamagana district has grown over time and land use patterns have altered, less land cover has been created. (Olson, 2021). The goal of the current research was to ascertain the effects of dense population growth on land use and the subsequent land degradation. There is a need for more focused research on ecological-economic interactions and to review national strategies and plans for action to give more attention to property use policies and environmentally sound land management in order to avert land degradation and loss of productive lands in light of the growing effects of resource limitations on the global economy. (Olson, 2021; Rushema et al, 2020).

➢ *Objectives of the Study*
This study paper has a general objective and specific objectives.

- *General objective*

The main objective of this study was to examine the relationship between the human population growth, its activities and land degradation in Rwamagana district, Eastern Province of Rwanda.

- *Specific Objectives*

✓ To assess the trend of population growth in the study area
✓ To analyze the extent to which land is being degraded in Rwamagana district
✓ To establish the relationship between population growth and land degradation

➢ *Hypotheses*

This study verified the null hypotheses follows.

- H_0: There is no significant relationship between the human population growth, its activities and land degradation in Rwamagana district, Eastern Province of Rwanda
- H_1: There is a significant relationship between the human population growth, its activities and land degradation in Rwamagana district, Eastern Province of Rwanda.

III. REVIEW OF LITERATURE

A. Concept of Population Growth

The net rate of people joining the community determines population growth. According to Abebe et al. (2022), it alludes to changes in population size that can be either positive or negative.the country, territory, or geographic area's annual average rate of change in population size over a particular time period. Usually multiplied by 100, it indicates the proportion between the annual growth in population size and the total number for that year. (Meshesha et al., 2016).

Over time, the population increase led to an increased demand for food, increased labor supply, more technological innovations and reduced transaction costs. With favorable market conditions, the subsequent increased cultivation led to a reduction in land degradation. Population pressure and unsustainable human activities such as over-cultivation of land which exhausts the soil, overgrazing which removes the vegetation cover that protects the soil from erosion, deforestation which removes trees and vegetation which binds the soil to the land, and poorly designed irrigation systems that turn the soil saline have been noted by (Beckers et al., 2020) as the key drivers of land degradation in the Southern African region. Land is under immense pressure as agriculture, urban land and wild areas all compete for the same resource degradation problems and on how to address it. Many conservation practices have failed because farmers often have not adopted the recommended conservation practices or have abandoned them once the project ended.

The unprecedented growth of the global population that has occurred since 1950 is the result of two trends: on the one hand, the gradual increase in average human longevity due to widespread improvements in public health, nutrition, personal hygiene and medicine, and on the other hand (Meshesha et al., 2016). High population growth and migration in response to the shortage of land resources are important factors contributing to the degradation of agricultural land in SSA.

Sub Saharan population continues to grow at higher rates than any other region of the world thus increasing the need for more food, fiber, and other resources. (Atsri et al., 2020) confirmed a significant relationship between population pressure, reduced fallow periods, and soil nutrient depletion. This indicates a generally unsustainable nexus between a changing population, agriculture and environment that leads through a downward spiral into a poverty trap (Tayeb & Kheloufi, 2019)

Over the past 30 years, land use in Central Asia has changed significantly due to population increase. He claims that overgrazing, over-cropping, and improper soil fertility management are common causes of land degradation in this region. He also claims that mining, logging, mono-cropping, and alien invasive species also have an impact on some countries' traditional land use. Because most of the world's economies are based on agriculture, land is a valuable resource. Due to climatic regimes, latitudes, altitudes, and topography, the region, which makes up 4.8% of the world's land area, exhibits an extraordinary variety of landforms.

➢ *Population Migration*

Urban population growth outpaces rural population decline due to population migrations. Due to increased pressure from urban development, agricultural areas lose output, become idle, and become less productive (Xia et al., 2019). It was therefore tried to preserve these areas in order to lessen the impact of urban development on the agricultural and natural resources.

However, because housing is a fundamental human need, these efforts were unable to lessen the pressure of urban growth on rural areas. Although we have laws protecting land use planning, it is still in danger due to demographic changes. Urban agricultural areas will shrink as the general desire for population growth concentrates in and around cities (Liu et al., 2019). Rapid urbanization places serious pressure on agricultural land and natural areas due to its effects on developing cities and countries where the majority of the population is anticipated to migrate (Chen et al., 2021).

Rural regions have significantly decreased due to urbanization. (Traore et al., 2021). Cities are the most significant sources of significant problems for rural regions, claim Kuo & Tsou (2017). Natural resources are depleted and biodiversity is reduced as a result of unchecked growth. All of these demonstrate how agricultural and natural areas are endangered by urban growth. (Kasraian et al., 2016). Due to the attractive living conditions, it drives the people of rural areas to urban areas and results in the eradication of rural areas. Additionally, because of the decline in rural population, urban areas view rural areas as potential growth sites.

The problem of rural areas can be better described in areas that have completed their urban development, and still continue to develop *(WHO and UNICEF, 2006)*

➢ *Land Use /Land Cover*

Divergent social theories of change in the environment and different explanatory factors are frequently reflected in explanations of land cover and land use change. A seemingly straightforward variable selection or interpretation may actually reveal a deep disagreement regarding the contribution of humans to environmental change. Some writers contend that increasing populations lead to deforestation and land degradation because they use too much agricultural land or convert forests to fuel for agriculture. (Ogbole, 2013).

Others contend that rather than converting forests, population growth is linked to intensifying the use of already-existing agricultural territory by utilizing more labor and technology. Numerous studies make a distinction between underlying causes, which account for the deeper roots of land use dynamics, and proximate causes, which are directly involved in a land-cover or land-use change.

Land use and land cover change (LULCC), which occurs in developing nations like those in Africa and Asia, is the transformation of various land use categories as a result of intricate interactions between people and their physical surroundings. (Halefom et al., 2018; Negassa et al., 2020). LULCC has a large effect on ecosystem processes and is a significant driver of global change. Land use and land cover (LULC) are constantly shifting in the various ecosystems, endangering sustainability and human livelihood systems (Zachary, 2018).

Due to the strain that the growing human population is putting on the environment, conflicts between various human activities are growing, and biodiversity preservation is becoming more and more important. Deforestation, biodiversity loss, and declining agricultural output have all been brought on by urban settlements and other biodiversity modifications, but almost all changes are related to changes in land use land cover dynamics. (Barnieh et al., 2020; Brempong, 2010).

➢ *Population Age*

More adults than children and adolescents have an impact on changes in land use and cover. Land use transition is the term used to describe how land use trends change as a result of socioeconomic growth and demographic changes. Land use decisions are some of the land use behaviors made by landowners, but their behaviors are restricted by a wide range of factors such as institutions and global markets (Rwanyiziri et al., 2020), which are notable influencing factors of land use transitions. The economic activities performed on land are primarily performed by people aged 18 years and older.

The two most essential components of agricultural production are farmland and agricultural labor, which are also significant elements of the study of human land interactions in rural areas. According to Tutu Benefoh (2008), the labor force is the most active production element in the growth of urban and rural areas. In the dual context of the aging of the rural labor force and the shortage of young and middle-aged labor, family economic growth ability is weakened due to the decline in physiological functions of elderly people.

Farmers must modify their land use choices as rational economic beings in order to deal with the effects of aging on agricultural output (Coulibaly & Li, 2020) and seek the greatest possible economic gains in light of the shrinking labor pool. The adjustment of farmers' land use decisions is shown in two ways: the first is to change the planting structure, which is related to the change in recessive morphology of land use and includes the features of land use in areas like quality, property rights, management style, fixed input, and productive ability.

➢ *Population Density*

Our ecosystem and natural resources may suffer as a result of population density. These pressures could result in overcrowding, deforestation, and the destruction of the delicate ecosystem that makes up our world. Large quantities of nonrenewable resources, such as timber, etc., are used by growing populations. Yalew (2015) demand for developed metropolitan land rises along with population and income potential, shifting land away from agricultural and forestry uses and raising land value. Farmers must farm more efficiently as populations rise and resources for agriculture become more limited. However, if farmers and governments do not develop technologies fast enough, it could lead to the degradation of the land. Stronger land development increases local population while displacing residents from nearby regions. (Dimobe et al., 2017). Although the scale of the current study is large, inter- or intra-area, local, and regional scale population density changes do occur.

B. Land Degradation

The term "land degradation" refers to the decline or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, or woodlands as a result of natural processes, land uses, or other human activities and habitation patterns like land contamination, soil erosion, and so forth (Yang et al., 2020)

Increased cultivation thus prevented further degradation of the soil. Due in part to population pressure forcing more intensive farming, erosion rates per acre in emerging nations are twice as high as the average. Despite being a physical process, soil erosion also has an impact on productivity and development (Deng et al., 2020).

The need for appropriate land use practices that prioritize sustainability and conservation is a result of the enormous losses of soil particles. The lack of vegetation in the majority of Africa's dry lands adds to wind erosion in these regions, which leaves the ground bare. Since the water carries the top fertile soils away, farmlands that are susceptible to this form of degradation also suffer from nutrient depletion and low soil fertility.

Because of its negative effects on agronomic productivity, the environment, food security, and quality of life, land degradation will continue to be a significant global problem in the twenty-first century. There are numerous immediate and indirect effects of land degradation on human livelihoods, vulnerability, and food security. (Mosleh et al., 2016). Concerns over food security, rural livelihoods, and natural factors like biological variety could be very serious as a result of land degradation.

