

Effect of Population Growth on Forest Degradation. “Case of Gishwati Natural Forest”, 1978-2019

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Option: Environmental Economics and Natural Resource Management

Submitted: 15-01-2022

Revised: 23-01-2022

Accepted: 26-01-2022

ABSTRACT

Globally, anthropogenic activities have great effects on environment over last many years, where forests, grassland and woodland have been cleared to permanent pasture and cropland. The study aimed to analyze effects of population growth on Gishwati forest degradation. Therefore, the study highlighted how the dynamics of Gishwati surrounding population and its demographic pressure led to Gishwati Natural Forest degradation. Literature review was taken on existing reports, documents and articles on population and Rwandan forests, paying a particular attention to Gishwati natural forest degradation. The study used GIS to enable the storage, management and analysis of quantities of spatially distributed data of Gishwati forest coverage which were associated with their respective geographic features and population. Shapefiles on Gishwati were gathered and comparison was made time to time. The study has shown how the pressures from the population increase have extended farming onto unsuitable land, and have also driven deforestation. This study remarked a strong relationship between population growth and forest degradation in Rwanda where the Gishwati surrounding population has dramatically increased from about 470 thousand in 1978 and tripled to 1.3 million in 2017 and as result; the deforestation reached a level of degradation from 28,000 ha in 1978 to 600ha in 2009. Finally, the study suggests that generation income projects may be created for people surrounding Gishwati forest, and buffer zone can be used to protect Gishwati Natural forest. Furthermore, the policy of

afforestation was found as one of the responses to the degraded forest.

Key words: Forest, Population, Degradation, Afforestation, Gishwati

I. INTRODUCTION

Globally, human activities have affected every part of the world since many years ago where forests, grassland, and woodland have been converted to lands for agriculture or permanent pasture. Rapidly increasing of human population and need of forestry and agriculture services have brought extensive changes on land use throughout many countries of the world. The destiny of humans and trees has remained tightly bound. Forests have intensity influence on economic development and livelihood in the society. The question of population growth and whether the earth's resources can sustain with the rapid expansion of population all over the world is one of most important concern of this age. (Simplice A. Asongu, Brian A. Jingwa, 2012). This created worldwide debates whether there is a relationship between population growth and forest degradation and environment sustainability in general.

The world population quadrupled from 1.6 billion to 6.1 billion during the period 1900–2000 (United Nations, 2001). United Nations showed world population as: our billion in 1975, five billion in 1987, six billion in 1999 in 2011 the world counted its seven billionth persons. In the same progressive vein, the projected estimates for 2027 are eight billion (United Nations, 2010). However, in many parts of the world it has proven difficult to manage natural forests because of

higher dependency of population on natural resources mainly forests for agricultural, energy, nutritional, medicinal, animal feeding, and other needs (Twayigira, 2012).

Developing countries often view Natural forests as source of income from timber, agriculture, mineral exploitation, or tourism by the government. In addition, the main problem of Natural Forest Management is ineffective legal systems and weak management capacities (Masozera, 2002). So, management of Natural Forest in Rwanda has become complex due to Resettlement which occurred mostly after the genocide against Tutsi (Kanyamibwa, 1998).

One hundred years ago, Gishwati Forest Reserve (GFR) was Rwanda's second largest indigenous forest that covered approximately 100,000 hectares. By the 1970s, it had been reduced to about one fourth of that size, covering only about 28,000 ha. By the 1990s it had been further depleted to about 61.7 % of this size because of human encroachment, large-scale cattle ranching projects, cattle grazing within the forest, resettlement of new refugees after the 1994 Genocide, clearing of the forest for small-scale farming, and the establishment of plantations of non-native trees. According to Humphrey, in 2002 Gishwati remained Only 2% of area from 1970s. (Humphrey, 2015)

It has shown by UNEP that the forests reserve were largely intact in 1978 and substantial forest cover remained until 1986. But during the

period of 15 years after, refugees of Genocide of arrived in Gishwati Forest and cut trees for subsistence farming. Then only small circular patch of 1500ha of natural forest remained out of 250,00ha of original forest by 2001. The Gishwati forest has witnessed dramatic deforestation during the last century from conversion to settlements, agricultural lands and pasture, and as well as for timber and energy usage. The forested area stood at about 70,000 ha in 1930, 28,000 ha in 1960 and 8,800 ha in 1990. Unsuitable management of land use policies in the 1980 led to conversion of 70% of forests in 1990, and it remained only 600 ha (Kisioh, 2015).

