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Research Article

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The Impact of Forest Products Demand on Deforestation in Rwanda: A Case Study of Burera, Gakenke, Gicumbi, Musanze, and Rulindo Districts

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ABSTRACT
The world's forests play an integral role in not only the well-being of their inhabitants but also in the overall health of other lifeforms on the planet. Some of the major benefits of forests include climate stability, ecological benefits, biodiversity and economic importance. Deforestation is one of the major challenges to gain the above benefits in the long run. It involves the permanent end of forest cover to make that land available for residential, commercial or industrial purposes. The purpose of this study was to assess the impact of forest products demand on deforestation in Rwanda. A case study of Burera, Gakenke, Gicumbi, Musanze, and Rulindo Districts. The study adopted a cross-sectional survey research design as its framework to guide the process of data collection. The target population was households living closer to the forest products demand. The study adopted a purposive sampling approach to select five districts. Twelve (20) households were randomly selected from each sector making a total sample size of 120 respondents. Descriptive analysis was done using SPSS version 20, and regression using STATA version 12. The results of the study indicated that the forest products used by the households were firewood, stakes, timbres, charcoal, building scaffolds, fodder, poles, and medicine. The results of the logit model showed that land size, family income, household size, occupation, education level, and fodder were statistically significant and positively influenced forest product demand in the study area at ($p< 0.01$). The result of the regression analysis also revealed that eight variables out of nine were positively significant and influenced deforestation in the study area. Agricultural activities, urbanization, forest fires, and overpopulation were statistically significant at the $P \leq 0.01$ level. Despite the roles provided by forests all over the world, the results of this study showed deforestation effectively causes climate change, wildlife extinction & habitat loss, decline in the life quality of people (100%). After these results of the study, the best solution to overcome deforestation is to curb the felling of trees by enforcing a series of rules and laws to govern it. Supporting research, extension and training for more sustainable grazing systems, including silvopastoral techniques that can simultaneously increase livestock production and protect the soil against nutrient depletion, compaction and erosion.
Keywords: Impact, Forest Products, Demand, Deforestation.

INTRODUCTION

Human beings through their agricultural activities have affected the world environment negatively. In many forest areas, trees have been cut down by surrounding people looking for cultivable and grazing land. This has resulted too many problems related to environmental degradation such as soil erosion, soil infertility, lack of firewood, lack of fodder, lack of timber, and lack of raw materials (Shackleton CM, *et al.*, 2007). The practice of agroforestry is viewed to offer solutions to the above problems. Forest resource utilization poses a major challenge to the delicate balance between complex and fragile ecosystems in many developing countries.

About 60 percent of the world's forests approximately 2.4 billion hectares are primarily or partially used for the production of wood and non-wood forest products. Wood fuel, including charcoal, accounts for about half of total global round wood production, and industrial round wood for the other half. Most wood fuel is used in

its country of production, particularly in rural areas and in developing countries, for heating and cooking, usually on open fires or in simple cookstoves (FAO, 2007). In Africa, more than two-thirds of the population relies partly on forest products to satisfy their livelihood needs (Duncan Brack, 2018). Aside from timber, NTFPs play an important role in providing between 29–39% of food, medicine, and income needs to about 80% of the local populations living in forest areas of Central Africa (Ayotebi, O, 2000).

The Republic of Rwanda is a landlocked country in the East African region, with an area of 26,338 km² and an estimated population of 12 million in 2017. Rwanda has an equatorial climate mainly modified by relief with constant annual temperatures ranging from 16 to 24°C and annual rainfall between 700mm and 1,400 mm in the drier areas and reaching 2000 mm in the wetter western provinces (NISR, 2012). Currently one of the limitations facing Rwanda is its high population density (estimated at 490 persons per km2), which impacts heavily on the fragile limited land resource characterized by the hilly terrain, high rainfall, and erodible soils. In addition, the country's population growth rate estimated at 2.27% in 2017 is a threat to the sustainability of the natural resource base (NISR, 2012).