- *Farming and Pressure on Land*

Currently, 11% of the world's land surface is regarded as prime land, which is farmed and used to support roughly more than six billion people. By the year 2020, it is expected that 8.2 billion people will be on the planet and will require food. Soil degradation could jeopardize long-term food productivity if the appropriate steps are not taken. Currently, 16% of the agricultural land has seen a drop in crop yields due to poor management.

In Sub-Saharan Africa, where the livelihood of those who live in dry land regions is constantly in jeopardy, there is the highest rate of land degradation. Modern agricultural practices like overusing pesticides and fertilizers, overwatering saline areas, and shifting agriculture have all added to the degradation of the land (UNEP, 2019). Subsistence farming is the main form of cultivation in the majority of African nations. In the final quarter of the 20th century, Sub-Saharan Africa's agricultural output was the worst among third-world nations.

Traditional production techniques are still the foundation of agriculture, and few contemporary inputs are used. According to Bagstad et al. (2020), Africa is expected to import more than 60 million metric tons of cereal annually by the year 2020 to meet the demand for food. This shows the low level of productivity in this sector, despite the fact that it employs about 67 percent of the labor force in the continent. Over the past two decades, there has been a substantial decline in the food security situation in Africa.

One explanation is that Sub-Saharan African farmers have historically plowed land, raised a few crops, and then moved on to clear more, leaving the previously cleared land fallow to reclaim its fertility. Due to population growth, the natural process of nutrient renewal is no longer feasible in many areas of Africa, and soil nutrient depletion is on the rise. The main factors contributing to land degradation on the continent are overgrazing, the expansion of agricultural lands, and a dearth of outside input. This is due to the fact that many farmers and pastoralists in Africa relocate to new land in response to decreasing land productivity. (Barbier, 2019). Due to increased population pressure, farmers in SSA do not adequately improve their land management techniques to accommodate continuous cultivation and shorter fallow periods.

- *Changes in Land Use and Land Cover*

Around the world, the human-induced alteration of Earth's surface is referred to as land use/land cover change (LULCC). The extent, intensity, and rate of LULCC are much larger now than they were in the past, despite the fact that humans have been altering the land for thousands of years in order to obtain livelihoods and other necessities. Unprecedented local, regional, and global shifts in ecosystems and environmental processes are being driven by these changes. As a result, LULC changes are crucial to the study and research of the current global change scenario because the information on these changes is crucial for informing future decisions about ecological management and environmental planning. (Padmanaban et al., 2017; Xia et al., 2019). Changes in land use and cover have been found to be crucial for a variety of applications, including those in agriculture, the environment, ecology, forestry, geology, and hydrology, according to some studies from various fields. (Fenta et al., 2017).

These applications discussed issues such as the loss of agricultural land, degraded soil, urbanization, altered water purity, etc. At the same time, a significant project to study land use change has emerged as an international endeavor in recent decades, and it has gained great momentum in its efforts to understand the forces driving land use change, according to (Martins et al., 2018). These initiatives have piqued researchers' interest in using a variety of methods to identify and further model the dynamics of the environment at various levels.

Due in large part to the availability of quantitative analysis of the spatial distribution of the population of interest, change detection has become an important process in managing and tracking natural resources and urban development. There are numerous methods that can be used to track and document differences that may also be related to change. (Singh 1989; Yuan et al. 1999). Simple change detection, however, is rarely sufficient on its own; instead, the "from-to" analysis, which requires knowledge of the beginning and final land cover/types/uses, is necessary. Understanding and evaluating the environmental effects of such shifts require accurate and current information on land cover change (Giri et al. 2005).

- *Reduction of Agricultural Land*

One of the primary causes of cultivated land loss and abandonment over the past few decades has been the decline and aging of the rural populace in many nations (Martnez, 2015). However, despite going through comparable rural demographic shifts, some areas have seen an increase in cultivated land, and the farming-pastoral ecotone is a common one.

Human population and agricultural output interact in a complex way. There have been ongoing, heated discussions pitting agricultural development against population expansion. Due to population pressure, subsistence agriculture in Africa is particularly susceptible to ongoing droughts and human-induced factors. (Abebe et al., 2022). This analysis reveals that agricultural output and population growth have both risen over time. In contrast to population development, production growth exhibits erratic trends.

Along with land degradation, despite the window of opportunity to collect the demographic dividend being opened up by falling mortality and fertility. (Jarah et al., 2019). The expanding population can access sufficient yields for household incomes as well as home consumption if this chance is combined with effective agricultural policies and strategies. Reduced pressure on land resources can be achieved through effective population policy, improved land resource management, and integrated strategies. As a result, this review indicates that one of the potential solutions is to critically examine agricultural policy and strategies. (Yalew, 2015).

- *Increased Basic Infrastructure Facilities (Housing)*

Rural regions also experience significant demographic changes, even though cities and towns in the developing world show the greatest population change. For decades, those who are interested in agriculture and rural development have assumed that rural populations are growing, frequently quickly. This assumption implies that agricultural production will need to grow even faster, as pressure from an ever-growing rural population increases on natural resources.

Migration from the countryside to the city may alleviate this pressure, but it is generally believed that this causes an excessively rapid urbanization that is characterized by the abundance of slums. The populace is expanding at a rate that has never been seen before. The population of the world has more than tripled since the middle of the 20th century, and is expected to hit almost 8 billion in 2022. According to UN estimates, the world's population could reach almost 11 billion people by the year 2100. However, since roughly 1970, the rate of global development has significantly slowed, and by the end of the century, the world's population is anticipated to stabilize.

One of the major issues causing the slow rate of urbanization and population growth is a lack of fundamental infrastructure facilities (Lu et al., 2022). The possible contribution of the urban sector to the national economic output in many countries has also been negatively impacted.

C. Theoretical Review

- *Individual Behavior Theories*

Research on the well-established relationships between population development and land use has advanced significantly over the last three decades. It is feared that excessive population growth and spending will worsen resource depletion, cause environmental damage, and/or result in ecological collapse or other dangers. The lessons learned also demonstrate the importance of education in establishing a "spirit of responsibility" toward environmental issues and the best solutions for addressing them (Gatzweiler & Baumüller, 2014). population change's impact on the ecosystem, especially on land use in developing nations.

A balance may be struck on the basis of specific cultural patterns of resource management by which the environment's production of particular renewable resources is artificially increased, or it may refer to a population that limits its demand for resources to a level that the environment can naturally supply.

The ecological system will be disturbed by either a rise in resource demand from the people or a fall in resource availability from the environment. The main cause of such disturbance is the pressure from the expanding populace. Systems in ecological disequilibrium are characterized by scarcity and struggle for resources. There has been much discussion about how demographic land scarcity affects agricultural development and sustainability (Warf, 2014).

- *Self-Regulation Theory (SRT)*

Through self-evaluation, motivation, and altering of feelings and perceptions of those behaviors, self-regulation theory (SRT) primarily aims to control an individual's capacity to exhibit a behavior (Julie, 2019).

SRT claims that people who dislike doing boring things will come up with creative ways to make those duties more enjoyable and productive.

Although SRT provides an effective psychological tool for managing and changing behavior, it suffers from a significant operationalization limitation because it includes a number of functions, decision-making processes, ongoing monitoring, and cognitive strategies that are subject to dispute among researchers. According to researchers, continuous self-regulation mechanisms deplete further regulation, causing people to behave negatively in specific circumstances. (Katiyar, 2019).

Additionally, some behaviors are uncontrollable because they are the result of irresistible impulses and exist outside the realm of cognitive awareness. For instance, some claim they overspend on clothing and other personal items simply because they find it impossible to avoid shopping. As a result, there is disagreement over the degree to which self-regulation can be identified as a key element of solid refuse management.

Self-regulation is the capacity to comprehend and control behavior, as well as your responses to emotions and the effects of population development on the deterioration of the environment around you. It entails being able to control how one responds to intense feelings like annoyance, excitement, rage, and embarrassment. after experiencing a thrilling or upsetting event, relax (Raghu & Rodrigues, 2020).

This theory accounts for the intention behavior gap by considering behavioral prepotency and self-regulatory capacity as direct predictors of behavior and as moderators of the intention behavior relationship with population growth (Peter, 2016)

- *Social Behavior Theories (SBT)*

According to social scientists, population growth and land degradation are related, and as a result, societal influence plays a significant part in land degradation (Rene et al., 2018). Additionally, as of 2022, the global population is expanding at a pace of about 0.84% annually. The switch to environmentally friendly waste disposal was strongly correlated with one's self-perceptions, personal outcome expectations, and social stigma (Gidey, 2021).

According to social behavior theory, humans only learn and make choices based on reason, leaving no room for feelings (Raghu & Rodrigues, 2020). Although a learning process may inspire people to manage land and safeguard the environment, this theory. Former researchers (Raghu & Rodrigues, 2022) who recommended the adoption of combined behavior change techniques within interventions to allow synergistic effects and enhance their effectiveness of the contribution in the land use management highlighted the significance of understanding theories and their benefits.

Therefore, expanding land use could result in erosion if hills are cultivated or a decline in soil fertility if fallow times are cut short so that the land doesn't have enough time to replenish lost nutrients (Jolly, 2013). According to the theory, there is a causal connection between population growth, a lack of available land resources, destitution, and land degradation. in keeping with reports on the declining productivity of land resources in developing nations as a result of the ongoing population increase. It is thought that the scarcity of land combined with extremely high population densities will accelerate land degradation, including soil erosion, vegetation loss, waterway drying, and biodiversity loss (Asfaw et al., 2018; Fentahun & Gashaw, 2014).