II. MATERIALS AND METHODS

2.1. Study area description

The area of study has been defined as the “former Prefecture Gisenyi” which can currently be related with the District of Rubavu, Nyabihu, Ngororero and Rutsiro where Gishwati natural forest was located. The total number of human populations of these 4 Districts is estimated about 1.3 Millions, with density around 430 inhabitants per km² (NISR, Statistical Year book , 2017). The community neighboring Gishwati Forest relies on subsistence farming, where almost half farmers practice their subsistence agriculture on land plots less or equal to 0.5Ha in size (NISR, Statistical Year book, 2010).

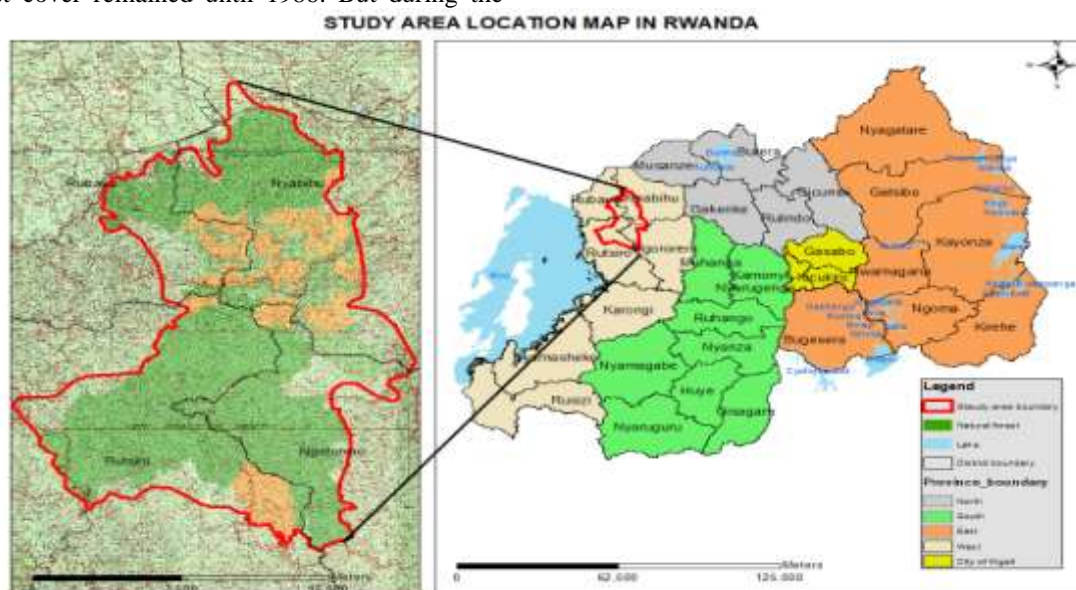


Figure 2. 1 map showing location of Gishwati forest

Source: Own map using CGIS, 1988 and 2019 shapefiles

2.2 Sample and data collection technics

The boundary of Gishwati in 1978 was merged with boundary 1988 to have a basic starting point as the boundary of 1978 was mentioning different areas compared to the boundary found in 1988. Some areas were covered in the 88's image but not covered in the 78s image and therefore the researcher decided to merge those two filesto obtain one map as the researcher did not find enough evidence of the changes in those 10 years. After collecting the shapefiles, the ArcMap software was used to perform actual map analysis and classification using supervised classification method (maximum likelihood classification) to generate land cover maps with Forest.

Finally, the forest cover change was produced using the ArcMap's Raster Calculator tool to show which changes have occurred in forest cover area of study among the different years. These maps were also complemented by a series of tables which show the level of change that has occurred for each map statistically and information on number of population and population density. Population growth was computed using the geometric growth rate where:

$$P_n = P_0 (1 + r)^n$$

P0=Initial Population, r = Growth rate and n= Number of elapsed years.

