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Effects of deforestation and its associated consequences resulting from demographic pressure in Rwanda

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This paper examines the effects of deforestation and its associated consequences as a result of demographic pressure in Rwanda. It came out that demographic pressure led to forest clearance and biodiversity disturbances in general, thereby leading to climate change. Using over 30 and 80 years of climatic variables and demographic data respectively, the analysis of the output of ORIGIN PRO 8.0 showed that the population has increased 4 times in the period of 80 years and this in turn has affected the environment. The forest ecosystems, which occupied 30% of the total surface of the country in 1930 has been reduced to 8.9% as by the year 2000. This severe loss of forests has remarkably led to more than 90% decline of fauna species in Akagera National Park. The analysis of deforestation has revealed some associated consequences on regulating services where a monthly increase of 0.5°C and a monthly decrease of 10 mm in rainfall has been remarked in the study period of 1970 to 2010. Finally, this study suggests the State to put in place tight mechanisms to control the population growth for the attainment of sustainable environmental development and reinforce management of ecosystems so as to inherit an enjoyable and productive environment to the future generations.

Key words: Deforestation, demographic pressure, climate change, Rwanda.

INTRODUCTION

Every citizen has a right to a safe, satisfying, and sustainable environment and it should be every person's duty of protecting, maintaining, and promoting the environment (MINITERE, 2005). However, there is growing evidence that human activities harm the environment and as the world's population grows, improving living standards without destroying the environment is a global challenge (Population Information Program, 2000). The later ones include concerns about public health, food supply, fresh water, forest clearance, biodiversity disturbances and global climate change. Nowadays, most researches have focused on climate variabilities due to human induced activities. As climate change is defined as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1992), Climate change may affect the dynamics of ecosystems and

affect the goods and services they provide (Wessel et al., 2004). Climatic factors, such as temperature and precipitation, are important parts of the environmental conditions that determine the composition and dynamics of ecosystems (World Resources Institute, 2003).

As forests ecosystems play an important role in the climate change problem because they can both be sources and sinks of CO₂ (Brown et al., 1996), forest cover helps to maintain a thermal balance in the atmosphere through evapotranspiration; forests regulate hydrological cycles, soil and water quality, and support the highest biodiversity (UNEP, 2002 Montagnini and Jordan, 2005 Denman et al., 2007; Bonan, 2008). Additionally, forests also play a major role in carbon storage and exchange with the atmosphere and regulation of climate (FAO, 2001).

Being a part of the environment, there is growing evidence that as human technology becomes more evolved, the human activities impact remarkably the

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environment. To prove this trend, an example taken here is the population pressure which accelerates the degradation of the environment when people are trying to strive on enjoying the ecosystems services and the most affected ones is the forest based on the fact that forests are attributed to socio-economic functions such as timber production and non timber production or commercial issues (Erwin, 2000).

With respect to population connection, the population growth since 1950 is behind the clearing of 80% of rainforests, the loss of tens of thousands of plant and wildlife species, an increase in greenhouse gas emissions of some 400% and the development or commercialization of as much as half of the Earth's surface land (www.envirocitizen.org). Nowadays, according to Reid et al. (2005), the forest is important in supporting the aesthetic and recreational interests. It is noted here that ecosystems services are grouped into 4 groups (provisioning, supporting, regulating and cultural services). The regulating services concern essential ecological processes that maintain temperature and precipitation (Costanza et al., 1997), while provisioning goods and services include food and services for human consumption (De Groot et al., 2002). The supportive services are the ones required to support the production of other ecosystems goods and services such as the production of grain, wool, fruit and vegetables, etc (Harpinder et al., 2010). Cultural services contribute to the maintenance of human health and well-being by providing recreation, aesthetics and education opportunities (Costanza et al., 1997 De Groot et al., 2002 and Harpinder et al., 2010).

It is notable from the above that the human being is the master and beneficiary for the aforementioned ecosystem services. The main thread to aggravate climate change is the deforestation which refers to conversion of area having forest cover to other uses example, croplands, pastures, or urban (Preet Pal Singh, 2008). Deforestation is concerned in terms of ecological disturbances where the removal or destruction of areas of forest cover has resulted in a degraded environment with reduced biodiversity and the destruction of forest-based societies as well as climatic disruption.

The objective of this paper is to study the impacts of population growth in Rwanda and its consequences on ecosystems degradation by giving a focus on the deforestation concerns and animals' disappearances in one national park (Akagera) as an example to illustrate the effects of demographic explosion on biodiversity and also study its possible effects on regulative services such as temperature and precipitation.