D. Empirical Review

The past few decades have seen a major change in and degradation of global land use. Population growth has historically been the main cause of soil degradation (Marondedze & Schütt, 2019). Although population increase is frequently used as a stand-in for land use change (Berger & Enflo, 2017), complex drivers also play a significant role at smaller scales. Population development has put more strain on land resources due to the rising demand for food. The goals for reducing land degradation vary between established and developing nations.

Rapid population growth, poverty, and the economic situation are the main driving forces in developing countries, while in developed countries, land use change and land degradation is based on economic reasons such as large-scale farming or urban development and an increasing need to conserve biodiversity and ecological integrity for current and future generations (ZAMAN, 2021). (Zhuge et al., 2019). Since humans have been causing disturbance in the Mediterranean area for thousands of years, it is currently one of the regions in the world that has undergone the most profound change. Sometimes, undeveloped land is subjected to deterioration.

Geographical Information Systems (GIS) are used to manage, analyze, and depict the physical world in the study of land degradation or changes in land use. Through the retrospective (Kayiranga et al., 2016) synoptic viewing of vast areas made possible by satellite remote sensing, changes in land use and land cover may be evaluated in depth both geographically and over time.

The information provided by remote sensing (RS) about the different spatial criteria/factors under consideration includes data on topography, drainage density, land use, and other topics. GIS and RS are effective instruments for integrating and interpreting data. In addition to saving time and producing high-quality data, integrated GIS and RS technology can identify possible new cropland sites.(Martins et al., 2018).

The loss of useful products and services provided by terrestrial ecosystems, that involve soil, vegetation, other plant and animal life, and the ecological and hydrological functions that take place within these systems, is therefore referred to as land degradation. Desertification, deforestation, overgrazing, salinization, and soil erosion are some of the more obvious types of land degradation, and they can all be caused by either human activity or environmental factors. (Maksimovich et al., 2017).

The Causes of land degradation refer to the agents that determine the rate of degradation of the land or the environment. These are biophysical, e.g., land use and land management including deforestation and tillage methods, socioeconomic, and political forces that influence the effectiveness of processes and factors of land.

Land use affects land cover and changes in land cover affect land use. A change in either, however, is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Opeyemi, 2006). As this process continues, land degradation is likely to occur on a varying scale.

Nkonya et al (2021) identified biophysical and unsustainable land management practices as the immediate causes of land degradation. However, unsustainable land management practices, such as deforestation, forest degradation, soil nutrient mining, and cultivation on steep slopes, are also identified as the direct contributors to land degradation.

Population density, poverty, land tenure, and access to agriculturalextension, infrastructure, and markets, as well as policies that promote the use of land degrading practices were outlined as the underlying causes of land degradation (Rwanyiziri et al., 2020).In most parts of the world, land degradation occurs due to human activities and natural factors. Pressure on land use due to urbanization and industrialization exerts excessive pressure on the environment's natural resource base thus causing land degradation in both poor and rich countries of the world.

In Bhutan, for instance,land degradation is said to be mostly manifested in displacement of soil material through water erosion and internal biophysical and chemical deterioration. These processes are reported to be triggered by human induced activities in the mountainous terrain of the country (UNEP, 2019).

Thus land degradation is largely a consequence of socio-economic constraints, dynamics of natural resource systems, and policy distortions on land use and management (Atsri et al., 2020) using remote sensing to study land use change and population growth in Papua New Guinea, reported that the driving force for most land use changes is population growth even though there are other interacting factors.

They stated that the need for increased food production results amongst others, in the conversion of forest and grassland to cropland, a process that accelerates land degradation. A region's or country's ability to supply food to its population is largely determined by productivity of the land, the ability to maintain crop yields, or the ability to purchase imported food (Rajabu, 2017)) used GIS techniques to study the dynamic land use and land cover changes and their effects on forest resources in Zanzibar, Tanzania.

They reported that about 6 million hectares of primary forest is lost annually due to agriculture, logging, and other human activities responsible for land use and land cover changes (Lambin et al., 2003) . With such magnitude of forest losses, there is overall concern on the prevailing land use practices, such as shifting cultivation and extraction of forest materials as important agents of forest losses and degradation. Another major cause of land degradation in the world today is the loss of vegetation due to pressure on forests resulting from increased demand for construction material by both the domestic and industrial sectors. Similarly, firewood extraction from forest lands in poorly developed countries of the world also exerts pressure to forests and increases the rate of deforestation thus causing land degradation (WMO, 2015).

Africa has the world's highest rate of deforestation, according to Ademiluyi et al. (2008). The decline of forest and woodland areas is attributed to competing land uses, primarily agriculture and human settlements, and the increasing demand for fuel wood and charcoal is a significant factor in deforestation and land degradation. Many species in the wild are thought to be declining as a result of overharvesting, farming encroachment, and uncontrolled burning.

Competition for less stressed regions increases as a result of the depletion and degradation of the natural resource base. (Ademiluyi et al, 2018). According to Maitima et al. (2014), continuous grazing without the proper soil and pasture management practices causes soil erosion, which is a common occurrence in heavily grazed areas. Another element that leads to environmental and land degradation is urbanization. A large portion of the young population leaves rural areas for metropolitan areas due to a lack of opportunities and jobs.

Muchena et al. (2015) made the point that decisions rural families face regarding resource allocation, the best places to put their labor and money, and risk-reduction strategies must take land degradation in East Africa into account. Proper investment would support a variety of livelihood strategies in rural areas, including migration, social investments, and off-farm incomes, which in the long run would help to ease the pressure on arable land and ultimately slow the rise in land degradation. Prager et al (2010) outlined three different types of measures that can be effective in supporting soil/ land conservation.

They discussed mandatory measures that are generally in the form of environmental legislation which follow a command and control approach and cross compliance regulations. In South Africa, land degradation is severe and widespread. It threatens food and water security, economic development, and natural resource conservation. The former homelands now called communal lands are a major concern; they are characterized by high human and animal populations, overgrazing, soil erosion, wood harvesting, and the loss of palatable pasture species (Hoffman and Todd, 2020). The trend is attributed to the combination of poverty and failure of regulation arising from both socio-economic changes and a legacy from the previous apartheid regime.

- *Gap Analysis*

Policies that support sustainable development are essential given the challenging economic situation in Sub-Saharan Africa, the weight of rural poverty, and the quick depletion of natural resources. One of the main issues is how a nation can achieve economic development while reducing environmental degradation in the face of a rapidly growing population, scarce resources, and infrastructure issues. The potential of reversing a degradation cycle in favor of conservation, as well as the compatibility of sustainable resource management with rapid population growth, appear to be the two key issues that need to be addressed (Silva et al., 2021).

A healthy balance between five essential ecosystem processes is seriously disrupted by land degradation, which can take many different forms. These include food production, fiber provision, microclimate regulation, water retention, carbon storage, and unconducted studies in the connected fields.(Suleiman et al., 2017). It can have far-reaching effects, such as decreased soil fertility, habitat devastation, biodiversity loss, soil erosion, and excessive nutrient runoff into waterways.

Degradation also has detrimental side effects on people, including conflict, disease, forced migration, malnutrition, and cultural damage. In the worst cases, land deterioration can lead to desertification or land abandonment. (or both). Long-lasting droughts and the loss of arable territory may have contributed to the wars. 43% of the world's population, according to the new study, resides in areas where land degradation is a problem. According to the study, 4 billion people will be residing in drylands by 2050. water and food poverty (Seki et al., 2018; Suleiman et al., 2017).

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E. Conceptual Framework

An analytical tool with many modifications and settings is a conceptual framework. It is employed to classify concepts and arrange ideas. Strong conceptual frameworks effectively represent something real in a way that is simple to recall and use. Shields (2013) claims that the conceptual framework is a visual depiction of the independent and dependent variables. The independent variable in this study is population growth, which includes population migration, land use/land cover, population age and population density. Land degradation is a dependent variable with the following independent factors as sub variables: farming and pressure, land use and land cover changes, reduction of agriculture land and increase of basic infrastructure.

Independent variable	Dependent variable
Population Growth	**Land degradation**
Population Migration	Farming and land pressure
Land use/Land cover	Land use land cover changes
Population Age	Reduction of agriculture land
Population density	Increased basic infrastructure

Fig 1 Conceptual Framework
Source: Researcher compilation; 2023

IV. RESEARCH DESIGN

The research design adopted quantitative research approach. It is indicating data collection, analysis to the result.