Forest Loss was also calculated by considering the initial Forest coverage and comparing to the remaining surface area by the use of the following formula

$$\text{Loss} = \left(1 - \frac{F_i}{F_c}\right) * 100$$

Where F_c = Current Forest size and F_i = Initial size of the forest

2.3 Statistical treatment methods and analysis method

The study has used GIS with spatial statistics toolbox to analysis Spatial distribution

of patterns of human behavior and its spatial expression in terms of mathematics and geometry in locational of the area of study. The Microsoft excel was used to produce the graphs and relationship between population growth and forest coverage. The study was based on describing Gishwati as Forest and the purpose for the analysis was based on forest degradation due to human activities.

The linear regression analysis was applied in order to find out the relationship of population and forest surface area

$$F_i = f(X_i, \beta) + e_i$$

Where:

F_i = Forest coverage

f = function

X_i = Population e_i = error

III. RESULTS AND DISCUSSIONS

3.1 Trends of population growth in surrounding of Gishwati forest

Population growth is related to the change in a population over time. The trends in population growth in selected area of study (Rutsiro, Nyabihu, Rubavu and Ngororero District) from 1978 to 2019 as presented in Table 3.1, generally highlights a dramatic increase in population number from 1978 up to 2019 where it has increased from 468,882 to 1,381,730 persons. Table 3.1 presents population density which is the average of number of populations per square km. Population density has been increasing all over the observed period as indicated.

As observed in the following table, population in the study area has been increasing all over the year as well as population density.

Year	Total population	Pop. growth in %	Pop density
1978	468,882	0.9	228.8
1991	734,654	4.4	295.5
1996	836874	2.8	321.6
2000	918650	2.4	328.2
2002	1,109,631	10.5	419.1
2012	1,358,745	2.3	427.6
2015	1,367,927	0.6	460.8
2016	1,371,002	0.2	473.0
2017	1,374,179	0.2	485.6

2018	1,378,449	0.3	483.1
2019	1,381,730	0.2	483.1

Table 3. 1: Trends in population and population density

Source: NISR,1981,1991, 2002, 2012, 2019

Along the years as observed in our data, the slight decrease in the population growth rate in 1991 to 2000 (compared to previous years) was a result of the Genocide of Tutsi which took place in 1994 where thousands of people were displaced and killed in the study area. We could also mention that a number of repatriates came in the area in the 1996 and were relocated in Gishwati and in the surrounding areas. As shown in Table 3.1 above, the population density has increased from 228 pop/Km² in 1978 to 483pop/Km² in 2019, which made the region to be the second densely populated in the country.

In other hand according to different censuses conducted by the National Institute of statistics of Rwanda surrounding population has also increased from 468,882 in 1978 to about 1.3 million in 2017.

3.2. The extent to which Gishwati forest has been degraded

Even though Gishwati natural forest has been established before 1981, the topographical

map of Gishwati in 1988 illustrates that the Forest area was made up with natural forest, woodland and plantation forest. It has been observed that some of the human activities have been operating inside the forest. MrMpayimana (Farmer in Gishwati) said “Gishwati has been hosting cattle since 80s’ where people could get butter (fromage) and milk, and a big Military Balax used to train army (Ex_Far) there”. This declaration and forest cover images helped the researcher to identify other pathogenic actions that have led to the deforestation inside Gishwati forest.

3.2.1 Deforestation of Gishwati1978-2019

Forest has different roles mainly in hosting animals and serving human needs for subsistence and welfare. The area has reduced up to 93% of the original size.Gishwati forest has been under intense pressure of deforestation for many years.The table below illustrates how GishwatiFirest has been degraded overt time.

Projection Year	Forest coverage	Forest loss in %
1970	28000	
1978	23000	-18
1991	8800	-69
1996	3800	-86
2000	600	-98
2002	600	-98
2012	886	-97
2013	2259	-92
2014	2259	-92
2015	2259	-92
2016	2259	-92
2017	2273	-92
2018	2273	-92
2019	2273	-92

Table 3. 2: Forest coverage loss of Gishwati forest

Source: Own computation based on secondary data.

On the other hand plotting forest coverage in different years show an increase in pine plantation forest as well as a slight increase in natural forest.