MATERIALS AND METHODS

This study is done based on over 30 years collected secondary data of climatic variables such temperature and precipitation obtained from Rwanda meteorology office. The demographic data

from 1930 up to 2010 were obtained from various reports of researchers and the Rwanda Institute of Statistics. The biodiversity data used in this study are documented in some reports and adapted in this study to facilitate the analysis. The study opted both quantitative and qualitative analysis by interpreting the output of ORIGIN PRO 8.0 Software and only final results and/or calculations are cited. Formula (1) has been used to determine the population growth rate, forest clearance as well as climatic variables trends. It here to note that for the forest status, the word population used in the formula was replaced by the area in ha:

$$\text{Growth rate} = \frac{\text{Population at the end of period} - \text{Population at the beginning of period}}{\text{Population at the beginning of period}} \quad (1)$$

The positive values indicate the increase while the negative values mean the loss or decline. The climatic data were processed based on the monthly and yearly data initially calculated from the office in charge mentioned earlier..

RESULTS AND DISCUSSION

Evolution of the population of Rwanda from 1930-2010

As the population growth is the change in a population over time the trends in population growth in Rwanda from 1930 to 2010 is presented in Figure 1 which generally highlights a dramatic increase in population number from 1930 up to 2010 where it increased four times. Figure 1 clarifies that the population slightly increased in the period 1930 to 1950 followed by a dramatic increase between 1950 to 1970. The trend in the previous period was slightly slowed down in the period 1970-1990 after which period the population continued to increase and reach 11 millions in the year 2010. The slight decrease in the population growth rate in 1990 to 2000 (compared to previous years) was a result of the war consequences and the Genocide which took place in 1994 where thousands of people were displaced and killed. Figure 1 also shows an increase from 1997 and recent studies shows that currently the population exceeds 11 millions, making Rwanda to be the most densely populated country in Africa with population density of 418 people/km². The ecological implications to this population growth is that the more the population is dense, the riskier the environment as the people will try to exploit the resources in order to meet or satisfy their needs and therefore, different kinds of ecosystem services are highly affected. An example of environmental degradation is the deforestation and implicates that associated services cannot be fully achieved or are somehow disturbed.

The high population pressure on the environment can be justified by a simple analysis of the evolution of population density as presented in Table 1a.

Table 1a clearly shows that as the population density increases, the forests reduces, the reason being the occupation of new land which implicates the destruction of forests mainly for agriculture and habitation. This trend

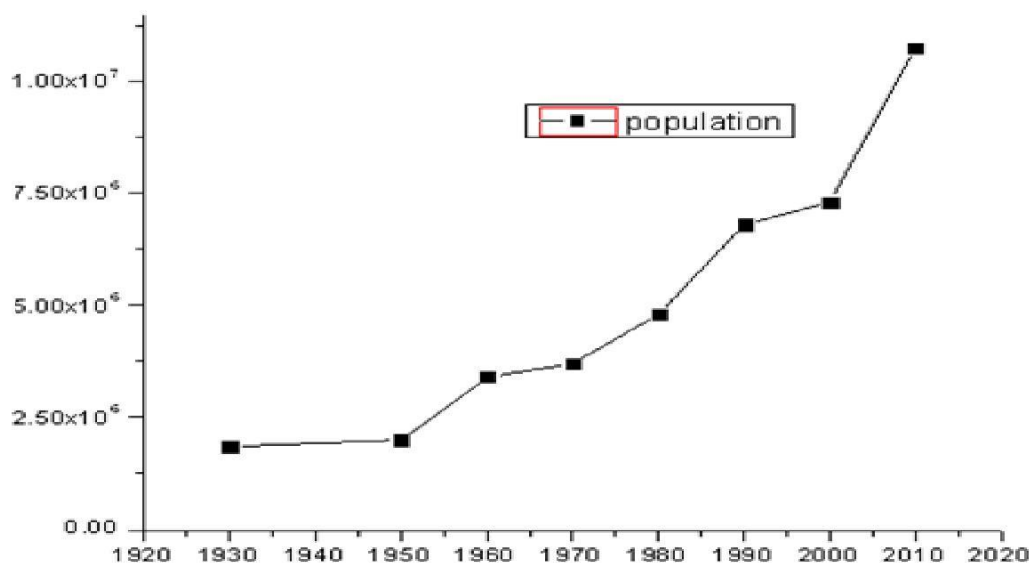


Figure 1. Evolution of the population of Rwanda from 1930 to 2010.

Table 1a. Evolution of the population density vs. forest clearance.

Year	1934	1950	1960	1970	1980	1990	2000	2010
Population density	70	75	129	182	195	258	277	417
Forest clearance (ha)	N/A	N/A	634000	591800	513600	451160	383660	221200

Table 1b. Pearson correlations between population density and forest clearance.