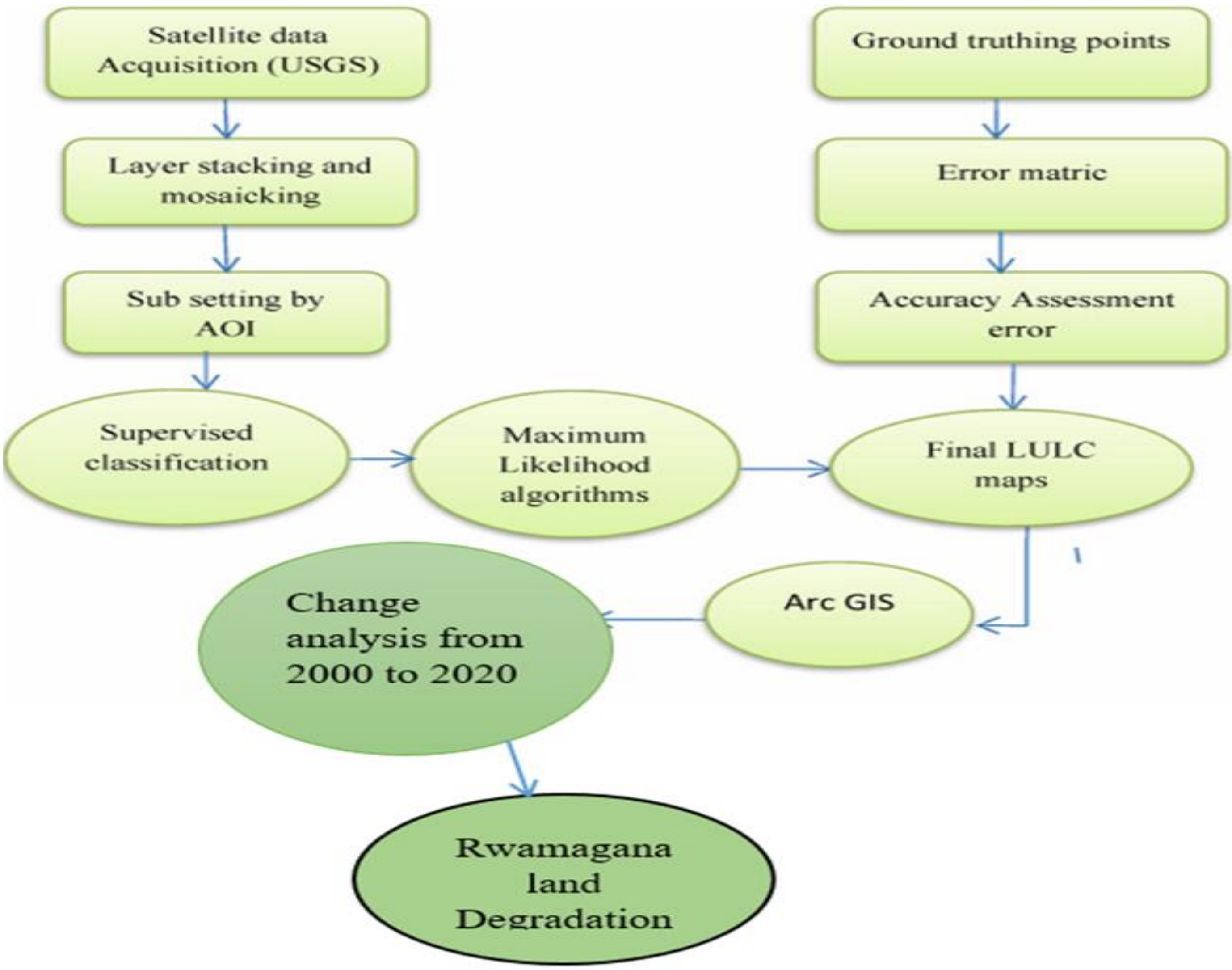

Fig 2 Study Design

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➢ *Area of the Study Physical Presentation*

The District of Rwamagana's topography is marked by low, undulating hills that are separated from each other by valleys, some of which are spongy and boggy. It is situated in the "eastern plateau" and is between 140 and 1700 meters high. The District, which is located at roughly 1° 57' 9" South and 30° 26' 16" East, is categorized as a middle altitude district.

Mount Nyirafumbwe in the Fumbwe Sector, to the district's northeast, has the highest elevation at 1825 meters. A small number of the soils are sandy with a loam blend, while the majority are loamy. Some swampy regions have clay soils.

In total, 5,459 hectares (on both public and private lands) of the Rwamagana District were mapped as forests in 2012. The remaining area was made up of a range of plantation species, including Pinus patula, Callistris robusta, Grevillea robusta, and Cuppressus lusitanica, with natural forests making up 2.19% of the total and Eucalyptus forests accounting for 96.83% of the total. A total of 1,556.5 hectares of the District is made up of 280 public plantation stands. In comparison, 9 stands of forests larger than 30 ha occupy an area of 436 halves, while small forests of less than 2 ha make 128 stands but only occupy 115 ha.

The larger forests are comparatively better stocked, with total wood volume of 70.5m3/halves for forests greater than 30ha. The smaller forests are poorly stocked (wood volume = 22.05m3 /ha in small forests of less than 2 halves). These public forests are dominated by exotic species, and the most deteriorated eucalyptus forests account for 92% of the total forest area, or 1,436.7 of the total forest area.

With a population density of 460/km2 and a total size of 682 km2, the Rwamagana District has a population of 313,461 people, 53% of whom are under the age of 19 according to the 2012 census (51% female and 49.0% male). 4% of the population is over the age of 65. With about 82% of people still under 40, youth makes up the majority of the populace. In the District, there are 51% female residents and 49% males.

Rwamagana District's populace over the age of 15 has a 79.7% literacy rate. (EICV4). The populace of Rwamagana ranges in age from 14 to 35 years. (NISR, 2016). Independent farmers predominate in the job indicators for the Rwamagana. According to the job report, agriculture accounts for a significant portion of employment, with more than 57.3% of working-age residents registering as independent farmers and 11.7% as independent non-farmers (Rwanda National institute of Statistics, 2012).

The overall employment rate is 85.3% of the resident population aged 16 years and above, while the unemployment rate is 9.7% (NISR, 2012).

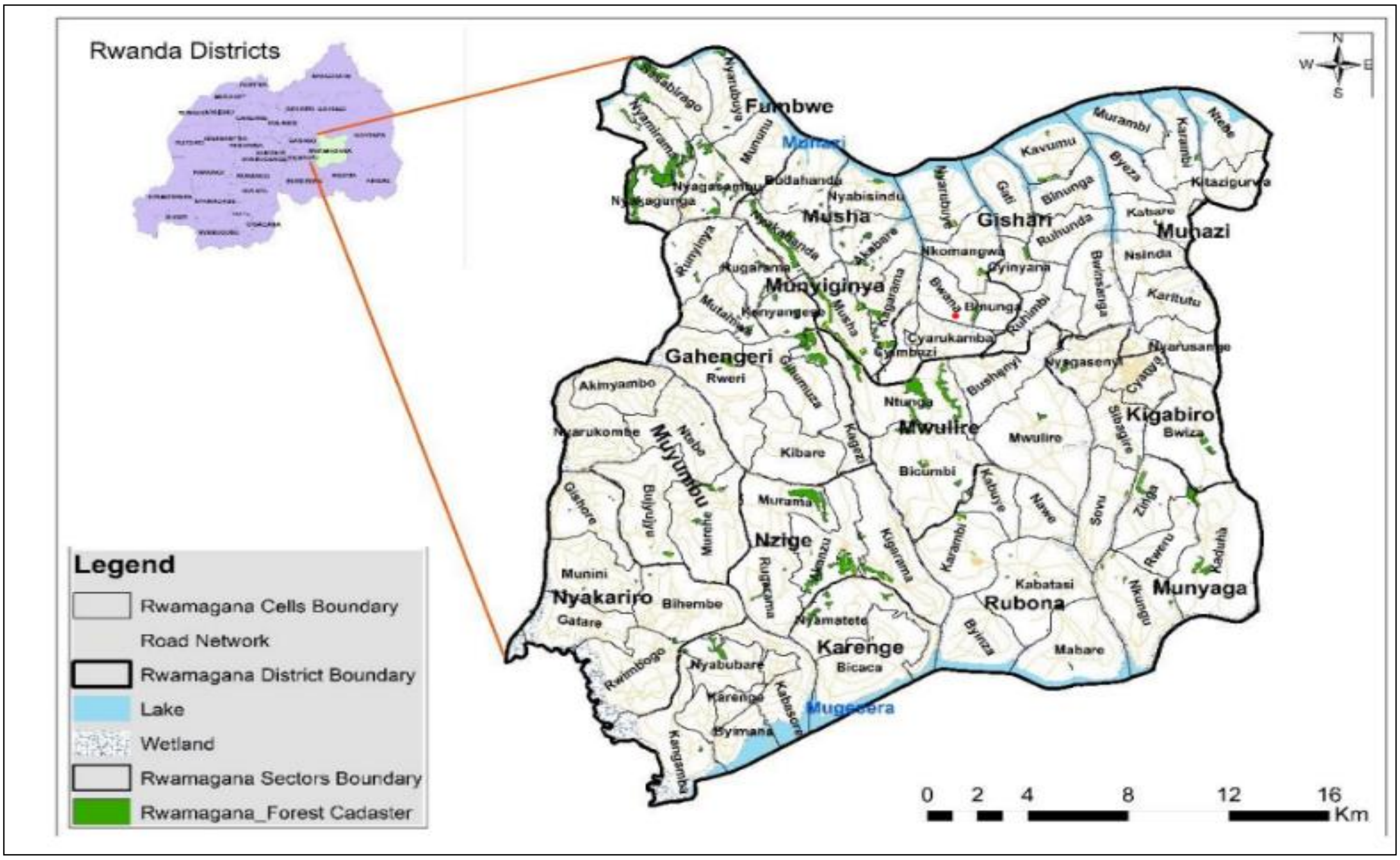

Fig 3 Location of Study Area

➢ *Sampling Procedures*

This study targeted Rwamagana district because its area is dominated by agriculture activities and it is a rural district where land use is majorly subsistence agriculture and livestock keeping for livelihood and sustainability. The district has been experiencing considerable growth in terms of human population, developmental activities such agriculture, infrastructural development, deforestation and brick making. These human activities have resulted in increased land consumption, modification, and alteration of the status of the land use and land cover over time. This situation is of concern in that these changes have and are still occurring without a detailed and comprehensive attempt to determine, keep track of and evaluate their status on the land in the district. Thus, this resulted in land use land cover change due to the impact of human activities in Rwamagana district from 2000 to 2020.