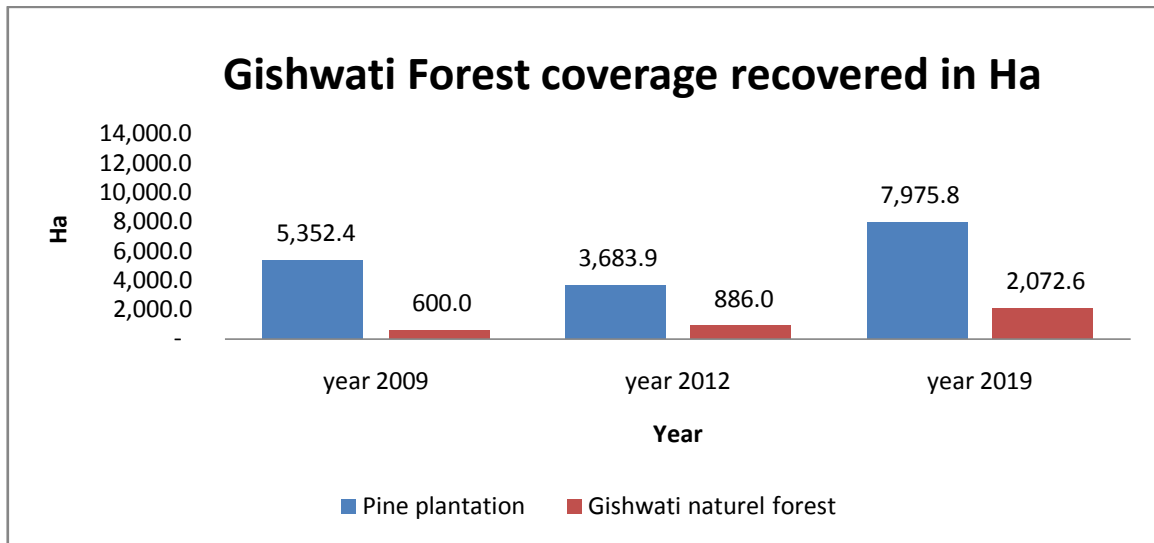


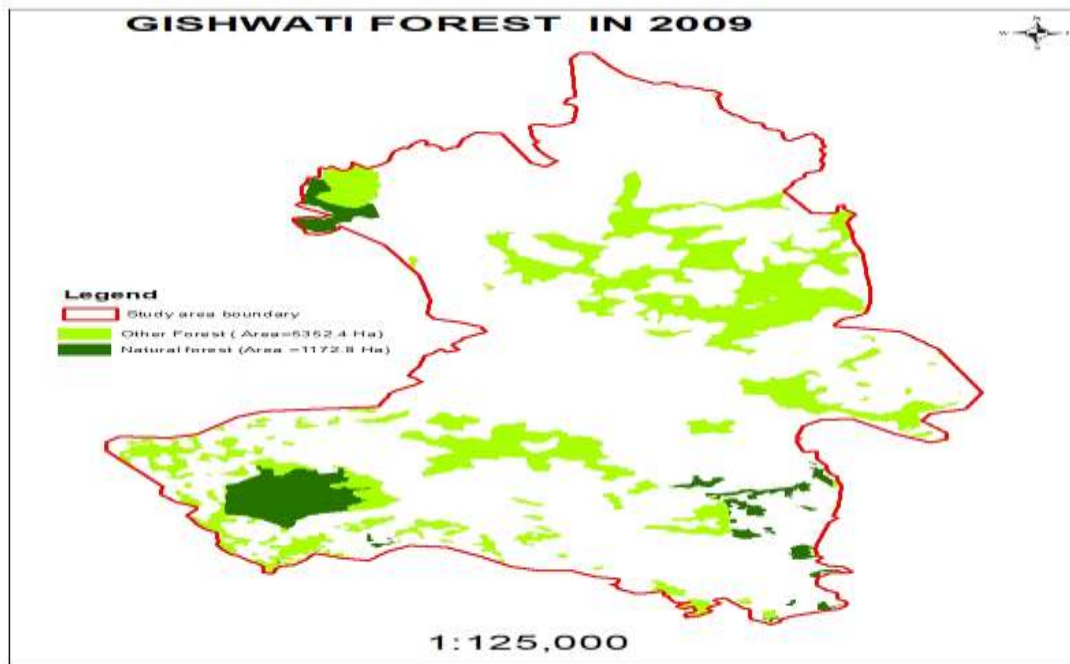
Figure 3. 1: Gishwati forest recovery

Source: Own computation based on CGIS data, 2019

Many years ago, Gishwati forest was fully covered with natural tree species and due to pathogenic activities Gishwati natural changed into different classes of forests including pine plantation in the program of afforestation. In 2009, afforested area was covering about 1.2 thousand of hectare increased to about 2.2 thousand in 2012 and declined to 2 thousand hectares in 2019. The fluctuation in afforested coverage was a result of