Rwanda is characterized by steep topography. Despite having almost 30% forest cover, the high population density of 490 people/Km² means land is very intensively used. Around 50%2 of the population is under 20, which is growing at 2.6% annually. The Agriculture sector provides 68%3 of the employment with small-scale farming predominating (NISR, 2012). Today, Rwanda has about 704,997 hectares of land with forest and shrub land cover, equivalent to 29.6% of the country, of which 17.7% are plantation forests and 11.9% are natural mountain forests and Savannah shrub land protected in national parks, including Nyungwe forest in the south-west, Gishwati & Mukura forests in central-west, Volcanoes forest in north and Akagera savannah shrub in East (MINILAF, 2017).

The 2012 forest cover mapping of Rwanda from Orthophotos, defined forests based on the ability to map them as a group of trees higher than 7 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ on a land area of 0.25 ha or more (FAO and UNEP,2020). Differentiation of forests into categories shows that the total forest area comprised 18% natural forests (123,538 ha), 39% shrublands (260,569 ha), and 43% (286,811 ha) forest plantations (FAO and UNEP,2020).

Rwanda's forests contribute greatly to the national economy. In the fiscal year 2016/17, the contribution of forestry to the GDP was estimated to be US$365 billion (i.e. 5% of the total GDP) (NISR, 2015). Forests have a significant role to play in Rwanda's national development. They provide 86% of the primary energy source mainly as domestic cooking energy. They hold the base for the country's tourism opportunities, which in 2013 generated US$ 294 million and are targeted to increase to over US$ 600 million by 2020. Rwanda's forests protect watersheds and downstream wetlands, supporting agriculture, which accounts for 36% of GDP, 80% of employment and generates more than 45% of the country's export revenues (NISR, 2014).

This economic value though is not fully quantified, but translated into tangible assets like wood consumption (construction, sawing, domestic and industrial energy), fruit sales, erosion control, etc., and in ecosystem services such climate, quality of landscape, tourism, recreation etc., forests and trees are now highly valued for the role they play in providing these benefits (MINILAF, 2017). They are better integrated with other land uses, providing a safe habitat and network for biodiversity, and supporting the rural industries while at the same time, maintaining the climate of Rwanda. Healthy forests, woodlands, and trees can help to provide clean water from well-managed supplies, resilient ecosystems, and good air quality (MINILAF, 2017). It is expected that by 2020, Rwanda's population will climb from 12 million registered in 2017 to 13.5 million and towards 26 million by 2050 of which about 35% will live in Kigali city and in the towns of Rwanda. This will put substantial pressure on Rwandan forests for wood construction and wood energy (https://news.mongabay.com, 2012).

The new threats and challenges to Rwanda's forests today demand new information about species choice, woodland management and restoration, land use and management, pest epidemiology, and control. There is a need to ensure that the resilience and adaptability of forest ecosystems to the changing climate is understood, and considered essential for the continuance of the crucial services that forests provide to Rwandan society (MINILAF, 2017). Climate change and global warming due to greenhouse gas emissions are a reality. The climate of Rwanda is expected to change towards a warmer and wetter climate by 2050. Although Rwanda, has one of the lowest emissions in the world, continuous deforestation to meet the timber and energy demands of a growing population, coupled with uncontrolled forest land use change to agricultural and human settlements6, will put a large part of Rwandan land into degradation and the cost of inaction will be higher than the cost of action in due time (MINILAF, 2017).

There is a severe and increasing gap between wood supply and demand, which is more than twice the sustainable supply. Shortage of fuelwood drives forest degradation in public forests while private forests are often seriously overcut; both these factors prejudice future productivity (Mfon, P *et al.*, 2014). An analysis of the wood demand and supply shows that the demand-to-supply ratio is 2:1 and the shortage is projected to increase in the future unless alternative sources of wood energy are sought. The consumption of fuelwood for Rwandan households is estimated at 2.7 million tonnes per year and charcoal-making accounts for about 50% of total fuelwood used (RNRA-DFNC, 2015). The Business-as-usual scenario on wood supply/demand

estimates the deficit between wood supply and demand to be 4.3 million tonnes (oven dry weight) in 2017, which is projected to increase to 7.5 million tonnes by 2026. This is due to a high increase in demand for firewood and wood for charcoal. This must imply over-exploitation of already low-stocked forests (RNRA, 2014).