➢ *Data Collection Instruments*

This Research utilized four Landsat satellite imageries that were obtained from United States geological survey (USGS). The satellite imageries cover the area of study for the period ranging from 2000 to 2020. The land sat images for the area are available since 1973, have high temporal resolution, and are easily available and affordable. The images were processed and analyzed using GIS software to produce GIS maps that were used to quantify and detect land use and land cover changes in the district for the years 2000, 2010, and 2020. These years are selected based on the land sat images that had been secured covering the entire area of study.

➢ *Data Analysis Methods*

Having LULC maps and results from detected changes in Rwamagana District, a comparison and analysis were made using maps and statistics from the classification and post-classification. Here the ArcMap 10.8 will be used to make maps while ERDAS imagine were used to determine the Changes in LULC over time (from 200 to 2020). These findings will be interpreted while discovering some impacts of the LULC changes on other land cover and land use.

Descriptive statistics were used to analyze data through frequencies, and percentages. The report findings were presented in form of graphs, pie charts and tables. in form of frequencies, percentages, and tables. The Correlation Coefficient and descriptive statistics were used to examine the impact of the electronic banking system on customer satisfaction.

➢ *Correlation Analysis*

The Pearson correlation coefficient was used in this research. The degree of correlation between two factors can be determined using Pearson's coefficient of correlation. This coefficient allowed us to assume that the two variables have a linear relationship, that they are causally related, that one of the variables is independent and the other is dependent, and that both variables are subject to a significant number of independent causes that combine to produce a normal distribution. As an example, it is denoted by and is by r_s design constrained as $-1 \leq r_s \leq 1$.

➢ *Regression Analysis Model*

The following multiple regression models were created to address and discover the effects and relationship between e-banking and customer satisfaction based on study objectives and null hypotheses. The research's regression model was applied in the following way: $Y= \beta_0+\beta_1X_1+ \beta_2X_2+ \beta_3X_3 + \beta_4X_4 +\varepsilon$

Where: Y= Land degradation; X_1= Population migration; X_2= Land use/land cover, X_3= population age and X_4= Population density, (Moderator); and $\beta_1 - \beta_4$ = Slope or coefficient of estimates. β_0= constant; ε = Error term

V. RESULTS AND DISCUSSION OF FINDINGS

➢ *Population Growth and Density*

In the study area, population number and density were increased (Figure 4.1&Figure 4.2). The population density in 2020, 2010 and 2020 was 411 persons/km^2, 463 persons/km2 and 499 persons/km^2 respectively. These Population densities for Rwamagana District have been ranked extremely higher than East province population density of 461 persons/km^2.

Fig 4 Rwamagana Population from 2000 to 2020

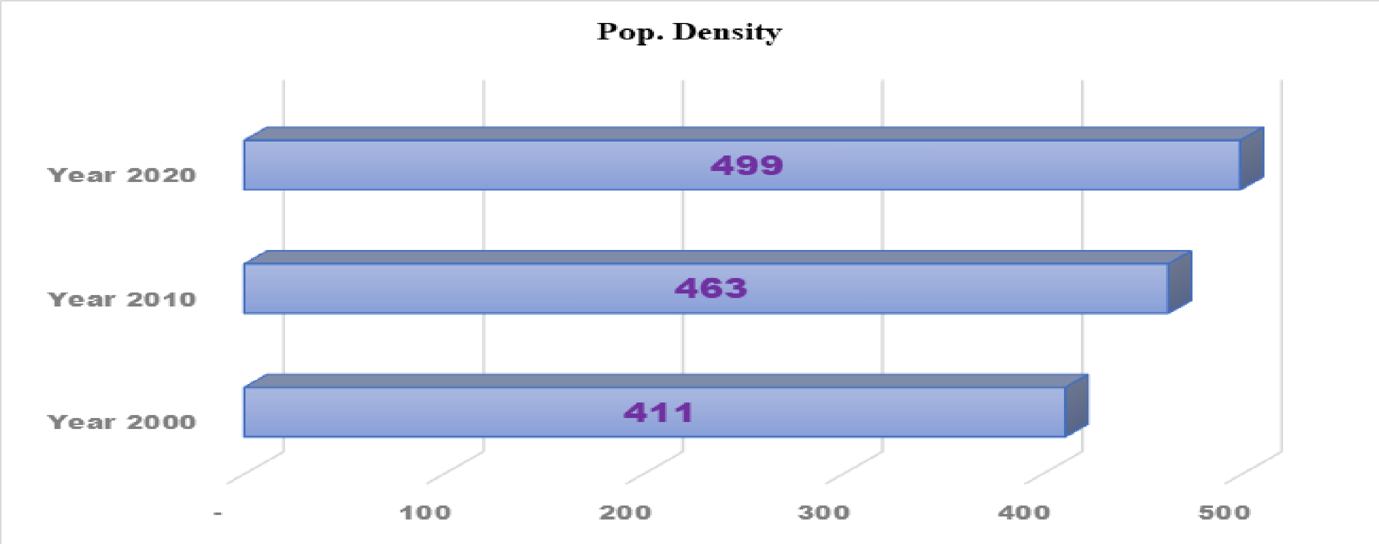

Fig 5 Population Density

The agricultural practices have extended into wetlands, forests, and marginal areas as a result of the population growth, and clearing of native trees and other vegetation has become commonplace. The yearly growth rate was raised from 11.1% (2000-2010) to 19.6% (2010-2020) due to the issue. (Table 4.1). The findings of this study are consistent with those of studies by Uwiragiye et al. (2020) and reports by the IUCN and JICA ((2010;2019), which claimed that population density and number had grown even before 2000. High population growth has increased the need for land, water, food, fuel for fires, and fodder, as well as for settlement and farming, which has placed strain on these resources (NISR, 2015). Putri et al. (2019) claim that the overpopulation of many underdeveloped areas has resulted in severe degradation and impoverishment of the land resources as well as a rapid collapse of the ecological and social circumstances. Additionally, he contends that soil erosion has been accelerated in some parts of Africa due to the expansion of farmland brought on by the continent's constantly expanding population, particularly on steeper slopes.

Table 1 Population and Growth Rate

Total Population			**Annual growth rate (%)**		
Year 2000	Year 2010	Year 2020	2000-2010	2010-2020	2000-2020
280,502	315,461	335,348	11.1%	6.3%	19.6%

- *Relationship between Population Growth and LULCC*

Land use, land cover, and eventual land degradation are all influenced by population change, which is a significant component. Human activities tend to expand and speed up as population size and development rise, so environmental degradation may result from human effects. It was attempted to look at how population transitions have happened in the study region.

When it surpasses the carrying capacity of the ecosystem or the threshold of the support system, population growth is a significant contributor to environmental degradation. (Fentahun & Gashaw, 2014). Table 1 shows the district of Rwamagana's population increase from 2000 to 2020. The district's overall population increased from 280,502 people in 2000 to about 335,348 people in 2020. The district's population had grown by 19.6%.

According to Jarrah (2019), one of the most significant causes of the declining use of fallows and rising land fragmentation in many African nations, including Rwanda, is population development and density. The complete Rwamagana district is located in the rural region of the eastern province, where settlements and agricultural use of the land are predominant.(Rwanda National institute of Statistics, 2012).

For instance, farming activities that cause soil erosion, a change in the salinity of the soil, and to some extent, a loss of soil fertility are direct effects of agricultural growth to support the growing population. High population density places significant strain on the available environmental resources, which frequently results in the unsustainable use of natural resources and may even cause their deterioration and depletion.

High population development and density put strain on the amount of arable land that is accessible, which causes fragmentation and encroachment into marginal lands, shorter fallow periods, and cultivation practices that degrade the land. (Appiah Mensah et al., 2019).

According to Putri (2019), population growth causes human settlements to rise, which raises the need for food, fuel, and construction materials. Human requirements are growing uncontrollably, which results in habitat destruction and biodiversity loss. Therefore, the degradation of the ecosystem is significantly impacted by the loss of vegetation cover brought on by human impacts in the Rwamagana district.

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The Rwamagana district's increased human population density has also resulted in a marked rise in the demand for energy for domestic use. Land degradation is a result of the region's increasing demand for energy, which has led to major changes and reductions in both natural and plantation land cover.

- *Extent of LULCC between 2010 and 2020*

The contingency tables obtained from the remote sensing based-classification shows the extent of each type of land use/ cover class at different study periods of the area. For instance, Table 4.3 gives a summary of the total area of land under each class in Rwamagana district between 2010 and 2020.