deforestation and the increase in natural forest coverage was a result of environmental policies.

The findings showed that several changes in Gishwati Forest cover derived from a growing population density in the selected area of study. We need to mention that relying on subsistence agriculture made the observed dramatic change and the loss of natural biodiversity.

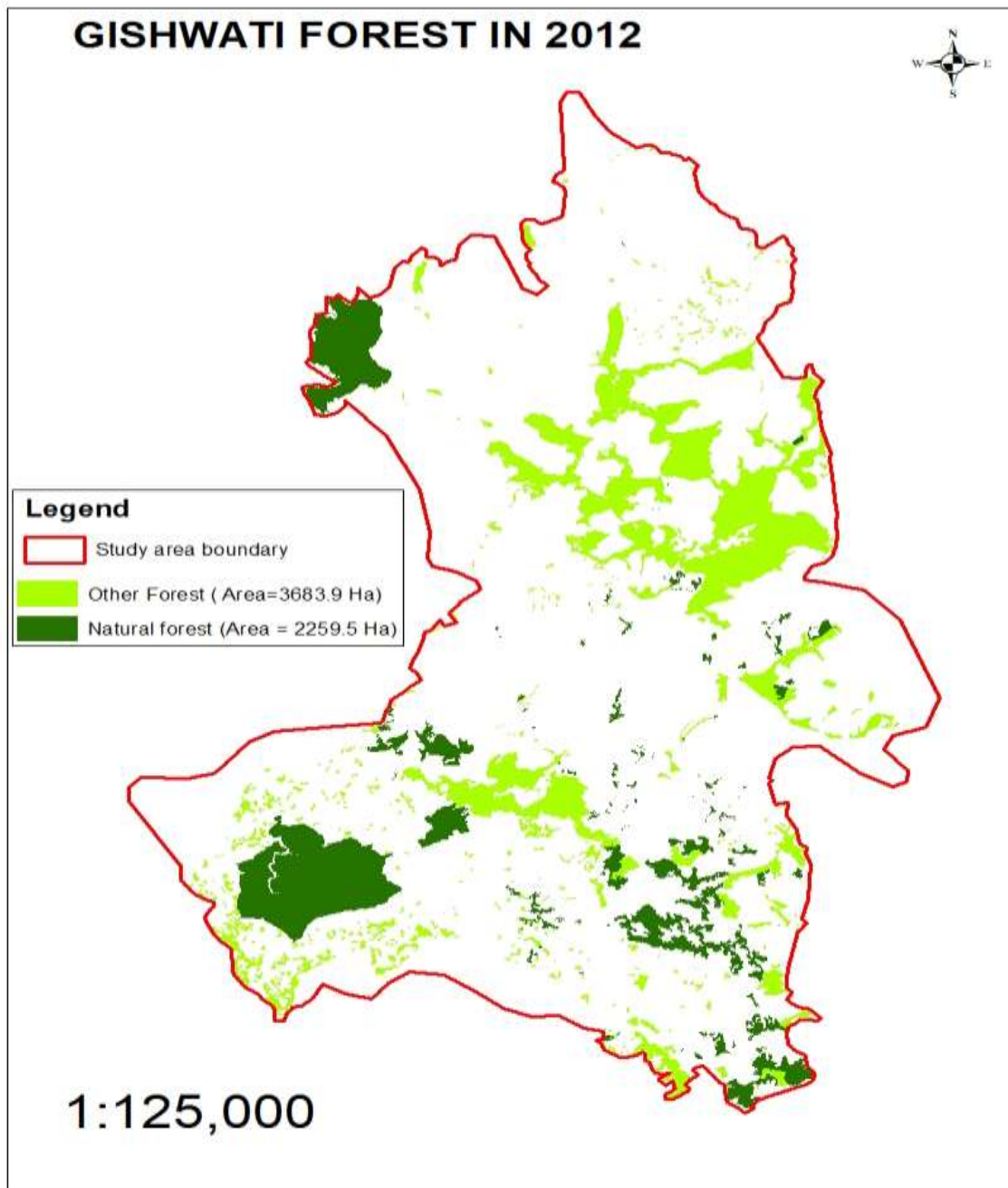


Map 3.1: Gishwati forest in 2009

Source: Own computation based on secondary data from REMA_2009

The program of forestation had begun around 2011 to restore the surface of Gishwati as you can observe in the following map. Gishwati was