Many factors contribute to the demand for wood products. These include population, not just its overall size but its rate of growth, levels of urbanization, migration and changing age structures. The population density in any given country, particularly density per unit of forest, provides a good indication of the pressure on the country's forests (FAO, 2007). Increases in working-age populations and levels of urbanization tend to increase the demand for housing and wood products used in construction and furnishing, though urbanization can also reduce demand for wood fuel, as access to electricity and alternative forms of heating is generally easier in urban than in rural areas (FAO, 2007).

Demand for wood products is significantly affected by changes in income. All else being equal, increasing income tends to be associated with rising demand for wood products (apart from wood fuel), particularly those used in construction and housing (FAO, 2007). More than 1.6 billion people worldwide almost a quarter of the global population depend on forests for food, medicines and fuel, as well as their jobs and livelihoods, and 200 million people, including many indigenous people, directly depend on forests for their survival (FAO, 2007). Pressures from the rising population have extended farming onto unsuitable land, and have driven deforestation. More than 95% of the rural population relies on wood for fuel, and the national dependency level is over 85% despite strong efforts to reduce this (Mfon, P *et al.*, 2014).

Deforestation is the conversion of forested areas to non-forest land use such as arable land, urban use, logged area, or wasteland. According to FAO, deforestation is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. Deforestation implies the long-term (>10 years) or permanent loss of forest cover (GIRI TEJASWI, 2007).

Deforestation defined broadly can include not only conversion to non-forest but also degradation that reduces forest quality - the density and structure of the trees, the ecological services supplied, the biomass of plants and animals, the species diversity, and the genetic diversity. The narrow definition of deforestation is the removal of forest cover to an extent that allows for alternative land use. The United Nations Research Institute for Social Development (UNRISD) uses a broad definition of deforestation, while the Food and Agriculture Organization of the UN (FAO) uses a much narrower definition (Hosonuma N, 2012).

Deforestation has been attributed to socio-demographic factors, such as population growth and the political economy of class structure, and specific exploitation activities like commercial logging, forest farming, fuel wood gathering, and pasture clearance for cattle production. Deforestation from logging operations, particularly in stands of tropical moist forest, is often claimed to occur in a two-step sequence. First, loggers build roads into primary or old-growth forests and remove selected trees. In many places of the world, it was observed that the logging operation destroys 45-74% of the residual trees. The logging damage, however, is compounded once the loggers have left (Hosonuma N, 2012).

The most important direct causes of deforestation include logging, the conversion of forested lands for agriculture and cattle raising, urbanization, mining and oil exploitation, acid rain and fire. In other countries, clear-cut logging practices have been the main reason for forest loss (GGCR, 2011). Probably the most serious and most shortsighted consequence of deforestation is the loss of biodiversity. The negative consequences of global warming are catastrophically increasing drought and desertification, crop failures, melting of the polar ice caps, coastal flooding, and displacement of major vegetation regimes (GGCR, 2011).

Technological change also affects demand as the main cause of deforestation; this includes developments in wood processing technology allowing improved rates of recovery the use of small-dimension timber, and improvements in reuse and recycling. As well as producing wood and non-wood products, forests provide solutions to challenges including poverty eradication, environmental sustainability, food security and agriculture, energy, clean water and watershed protection, biodiversity conservation, climate change, desertification and land degradation, and disaster risk reduction (FAO, 2007).

The main drivers of deforestation and forest degradation in Rwanda are agriculture, with 95% of households practising traditional subsistence agriculture on small plots that have degraded soil structure and fertility due to continuous cultivation (Rishi P, 2007), infrastructure development, Urbanization including the growing of built-up area, which increased by over 300% in the period from 1990 to 2016 (R. Uma Shaanker,2004). Artisanal mining practices, with a high increase in issued mining permits (in 2014 a total of 548 mining permits were issued to 213 registered mining entities (R. Uma Shaanker,2004) but no restoration of abandoned mining sites, forest product extraction, mostly firewood, charcoal, and timber and limited forestry extension services (An L, 2002).

Forestry is a source of livelihood for many farmers and rural households in developing countries, especially in Sub-Saharan Africa (Cavendish, W. 2000; Abebaw D, 2007). However, the utilization of fuelwood in Rwanda

contributes greatly to desert advancement and consequently has implications concerning climate change. Yet, few people understand the drivers and dynamics of fuelwood consumption in Rwanda and other African countries (Abebaw D, 2007; Bart Muys, 2020). Evidence from China, another developing country, indicates that a considerable majority of households in the Wolong region remain dependent on fuelwood despite their access to electricity.