Table 2 Land use/ Cover Change for Rwamagana District between 2010 and 2020

Land use	Area (Ha)2010	Area (Ha)2010	Area (Ha)2020	Area (Ha)20200
Vegetated land	6736.1340	6841.0110	6223.8730	4785.4440
Cultivated land	4079.4790	3749.9640	3593.8730	4671.2300
Built-up	45836.9280	46124.4620	46002.9100	46423.4500
Open land	2129.1820	2010.6750	1810.3720	1210.6250
Bare land	2277.3720	2079.7410	1819.5510	1659.6800
water	5690.5480	5993.7910	7399.1540	7999.2040
Wetlands	261.2460	211.2450	161.1560	121.2560
Total	**67010.8890**	**67010.8890**	**67010.8890**	**67010.8890**

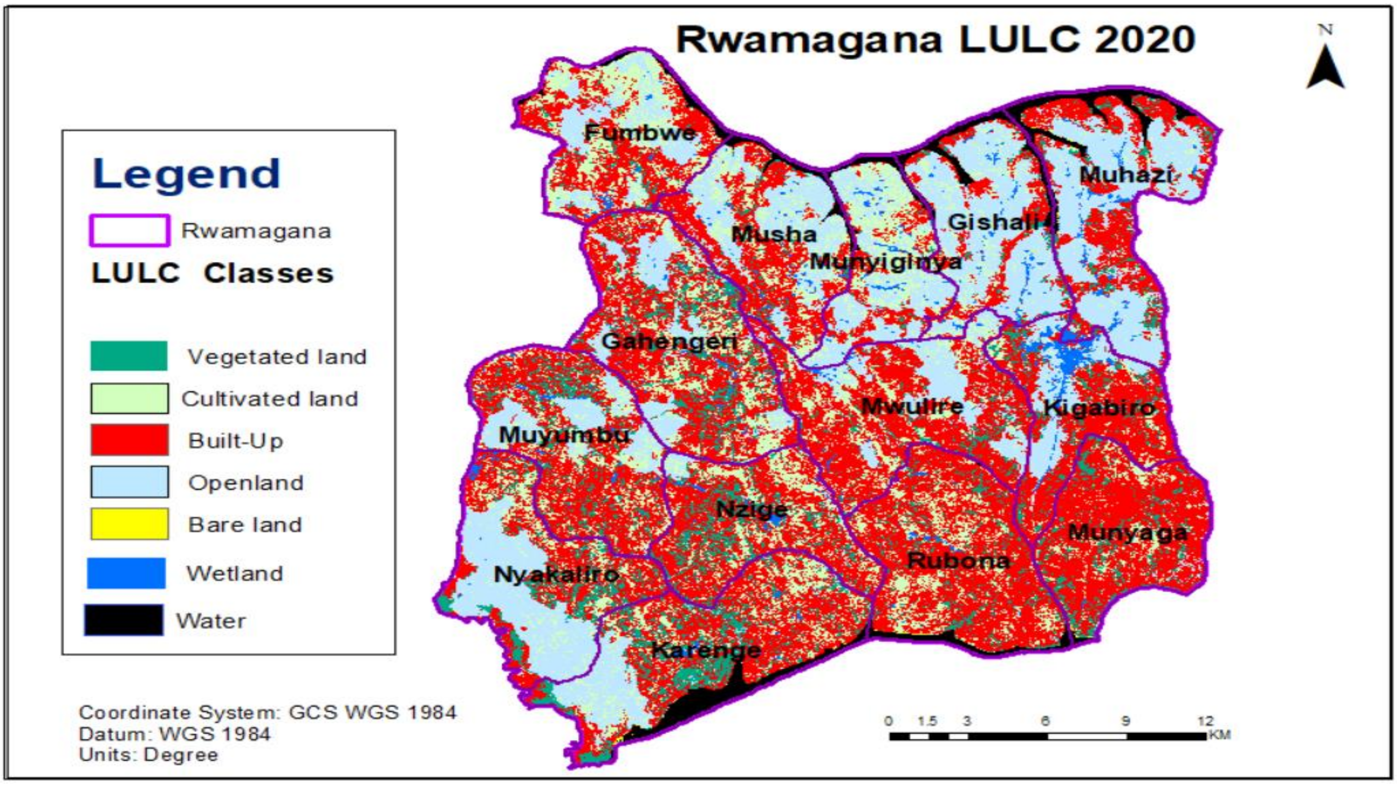

Fig 6 Geospatial Distribution of LULCC 2020

For purposes of comparison, the rate of change in LULC in the area was divided in two broad periods of time i.e. 2000 – 2010 period, and 2010 – 2020 period. Tables 4.3. & 4.4. give a summary of the changes that have occurred in the LULC in the area for the two broad periods respectively.

Table 3 LULCC in Rwamagana District between 2000- 2010

LULC Type	Area (Ha) 2000	%	Area (Ha) 2010	%	Annual change (ha)
Vegetated land	7,891.13	11.58	5,165.01	7.58	-272.61
Cultivated land	29,079.48	42.66	26,491.95	38.86	-258.75
Built-up	20,836.81	30.57	29,124.46	42.73	828.77
Open land	2,129.18	3.12	1,110.50	1.63	-101.87
Bare land	1,277.30	1.87	1,078.74	1.58	-19.86
water	5,690.55	8.35	3,983.79	5.84	-170.68
Wetlands	1,261.25	1.85	1,211.25	1.78	-5.00

Table 4 LULCC in Rwamagana district between 2010 and 2020

LULC Type	Area (Ha) 2010	%	Area (Ha) 2020	%	Annual change (ha)
Vegetated land	5,165.01	7.58	4,890.12	7.17	-27.4891
Cultivated land	26,491.95	38.86	23,751.23	34.99	-274.072
Built-up	29,124.46	42.73	32,423.45	47.57	329.8988
Open land	1,110.50	1.63	1,200.51	1.47	9.001
Bare land	1,078.74	1.58	1,100.18	1.76	2.1439
water	3,983.79	5.84	3,700.20	5.43	-28.3587
Wetlands	1,211.25	1.78	1,100.01	1.61	-11.1235

- *Cultivated (Agricultural) Land*

The general trend observed for agricultural land use in the district is that it has been on the fall throughout the study period. For instance, the area of land under agriculture decreased from about 29,079.48 ha to 26,491.95 ha (Table 4.4) between 2000 and 2010. This was a annual change of -258.75 ha in a period of 10 years. In the next study period, the area of land under agriculture keep changed by slight decrease due to the increase of settlements in Rwamagana District, it decreased from 38.86 %(26,491.95 ha) to 34.99% (23,751.23 ha of the total area (Figure 4.4). This period recorded a percentage change of - 0.4 in only 10 years because it had annual change of -274.072 ha. Compared to the previous period, cultivated land kept decreasing and it was mostly accelerated by human activities of the changing population in Rwamagana district. In order to cultivate more land for agriculture, intensive land use practices were used, which resulted in the destruction of wetlands and the clearing of shrub flora in order to meet the increased food needs of the district's expanding population. This demonstrates a notable rise in human population and activities on the land that involved clearing vegetation to boost farming in order to meet the expanding demands of the shifting population.

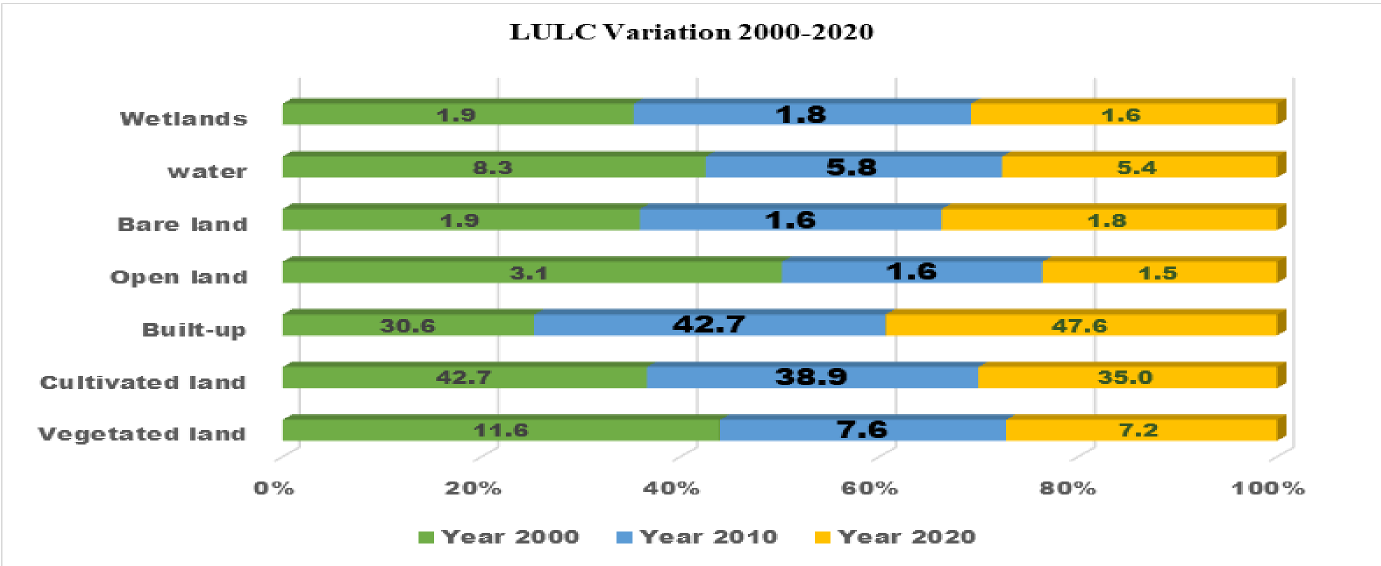

Fig 7 Percentage of LULC FROM 2000-2020

Since many crops like beans, maize, banana are mainly grown for not only family use but commercial purposes, more land is required for its cultivation as the population changes over time. the loss of about 5,328.25 ha of land originally under vegetation and further destruction of about 161.24 ha of land under wetlands show a significant relationship with the increased land under sugarcane plantation in the district.

- *Built-up Areas*

One of the most important indicators of population development is the transformation of much of the land's use and cover into built-up areas. In the district, built-up land has generally been increasing over the course of the study time. For instance, between 2000 and 2010, the area of land that was built up grew from approximately 30.57% (20,836.81 ha) to 42.73% (32,423.45 ha) (Table 4.4 & Table 4.5 and Figure 4.4). Over the course of ten years, there was a shift of 828.77 ha per year. Due to the growth in Rwamagana District's population over the following study period (2010–2020), the area of land that is built up grew from 42.7% (29,124.46 ha) to 47.6% (32,423.45 ha) of the total area. (Figure 4.4). This time period had an annual change of 329.8988 ha, which resulted in a percentage difference of 0.5 in just 10 years. Built-up land continued to rise over the course of the previous time, and in the Rwamagana district, this growth was primarily accelerated by human activity due to the shifting population.