about to become an area for pastoral activities conducted by the population resettled in the area with their cattle. People found in Gishwati the area

that was favorable to agro pastoral activities and degraded the area for agro pastoral activities. Since 2012, different projects intervened to protect the depredating environment and restore some of the degraded areas.



Map 3. 2: Gishwati Forest in 2012

Source: Own computation based on secondary data, REMA_2012

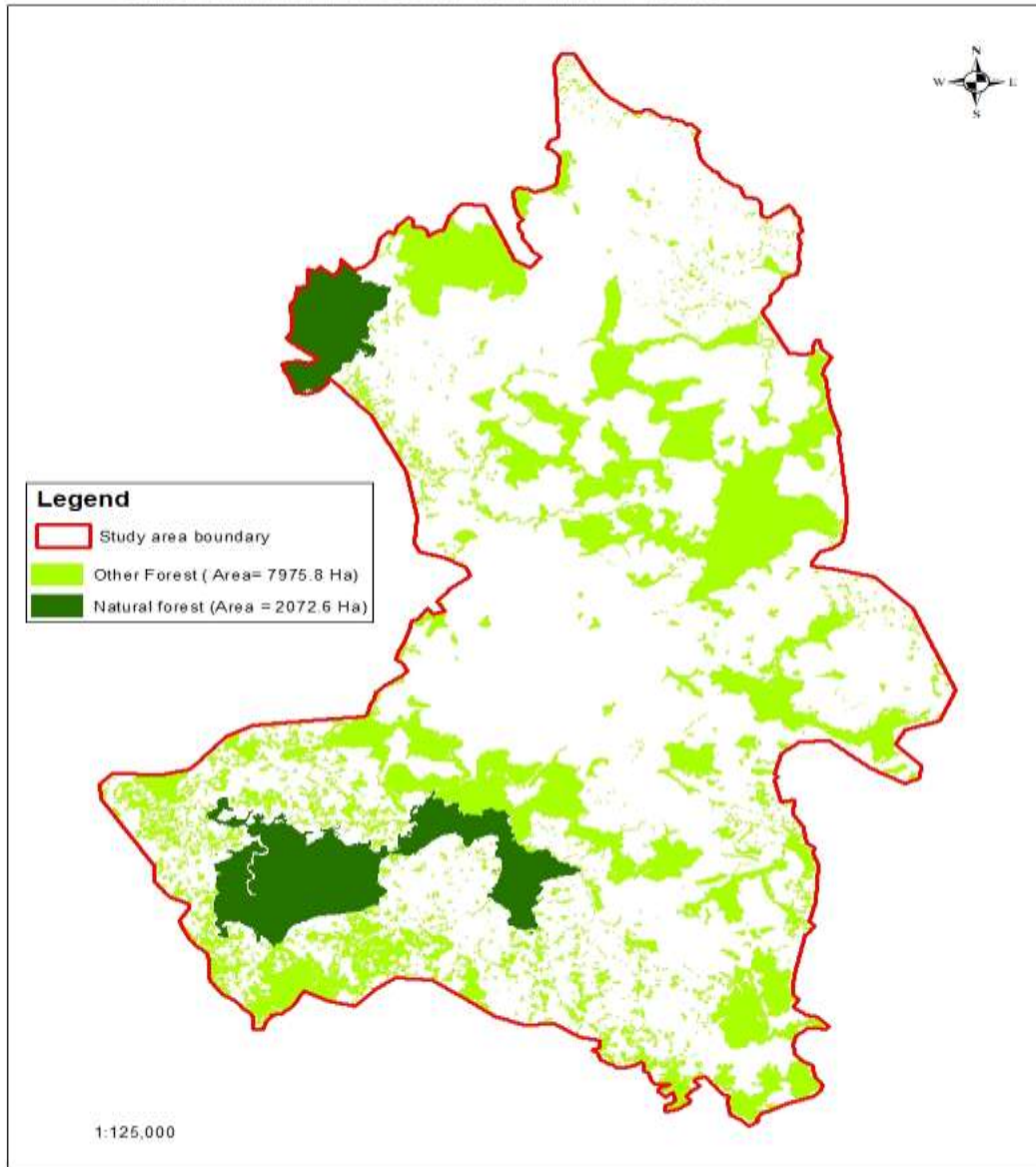
Despite different intervention programs to restore Gishwati, the findings have shown that natural forest had not been recovered and different