Variable		Forest clearance	Population density
Forest clearance	Pearson correlation	1	0.98644
	Sig.	--	
Population density	Pearson correlation	0.98644	1
	Sig.	2.7445E-4	--

2-Tailed test of significance is used.

is evidenced in Table 1b where the Pearson Correlation is -0.98 meaning a perfect decreasing (negative) linear relationship.

The country surface area remains constant but the population grows disproportionally to the capacity of the environment to accommodate it with limited adaptative measures like dispersed settlements and therefore, as the new land is required, forests become highly vulnerable.

Deforestation status from 1960-2002

From ancient times, forests have played a great role not

only for human welfare and subsistence but also for the animals. Table 2 presents how forests have been reduced with time from 1960 to 2000.

Based on how Rwandan economy is primarily based on rudimentary agriculture where 90% of the population is engaged in subsistence agriculture, this may explain the reason why the area of natural forests reduced from 634000 to 221200 ha for a period of 40 year. In other words, a decrease of 65% of forest cover which means an annual decrease of 1.625% of the forest area from 1960 to 2000 has been remarked.

It is noticeable that total area forested in Rwanda was 30% of total land area in the 1930s, reduced to 25.7% in 1960 and finally to 8.9% in 2000 (Masozera and

Table 2. Degradation of forests areas in Rwanda from 1960-2000.

Year	1960	1970	1980	1990	1996	2000	Percentage of ha lost
Nyungwe + Cyamudongo	114000	108800	97500	97500	94500	92400	18.95
Gishwati	28000	28000	23000	8800	3800	600	97.86
Mukura	3000	3000	2100	2100	1600	1200	60.00
Volcano park	34000	16000	15000	12760	12760	12000	64.71
Akagera Park	241000	241000	241000	241000	241000	90000	62.66
Hunting area	64000	45000	45000	34000	0	0	100.00
Eastern gallery forests	150000	150000	90000	55000	30000	25000	83.33
Total (ha)	634000	591800	513600	451160	383660	221200	65.11

Table 3. Impacts of population growth on the forests and climatic variables.

Period	PGR	PFC	AMT	AMP
1930- 1950	4.7	0	N/A	N/A
1950-1970	71	-7.3	N/A	N/A
1970-1990	93.1	-31.2	20.2	85.5
1990-2010	50.6	-103	20.7	75.6

PGR: Population growth rate in %, PFC: percentage of forest clearance, AMT: average monthly temperature in degree Celcius, AMP: average monthly precipitation in mm.

Alavalapati, 2004). The reforestation and afforestation efforts to adapt to this situation is documented in MINITERE and CGIS- NUR (2007) and indicates that in 2005, the MINITERE and CGIS-NUR forest mapping project estimated the Rwandan forest cover to be 240 746 ha, equivalent to 10.1% of national land area.

Overview of population impacts on forests and climate variables

Antropogenic impacts on the environment are remarkable worldwide and Rwanda is not left behind. Table 3 summarizes the impacts of "population growth on the forests and climatic variables". Table 3 shows that the population growth rate dramatically increased from 4.7 to 93% from 1930 to 1990. It is noticeable that during the period 1990 to 2010, the population growth slightly increased by a value of 50.6% due to the horrible events, such as war consequences and genocide. The deforestation rates rose from 0 to 103% from 1930 to 2010 which corresponds to the increase of population which surely necessitates more land to occupy for various purposes. The increase in population growth involving the massive destruction of forests as indicated in Table 3 has resulted in the increase of 0.5°C and therefore, it is remarkable that the precipitation underwent a monthly decrease of 10 mm. Considering the above trends, there is a need to adapt accordingly so that the country does not desertify and efforts have to be reinforced in order to control the population growth so as

not to overpressure the environment given most times the population relies on ecosystem services to survive and without such control, it will be hard to reach a sustainable environment or natural resources not to ourselves but also to future generations as well as meeting the Rwanda vision 2020 and beyond.

Anthropogenic impacts on the degradation of Akagera National Park

The Akagera National Park (ANP) covers a surface of about 108,500 ha and hosts more than 900 species of plants, 90 mammals, of which 47 species of big mammals, 530 species of birds, 9 species of amphibians and 23 species of reptiles (Twagiramungu, 2006). This ecosystem of Akagera National Park (ANP) (Wooded Savanna) is entirely fragmented and its wildlife population is found only in small disturbed enclaves. The deforestation was not possible to overcome in the mid 1990 because Under the 1993 Arusha Accord, it was resolved that returning Rwandan refugees would be settled into open unsettled areas; the areas deemed most suitable were the ANP and the Mutara Hunting Reserve reason why all the hunting reserve places were completely removed and the area of the ANP area was reduced by two-thirds (USAID/Rwanda, 2003).