To meet the additional requirements of settlements of the growing population in the district, mass construction of homes on land was undertaken which brought about clearing of shrub vegetation and destruction of wetlands to bring more land under agriculture. This shows significant increase in human population and activities on the land that cleared vegetation to expand farming in order to sustain the rising needs of the changing population.

➢ *Land Cover Transitions in Rwamagana District*

A part from agricultural land use and cover, vegetated land, and wetlands lands form other major types of land use/ cover classes in the district. Significant changes have also been recorded in these land use/ cover classes during the study period. vegetated land recorded a negative deviation of about 11.7% to or a 7.2% between 2000 and 2020. This happened at the time when the areas of land under both agricultures were decreasing steadily. Unsustainable logging/ harvesting of forest products due to higher demands of timber and building material might have accelerated these sharp changes in vegetated land. The rate of deforestation was higher as compared to re-afforestation and other forest management efforts, and that's why, significant decline has been recorded in a period of 20 years Significant changes in this class have also been witnessed as a result of the impacts of the changing population in the area. This practice of soil harvesting from the areas that harbor natural vegetation is accompanied by massive destruction of vegetation, soil erosion, and loss of biodiversity in the area.

- *Wetlands and Open Land*

Wetlands are a minor class of land use or land cover found in Rwamagana district.Significant changes have been recorded during the study period for small areas that were captured during image processing and were classified as wetlands. For instance,Table 4.3 and Table 4.4 show that the total area of land under wetlands during the beginning of the study period was about 1,261.25 ha and about 1,100.01 ha at the end of the study period in 2020.

Wetlands play very significant role in the environment and their loss or destruction is directly linked to environmental degradation. For instance, wetlands are known to protect water quality by removing and breaking down sediments, nutrients, and toxins, they also provide floral diversity and wildlife habitat protection in the ecosystem, and wetlands form an important hotspot for care and protection of biodiversity. Wetlands nourish the land during the dry periods, and they also form important habitats for biological diversity in the environment (Nicodemus Osoro et al., 2019).

Wetlands have declined in size in this area due to human activities such as mining of sand in wetlands, clearing of swampy vegetation for agricultural expansion thus leaving the wetlands open and susceptible to high evaporation rates and drying up. Other factors that have led to decreasing sizes of wetlands would include draining and clearing them for farming activities and construction of settlement areas, increased rate of soil erosion from farmlands which bring massive sediment loadsinto the wetlands causing them to decrease in size and eventually disappear.(Y. Zhang et al., 2015)

Erosion of chemical fertilizers by storm waters from the surrounding agricultural farms drain nutrients such as nitrogen and phosphorous into the wetlands hence causing accelerated growth of algae causing the wetlands to decline and reduce in size. In the first period, i.e., between 2000 and 2020 the total area under wetlands in the district decreased.

This means that human activities intensified in the area between 2010 and 2020 as a result of increased population that put a lot of pressure on environmental resources thus causing degradation. Other notable changes in land use/ land cover from the maps and the tables are the area under open or cleared forest. Significant changes have also been witnessed inthis category of land use/ land cover during the study period of the area.

➢ *Accuracy Assessment*

It is important to be able to perform accuracy assessment for individual classification if the resulting data is to be useful in change detection analysis (Mugiraneza et al., 2019). To test the classification process, an accuracy assessment was carried out using the classified data and the referenced data. Information or data obtained using a GPS during ground investigation (ground truthing) in the area of study coupled with random points that were identified and located using a stratified random method in ERDAS software to represent the different land use types and vegetation classes in Rwamagana district was used as reference data for the accuracy assessment. The reference data and the classification results were compared and statistically analyzed using error matrices, and the results are shown in Table 4.5.

Table 5 Error Matrices and Total Classification Accuracy for Classified Image of 2010

	Reference Data							Classification Accuracy		
Classified Data	**Unclassified**	**Vegetated land**	**Vegetated land**	**Vegetated land**	**Vegetated land**	**Vegetated land**	**Vegetated land**	**Producers Accuracy**	**Users Accuracy**	**Kappa**
Unclassified	4	0	0	0	0	0	0	---	---	1.00
Vegetated land	0	3	1	0	0	0	0	50.0%	75.%	0.68
Cultivated land	0	0	4	0	0	0	0	66.7%	100.%	1.00
Built-up	0	0	0	3	0	0	1	100.00	75.%	0.72
Open land	0	1	0	0	3	0	0	100.00	75.%	0.72
Bare land	0	2	1	0	0	1	0	100.00	25.%	0.22
water	0	0	0	0	0	0	4	80.00	100.%	1.00
Total Accuracy								78.6%		0.75

From error matrix table output, an overall total accuracy of 78.57% and a kappa statistic of 0.75 were obtained. The Users accuracy is a probability that shows how many cases on the results or the classified image were correctly classified while the Producer's accuracy is a probability that shows how many known classes of land use and vegetation cover were correctly classified

➢ *Drivers of LULCC and Land Degradation an Rwamagana District*

- *Agricultural activities*

On the classified images in figures 4.4 and 4.5, one notices an increase in area under cultivation which corresponds with decreases in areas of land under vegetation cover.Agriculture can then be attributed to be responsible for most of the land use land. Agriculture can then be attributed to be responsible for most of the land use land cover change that has occurred in Rwamagana district over the years. Agriculture is the predominant land use activity in the district and this situation is similar to what (Nabahungu & Visser, 2011) discussed in their report that agriculture accounts for more than 25% of the gross domestic product (GDP) of most African countries, andis the main source of income and employment for at least 65% of Africa's population.

Agriculture in Rwamagana district is characterized by both small-scale mixed and large-scale farming, which includes subsistence and cash crops.

Average land holdings are approximately small for most farmers/ households that are involved in crop production. Agriculture is responsible for most of the land use/ land cover changes that have occurred in the most parts of Rwamagana district. Agriculture for crop production was ranked the highest at 84% followed by wage employment at 9.5%, rural self- employment at 4% and urban self-employment at 2.5% (NISR, 2015). As evidenced by the statistical figures, increasing pressures on agricultural land in Rwamagana district have resulted in much higher nutrient outflows from the land and the subsequent breakdown of many traditional soil-fertility management practices such as long periods of fallowing and incorporation of the crop residues into the soil.

Fig 8 Overstocking and Poor Roadside Drainage Causing Soil Erosion and Degradation of Land in Rwamagana District

- *Overexploitation of Vegetation*

Firewood was noted and recorded as the main source of domestic fuel for the most households in the entire Rwamagana district during the field surveys. Forest plantations that form the major part of forest in the district were noted for their valuable forest products like timber, poles, building materials, and source of fuel for the many residents in the area.

One other common practice that requires fuel wood that was noted in Mushya and Munyiginya Locations is brick making. Brick making as an emerging industry in the area requires large quantities of wood fuel than what most domestic households would need. This practice is widely carried out by a youthful generation (school drop- outs) without any stable source of income. Consequently, large amounts of firewood required in brick production come from the declining vegetation cover in the district thus causing degradation Trees or vegetation cover on land play important role in landscape conservation and management.

For instance, vegetation cover protects the soil by preventing the direct impact of weather elements as rainfall, temperature and wind (Forkuo & Frimpong, 2012)A reduction in tree/ vegetation cover as a result of tree cutting/ deforestation accelerates the rate of soil erosion through water and wind and increases the chances of surface run-offs thus leading to land degradation.

Muchena et al (2005) report that loss of vegetation cover is seen as one of the major causes of land degradation in SSA. For the case of East Africa, due to increasing poverty, most of the rural poor households depend on fuel wood, as they do not have enough cash to obtain alternative sources of fuel. Kenya is said to harbor 72% rural households that consume fuel wood that is obtained by cutting down trees.

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This scenario is similar to the results that were obtained from Rwamagana district which fall among the rural category. With an average rural population of about 90%, tree cutting or rather deforestation in the district is common as a result of encroachment for settlement, high demand for wood fuel and timber for building and sale. A report from the District Agricultural Office Rwamagana (2010) stated that there is a critical challenge on how to deal with illegal encroachment on the protected areas, and potential for forest excisions to give room for human settlements and urban development, as the population increases.

The household survey results showed that 84% out of the total number of sampled households rely on fuel wood as the major form and source of domestic fuel/ energy.

Similar findings had already been recorded in the District Development Plan for Rwamagana district 2018-2025 which reported that 83.9% of the total households in the entire district rely on fuel wood as the major source of domestic fuel, thus posing a serious threat to vegetation and forest sustainability in the district. Overexploitation of vegetation cover in Rwamagana district therefore leads to land degradation in a number of ways: loss of vegetation cover normally leads to the decrease of the water storage capacity of the soil and vegetation thus accelerating the rate of degradation.

It also leads to the decrease in the soil moisture content that affects the productivity of the land. Loss of vegetation also causes a decline in the rate of water infiltration into the soil resulting to increased surface runoffs, slower plant growth and increased rates of water erosion that leads to reduced soil fertility.

- *Deforestation and Tree Harvesting*

Deforestation in Rwamagana district has mostly occurred in the riverine vegetation and the clearance of shrub lands due to expansion of agriculture, encroachment for settlements and development activities. Riverine vegetation and shrub lands in this area are the main natural forms of land cover that harbor important biodiversity.