plantation made could not reach the existing forest cover before 1988. The findings have shown that natural forest is about 2 thousand ha and afforested

area about 8 thousand ha. A part from a block of around 300 ha in southern part of Gishwati forest and another small in the North-west part of

Gishwati Forest, the rest of the area has been totally exploited by the surrounding population.

GISHWATI FOREST IN 2019



Map 3.4:Gishwati Forest in 2019

Source: Own computation based on secondary data, REMA_2019

3.3. Relationship between population growth and forest degradation

3.3.1 Population density and forest coverage

The results indicate that evidence of linkage between increasing population density and forest coverage higher population density up to

around 485.6 pop/ km. the graph presented below illustrated how population density of the surrounding Gishwati forest population increased and how Gishwati Forest coverage declined all other the selected period.

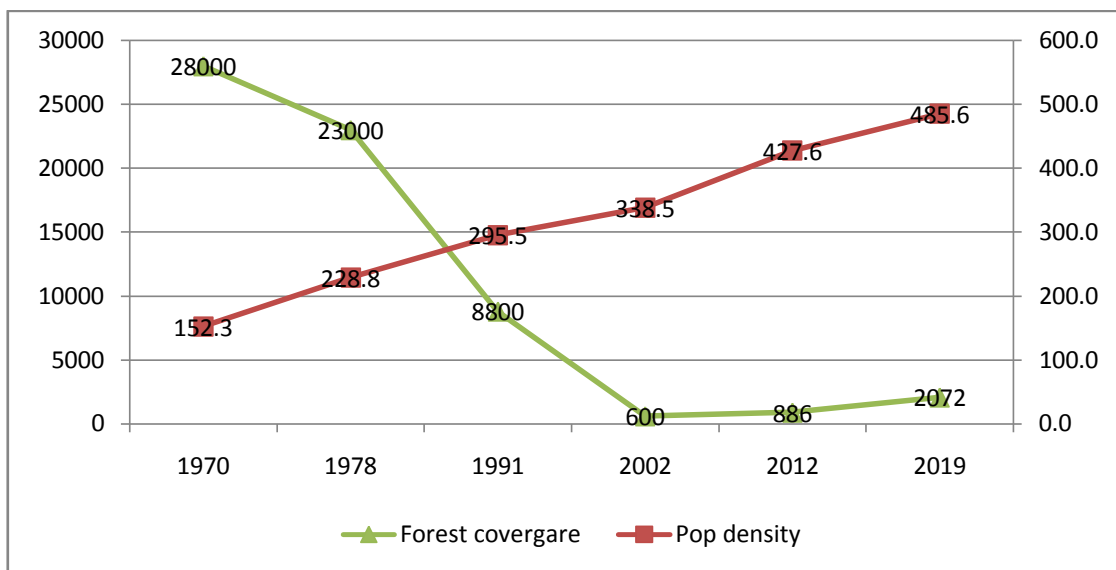


Figure 3. 2: Trends in population growth (Population density) and forest coverage

Source: Own computation based on: NISR,1981,1991,2002,2012, 2019

3.3.2: Statistical relationship between population growth and Forest coverage

Table 4.1 below illustrates the relationship between surrounding population and Gishwati forest coverage. The use of regression analysis reveals that population growth has a negative impact on the forest coverage. For example, an

increase of one person surrounds Gishwati has resulted in a decline in surface coverage of 32 square meter. We are 95% confident that there is a negative relationship between population growth and Gishwati Forest coverage with p-value less than .05 (0.006882).