Due to the severe loss of biodiversity and ecosystems, the loss of this habitat has resulted in a further decline of all fauna species in the area as it can shown in the Figure 2.

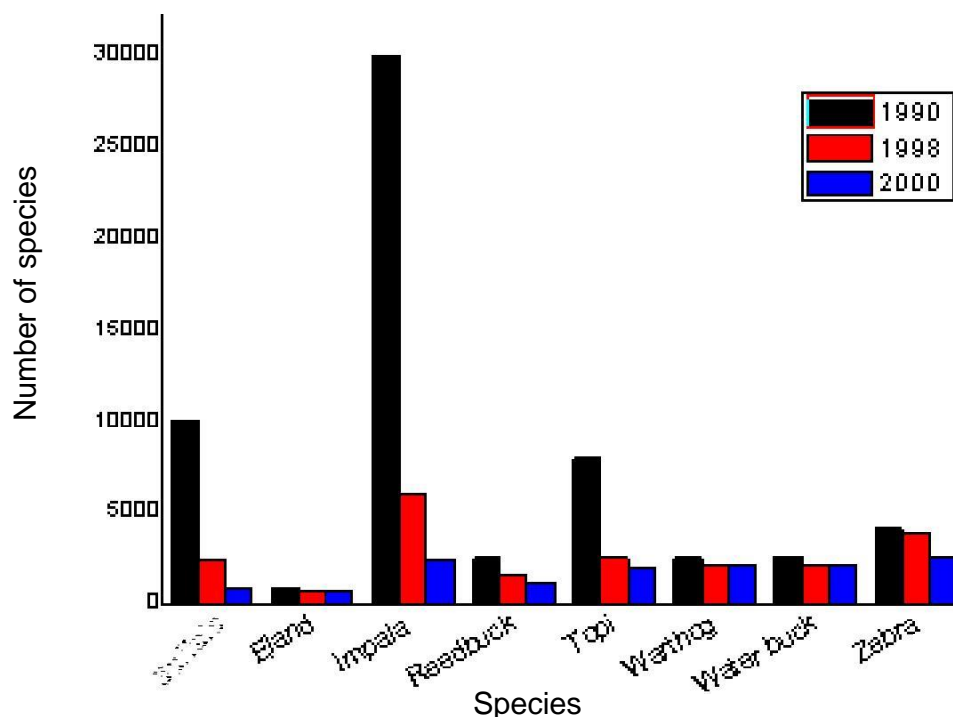


Figure 2. The status of fauna species degradation in Akagera National park.

The Akagera national park has lost its vegetation and wildlife due to the grazing pressure which greatly reduce the palatable –nutrients rich grasses and an increase in weeds, charcoal production, tree-cutting for various uses (USAID/Rwanda, 2003).

The decline in number of animals in the park as indicated in the Figure 2, is attributable to the reduction of range and vegetation degradation from overgrazing and poaching as well as to the exclusion of wildlife from water resources and loss of access to traditional breeding grounds.

The calculations of animal percentage change from 1990 to 2002 show alarming changes as indicated against their names as follows: Buffalo (-95.1%), Eland (-65%), Impala (-93.7%), Reedbuck (-96.1%), Topi (-90.5%), Warthog (-74.5%), Waterbuck (-90%) and Zebra (82.8%). From these figures, the study suggests the entities in charge of environmental conservation to act jointly to safeguard the remaining species otherwise, the later ones are exposed to extinction.

Conclusion

The technosphere is burdening the environment and sustainable environmental development is hard to achieve if no serious measures are adopted accordingly to safeguard the environment. Evidences are available on how human activities are harming the environment when exploiting the environmental assets and in most cases,

the environment is destroyed in one way to another. This study remarked a demographic explosion in Rwanda where the population has dramatically increased by 4 times from 1930 to 2010 and as result, the deforestation reached a level of 65%. The deforestation of this kind has lead several ecosystem services be limited. A focus was mainly made on regulating services where we remarked a monthly increase of 0.5°C and a monthly decrease of 10mm in rainfall.

The deforestation does not only affect the regulating services but also the others are affected. As the forest is a shelter of several animals, this study shows that the Akagera National Park is suffering as the fauna species percentage loss is very disastrous and most of them are reduced at level higher than 90% from 1990 to 2002.

Finally, this study remarked that the striking population growth and its activities have progressively degraded our environment and this study suggests the State to carefully control the population growth and establish new policies concerning grouped settlements so as to reduce forest vulnerability. Lastly, further researches on other forest ecosystems like volcano and Nyungwe national parks are used to study their local people interactions with these ecosystems.

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