This has also led to degradation of rivers, watersheds or water catchments through riverbank cultivation, illegal logging, and soil harvesting in these areas that are associated with destruction of vegetation. Encroachment for settlement and cultivation in marginal areas continues in hilly regions of the district that are dominated by natural vegetation thus important biodiversity areas.

On average, approximately 7 hectares of land under riverine vegetation and 13.1 hectares of land under shrubs were destroyed annually between 2000 and 2010, a period of fifteen years. This rate would tremendously change in only seven years between 2010 and 2020 with forest plantations disappearing at the rate of 205.4 hectares per year, riverine vegetation at the rate of 85.7 hectares per year and shrub lands disappearing at the rate of 22.9 hectares per year.

Deforestation and other forms of loss of vegetation continue, loss of agricultural land will increase leading to poor agricultural yields. Loss of vegetation also continues to accelerate soil erosion and watershed destruction. This is also responsible for destruction of habitats and genetic diversity found in the area thus leading to more environmental degradation. A reduction in vegetation cover as well reduces the capacity of the soil to retain moisture for plant productivity, which is a direct link of how biodiversity loss leads to land degradation (Maitima et al, 2005).

Rwamagana district also has traces of bushlands mainly found on the hills and ridges which are located throughout the district. These areas are characterized by thick natural vegetation covers that are very distinct from the high forests and grasslands. These forests are threatened by degradation due to encroachment for settlement and cultivation, by extension of boundaries by the neighboring communities, overgrazing, deforestation and burning.

- *Linkages between LULCC and land degradation*

Correlations are a branch of inferential statistics that seek to explore the strength of association between the dependent and independent variable. However, correlations only give us the numerical value of the strength of this association whereby X has on Y. The study carried out a correlation to investigate the association between different land use practices responsible for land conversion and the existing land conservation measures. Highlights the findings that were generated from the computer software to show the relationship strengths.

Table 6 Correlation Matrix between Land Use, Land Cover Change and Land Degradation in Rwamagana District

Land Size		**Cultivation**	**Construction**	**Grazing**	**agro forestry**	**Fallowland**	**Forest Plantation**
Land Size	1						
Cultivation	-.370**	1					
Construction	-.167	.228	1				
Grazing	-.354**	.333	.129	1			
Agro forestry	-.300**	.137	.105	.213*	1		
Fallow land	-.037	.048	.037	.035	-.122	1	
Forest Plantation	-.190	.100	-.088	.058	.335**	-.089	1

* Correlation is Significant at the 0.05 level (2-tailed).
** Correlation is Significant at the 0.01 level (2-tailed).

The output shows that land cultivation is negatively related to land size with a Pearson correlation coefficient of r = -.370 at significance level of $p < 0.01$. This thensignifies that the impact of cultivation on the land in the area would reduce by 37% ifthe land size under cultivation is increased. The output also shows a negative relationship between grazing and land size with a Pearson correlation coefficient of

r = .354 and the relationship is significant at 0.01 level of confidence. This level of significance indicates that the impact of grazing activities on the land will reducewith a larger land size. The correlation output also gives a negative relationship between agro forestry and land size with a Pearson coefficient coefficient of r = .300, which is a significant relationship at the confidence level of 0.01. At the same time, agro forestry is as well positively correlated to grazing with a Pearson correlation coefficient of .213 and it is significant at $p < 0.05$ confidence level.

A positive relationship between agro forestry and grazing indicates that adopting agro forestry, as a land conservation and management measure in the area would make it possibleto increase the land for grazing of animals because intensified cultivation would definitely reduce. Lastly, the output indicates a positive, significant, linear relationship between forest plantation and agro forestry practices in the area with a Pearson correlation coefficient of r = .335 at $p < 0.01$ level of confidence.

This positive relationship between the two variables would signify that the households in Rwamagana district engaged in forest plantation or on-farm tree planting are more likely to adopt agro-forestry practices as additional methods of land conservation and management and vice versa. The study also undertook a regression analysis of the linkage between LULCC and land degradation to determine the influence of the independent variables on the dependent variable. Regression analysis allows us to be able to make predictions of relationships between variables. Table 10 highlights the results generated from the analysis.

Table 7 Linear Regression Coefficients for LULCC and Land Degradation in Rwamagana District

	Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**	**95% Confidence Interval for B**	
Model	B	Std. Error	Beta			LowerBound	UpperBound
(Constant)	6.027	1.143		5.272	0.000	3.755	8.299
Cultivation	-0.890	0.368	-0.242	-2.417	0.018	-1.622	-0.158
Construction	-0.438	0.468	-0.093	-0.935	0.352	-1.368	0.493
Grazing	-0.359	0.175	-0.207	-2.047	0.044	-0.707	-0.010
Fallow Land	-0.060	0.430	-0.015	-0.140	0.889	-0.916	0.795
Agro Forestry	-0.368	0.192	-0.198	-1.917	0.059	-0.750	0.014
(g) Forest Plantation	-0.225	0.234	-0.100	-0.963	0.338	-0.691	0.240

This is a way of predicting some kind of outcome from one or more predictor variables. The β- values tell us about the relationship between land degradation and each predictor variable (land use and land management practices). From the table, a negative relationship has been generated for the model with Land degradation as the independent variable and Land use activities and management as the predictor variables for the model. Only livestock grazing and land cultivation show a significant

Cultivation (β = -.890). This value indicates a negative relationship between land degradation and cultivation as a predictor variable. Therefore, as cultivation of land reduces, land degradation will definitely reduce.

Grazing (= -.359) also shows a negative relationship, which means that, when other variables that cause or contribute to land degradation are kept constant, decreasing the amount of livestock grazing on the land in the area will result in a slower rate of land use, land cover change, and land degradation. The equation shows that there is a unidirectional relationship between LULCC and land degradation, which is defined by comparatively lower values, and that a higher absolute value of Beta represents a significant impact of the independent variable on the dependent variable.

relationship. Regression analysis assumes that the relationship between variables is linear. It is a statistical procedure that measures the relative impact of each independent variable on the dependent and is useful in forecasting. The multiple regression formula that best describes the relationship between the variables is

Land Degradation = $\beta_0 + \beta_1$ Cultivation + β_2Grazing + €Land degradation= 6.027+ -.890+ -.359 + €

Grazing and farming are both significant at a 95% confidence level or a p value of less than 0.05. A test statistic value that matches the one we would see if the research hypothesis were truly false would be extremely unlikely to be obtained, according to small values for the confidence level. High population density and increased human activities in the Rwamagana district are significantly related to land degradation, so the hypothesis is accepted. The lower values of confidence level (p 0.05) from the table output of linear regression, i.e., cultivation (p .018) and grazing (p .044), indicate that the sample results correspond to the research hypothesis. The regression table shows that the t-test connected to the - values for cattle grazing and land cultivation are important because both have values that are less than .05. level of significance.

This therefore means that land cultivation and grazing of livestock in Rwamagana district (two major land use forms) as predictor variables are making a significant contribution to the model. From the model, cultivation, [t (-2.417) = .018, p < .05] and livestock grazing [t (-2.047) = .044, p < .05]. From the magnitude of the t- statistics, we can see that both cultivation and grazing have a similar impact on the land in the area of study.

In fact, these findings support the findings in the DDP and the GIS maps, which show that land cultivation and livestock grazing as a result of overstocking are the main causes of land degradation in the Rwamagana district. This results supports the alternative hypothesis, H1, which states that there is a significant relationship between human population growth, its activities, and land degradation in the Rwamagana district, Eastern Province of Rwanda, and rejects the null hypothesis.

VI. CONCLUSION AND RECOMMENDATIONS

➢ *Conclusion*

Rwamagana district has experienced significant changes in land use and land cover reduction between 2000 and 2020 emanating from a rising human population thus causing land degradation. The greatest changes occurred between 2010 and 2020 in most parts of the district.

The major cause of the changes in land use and land cover was human activities which saw the following changes take place: between 2000 and 2020 the area of land under forest plantation slightly increased by 1.56%, open forest increased by about 8.1%, agricultural land increased by 0.63%, riverine vegetation reduced by 5.57%, shrublands land reduced by 8.68%, sugarcane plantation increased by 5.33%, and wetlands reduced by 19.14%. The period between 2010 and 2020 registered the following significant changes in only seven years: forest plantation reduced by 23.11%, open forest increased by 29.98%, agricultural land increased by 0.91%, riverine vegetation reduced by 33.13%, scrubland reduced by 8.79%, sugarcane plantation increased by 10.00%, and wetlands reduced by 24.76%.

Land cultivation and livestock grazing are the major contributing factors to land degradation in the district. At confidence level of 95% or $P \leq 0.05$ both cultivation and livestock grazing had significant values as follows: cultivation (P = .018) and livestock grazing (P = .04). The area has also experienced a rapid growth in population density over time. For instance, population density was 206, 321, and 440 persons per square kilometer in 2000, 2010, and 2020 respectively. The growing trends of population and the consequent demand for food, energy, and housing in the area have considerably altered land use practices, reduced both plantation and naturalland covers and severely caused land.

➢ *Recommendations*

For proper management, conservation, and sustainable land use practices in the area, the Rwandan government must take the following actions in cooperation with the interested parties, local residents of Rwamagana district, and development partners. Through specifically created Information, Education, and Communication (IEC) activities, efforts should be made to inform the people of the Rwamagana area and their local leaders about the detrimental effects of dense population on the environment.

To safeguard the area's land cover and to maintain the region's forests and vegetation, reforestation, and social forestry initiatives should be implemented at the local level. Additionally, studies on the carrying capacity of the land in the Rwamagana region must be conducted. Following this, a taxation plan must be implemented to deter locals from raising more livestock than the area's carrying capacity.

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