ANOVA

	Df	SS	MS	F	Significance F
Regression	1	7.86E+11	7.86E+11	26.22233	0.006882
Residual	4	1.2E+11	3E+10		
Total	5	9.06E+11			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1249640.4	96434.3	12.95845	0.0002	981895.6	1517385
Forest coverage	-32.4164	6.3303	-5.12077	0.0068	-49.9925	-14.840

Figure 3.2: Statistical relationship between population growth and Forest coverage

Thus, the researcher has rejected the null hypothesis assuming that Gishwati surrounding population was not growing as Gishwati forest was growing and therefore we have enough evidence support to confirm that as population increases, forest are degraded.

3.4 Discussion

Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Unless the relationship between the multiplying population and the life support system can be stabilized,

development programs, howsoever, innovative are not likely to yield desired results. Population impacts on the environment primarily through the use of natural resources and production of wastes and is associated with environmental stresses like loss of biodiversity, air and water pollution and increased pressure on arable land. Human population issues are

extremely important when it comes to our way of life and our future on this planet. (Ray Ishita Aditya, 2011)

The study has analyzed the relationship between Rwandan population and forest degradation by showing how demographic pressure and its dynamics led further to degradation of Gishwati Natural Forest. Therefore, the study highlighted the important forest of the selected area, and describes their state highlighting deforestation/forest degradation, fragmentation, species composition, population size and general condition of the settlement surrounding Gishwati Natural Forest.

The study has shown how the pressures from the population increase have extended farming onto unsuitable land, and have also driven deforestation. This study remarked a strong relationship between population growth and forest degradation in Rwanda where the Gishwati surrounding population has dramatically increased from about 470 thousands in 1978 and tripled to 1.3million in 2017 and as result; the deforestation reached a level of degradation of 92%. The study suggests the reinforcement of control the population growth through family planning and establishes new policies concerning grouped settlements and so as to reduce forest vulnerability as well as the reinforcement of measure of forest protection from local administrative level.

The study has shown that populations should be supported by alternative energy (Renewable source of energy) for them not to rely on forest as source of energy. Furthermore, the policy of afforestation was found as one of the responses to the degraded forest. The findings showed that several changes in Gishwati Forest cover derived from a growing population density in the selected area of study. We need to mention that relying on subsistence agriculture made the observed dramatic change and the loss of natural biodiversity.

The use different maps produced in different time period and interpreted land cover maps for the year 1988 2005, 2009, 2012 and 2019 has shown that Forest loss also were fairly detected and pressed on visible scale. The natural forest has been exploited since 1980's and in 2005 Gishwati

forest was about to be cleared. Along the years, people living in surrounding villages have often encroached upon and grazed their cattle. There was a gradually conversion from natural forest to Pine plantation and Pasture as illustrated by presented maps above (The increase in forest coverage may be attributed to pine plantation). Forest cover map of 2019 revealed the actual status of forest cover in Gishwati.

This led the researcher to confirm the claim that in-migrants the repatriate together with surrounding population has led to deforestation. Moreover, in-migrants was in need of land for agro-pastoral activities and for subsistence and therefore deforested the area to get land for subsistence agriculture.

IV. CONCLUSION

The former Gishwati Forest which was once an important source of different goods and services such as wild fruits, wild vegetables, wild animals, foods medicinal herbs and tourism can only provide a part of those goods or services. The surrounding population was heavily depending on subsistence farming and agricultural incomes which is derived from the increasing population while also being vulnerable to flood and landslide events due to over exploitation. The Gishwati forest has known serious threats to its sustainability from a variety of stresses of demographic pressures. Evidences are available on how human activities are harming the forest when exploiting the Gishwati forest assets and in most cases, natural species have been degraded and the forest coverage declined. This study remarked a strong relationship between population growth and forest degradation in Rwanda where the Gishwati surrounding population has dramatically increased from about 470 thousand in 1978 and tripled to 1.3 million in 2017 and as result; the deforestation reached a level of degradation of 92%.

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