Forests in such economies are major sources of livelihood for the rural communities that depend on forest resources for fuel wood, construction material, and livestock grazing, among others. The extraction of biomass in the form of forest products like timber, fuelwood, and fodder alters wildlife habitat and constitutes one of the most important threats to forests and wildlife (Prasad, *et al.*, 2015). At the same time, an increase in the populations of communities surrounding forests increases the demand for forest resources, which in turn leads to an increase in degradation. Other factors associated with the increase in forest degradation broadly include demographic, economic, institutional, and technological factors (REMA, 2009; FAO, 2007).

Despite the above measures, the negative effects of forest products demand on deforestation seem to increase due to poor or non-adoption of measures. Such practices like continuous cropping, mono-cropping, overgrazing of farmland, bush burning, use of heavy machines and tools to till the land and use of inorganic fertilizer and chemical pesticides and herbicides are still in practice. There is doubt whether farmers are aware of the forest degradation effects of these farming practices employed or perhaps the farmer's socioeconomic factors are constraints to the adoption of these measures. The purpose of this study was to find out the impact of forest product demand on deforestation in Rwanda. A case study of Burera, Gakenke, Gicumbi, Musanze, and Rulindo Districts. The specific objectives were to identify the forest products demanded by households in the study area, to analyze the factors influencing forest product demand in the study area, to analyze the factors influencing deforestation in the study area, and to determine the impact of deforestation on human livelihood in the study area.

MATERIALS AND METHODS

Description of the Study Area

Northern Province is one of Rwanda's five provinces. It was created in early January 2006 as part of a government decentralization program that reorganized the country's local government structures. Northern Province comprises most of the former provinces of Ruhengeri and Byumba, along with northern portions of Kigali Rural. It has a Surface Area of 3293.3 km^2 and it is composed of five namely Burera, Gakenke, Gicumbi, Musanze, and Rulindo.

(NISR, 2012). The Northern Province shares its Eastern border with the Eastern Province, it borders Uganda in the Northern, shares its Western border with the Western province, while Kigali city and the Southern province border in the Southern part. The 4th Rwanda Population and Housing Census (PHC4) has enumerated 1,726,370 residents in the Northern Province, which represents 16.42% of the total population of Rwanda (10,515,973 residents) (ngm.nationalgeographic.com, 2009).

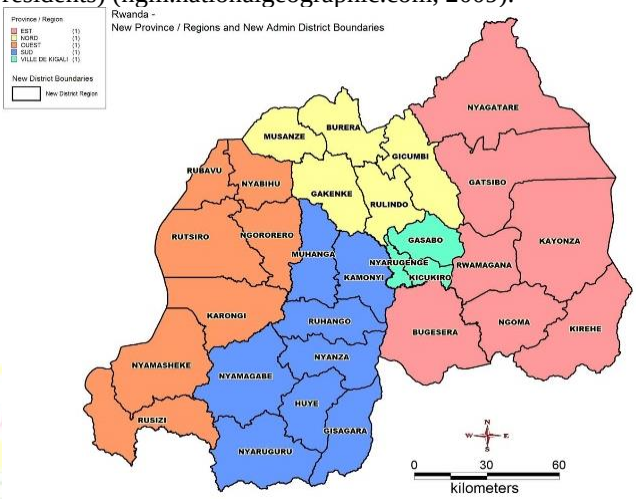

Figure 1. Administrative Map of Rwanda

Research Design

Research design provides a logical structure for research data gathering and analysis (Bryman, 2008). The study adopted a cross-sectional survey research design as its framework to guide the data collection process. According to Bryman (2008), cross-sectional survey research design is the collection of data mainly using questionnaires or structured interviews to capture quantitative or qualitative data at a single point in time.

Target Population, Data Collection, and Sampling Procedure

The target population was households living closer to the forest products demand. The study adopted a purposive sampling approach to select five districts such as Burera, Gakenke, Gicumbi, Musanze, and Rulindo of Northern Province of Rwanda within these ten sectors (Butaro, Cyanika, Gakenke, Muzo, Byumba, Kageyo, Muhoza, Cyuve, Shyorongi, and Buyoga) were selected based on high number of population and households within sector demanding high quantity of forest products for their livelihoods. The respondents were stratified into one category namely forest products users. Twelve (12) households were randomly selected from each sector making a total sample size of 120 respondents. Data was collected between July-September June 2021 through personal interviews using pretested questionnaires. The information collected included bio-data and information relating to the forest products demand and deforestation.

Data Analysis

The study used structured questionnaires to obtain information from the respondents. The data was coded and entered into the Statistical Package for Social Scientists (SPSS). Descriptive analysis was done using SPSS version 20, and regression using STATA version 17. The analysis included the assembling of tables and a logistic regression analysis to determine factors that influenced

household forest product demand and deforestation in the Northern Province of Rwanda.

Table 1. Sample Size Distribution.

Local Government Areas/District	Local Government Areas/Sector	Sample size
BURERA	Butaro	12
	Cyanika	12
GAKENKE	Gakenke	12
	Muzo	12
GICUMBI	Byumba	12
	Kageyo	12
MUSANZE	Muhoza	12
	Cyuve	12
RULINDO	Shyorongi	12
	Buyoga	12
TOTAL		120

Model Specification

To examine households' forest products demand and deforestation in the study area, a logistic regression model was mostly adopted for this study. The study regressed household forest product demand and deforestation as dependent variables as a function of the independent variables which are socioeconomic and demographic. The choice of the logistic regression model is premised on the specification of the dependent variable as binary in nature and outcome.

Logistic Regression

Following Maddala (1983, 2001), the probability, *p*, that a household uses forest products is given by:

$$P = \frac{e^{z}}{1+e^{z}}$$

Central to the use of logistic regression is the logit transformation of p given by Z

$$Z = \ln\left(p/1-p\right)^{2}$$

Where;

$$Z = Z(f, d, a) + \varepsilon$$

Z is a latent variable that takes the value of 1 if the household used forest products and 0 otherwise, f is a vector of farmer characteristics, d is a vector of farm-level variables, a is a vector of asset endowment variables, and ε is the stochastic term assumed to have a logistic distribution. Based on the above equation, the logistic regression model was estimated using multiple regression analysis.

Estimated Logistic Model

Specifications of the Empirical Model used for the forest products (Z) = f (age, household size, educational level, major occupation, membership of cooperative, farming experience, farm size, extension contact, gender, marital status, distance forest) + e

Specifically, the empirical model is specified as:

$Y = \beta0 + \beta1\ X1 + \beta2\ X2 + \beta3\ X3 + \beta4\ X4 + \beta5\ X5 + \beta6\ X6 + \beta7\ X7 + \beta8\ X8 + \beta9\ X9 + \beta10\ X10 + \beta11\ X11 + e$

Where:

Y represents the total forest products demanded in store (st)

X1= Age (years)

X2 = Household size (number of persons in the household)

X3 = Educational level (years spent in school)

X4 = Major occupation (Dummy, farmer = 1, off-farming = 0)

X5 = Membership of cooperative (Dummy, yes = 1, no = 0)

X6 = Farming experience (years)

X7 = Farm size (hectares)

X8 = Extension contact (number of monthly visits)

X9 = Gender (Dummy, male = 1, female = 0)

X10 = Marital status (Dummy, married = 1, other = 0)

X11 = Distance from forest (km)

e = Error term

β0 = Intercept

RESULTS AND DISCUSSIONS

This study discussed the results and findings as well as the linkage to the previous parts. The first results relate to the sociodemographic characteristics of households surveyed within the selected sectors/communities under study as shown in Table 1 below.

Socio-economic Characteristics of Respondents Sampled

The data collected from the respondents were used to run regression analysis as well as to find out the relationship between inputs and output. The results obtained are shown in table 4.1 below.

Table 2. Socio-economic characteristics of survey respondents.

	Frequency	Percentage
Gender		
Male	69	57.5
Female	51	42.5
Age		
21-30	16	13.3
31-40	30	25
41-50	52	43.3
>50	22	18.4
Family size		
1-3	20	16.7
4-7	61	50.8
8 and above	39	32.5
Education		
Illiterate	52	43.3
Primary	73	60.8
Secondary school	29	24.2
Vocation	12	10
University	6	5

The study indicated that 57.5% of the respondents were male and 42.5% were female. This implies that most of those who participated were male and were the most likely to participate in forest product use and

conservation. The findings displayed that 43.3% of the respondents are in the range of between 41-50 years old followed by 25% whore are in the range between 31-40 years. The third class is 50 years and above with 18.4%. The last class was that is in the range between 21-30 years with 13.3%. The findings showed that 50.8% of the respondents are in the range of between 4-7 members of a household followed by 32.5 with eight and above members per household. The last class was in the range between 1-3 members with 16.7%. This plays a very significant impact on product use and its conservation due to the supply of labor from the same household and that minimizes the costs of labor from outside the family. This was supported by studies like Seidu [48] which emphasize those large households are better at providing free labor, indicating the usefulness of larger households in improving farm efficiency. Results also pointed out that the majority of respondents in the study area are not educated. The results showed that 43.3% are illiterate, followed by 34.2% of those who studied primary school and the last is the respondents have university studies with 2.5%. The high percentage of no educated farmers should harm better use of forest products and conservation through harvesting, collection, and long-time to understand different better advice given by forest officers, agronomists, and other advisors of forests and environment management like forest practices such as pruning, thinning, pollarding and coppicing that control facilitate the conservation of forests in the study area.

Types of Forest Products Demanded by Households in the Study Area

The forest products used by the households were firewood, stakes, timbres, charcoal, building scaffolds, fodder, poles, and medicine (table 1). By considering the responses from respondents all the users of forest products, 55% used firewood followed by stakes with 22% while other products were used by less than 20% of the households. The least used product was medicine, which was used by 0.8% of the households.

Table 3. Types of forest products demanded by households in the study area.

Products used	Frequency	Percentage (%)
Firewood	55	45.8
Stakes	22	16.7
Timbers	17	14.2
Charcoal	10	8.3
Building scaffold	8	6.7
Fodder	5	5.8
Poles	2	1.7
Medicine	1	0.8
Total	120	100

Factors Influencing Forest Products Demand

The results of the logit model show that land size, family income, household size, occupation, education level, and fodder statistically significantly and positively influenced forest product demand in the study area ($p< 0.01$). While, gender, stakes, and distance to market indicated a positive influence of forest product demand in the study area at 5%. Therefore, a unit increment in the area under forest increases the likelihood of using forest products by 0.210, holding other factors constant. This suggests that farmers accessing larger pieces of land are likely to set aside part of their land for forest plantation. The findings also indicated that household size significantly influences the forest products demand in the study area at ($p< 0.01$). This is because the larger household sizes are prone to have more members available to require resources from the forest especially firewood for their daily food cooking.

The results showed that family income also positively and significantly influenced household forest product demand in the study area. Moreover, households with higher income usually have a strong purchasing power that enables them to buy more food to compensate for low harvest while the low-income households rely heavily on natural resource extraction from forestlands around them (Tiziano Gomiero, 2016). Infrastructure is expected to influence the ease of accessing places and facilities such as markets. Therefore, if distances to such facilities are large, the likelihood of using forest products for sale may be less. This was supported by Mulenga *et al.*,(2014) who reported that returns on labor and agricultural income are higher among communities that are closer to markets hence making them better off than their rural counterparts. This implies that the higher rural wages and greater off-farm employment opportunities reduce reliance on environmental resources.

Results further showed that the main occupation of the household head influences the use of forest products. The households practising farming as the main occupation were more likely to use forest products than those whose main occupation was off-farm. This is due more particularly to too many stakes used in farming climbing beans, and fodders used for livestock farming without forgetting timbres and woods used in building animal houses in the study area. In addition, the results showed that income influences the use of forest products. An increase in income has a positive influence on the likelihood of forest product use. This finding is in line with the findings of Hedge and Enters (2000) who indicated that higher-income groups utilize more forest resources than lower-income groups when no forest use restrictions are in place. However, it is in contrast with the findings of most past studies (Seidu A, 2008; Vedel, *et al.*,2004) that suggest that as incomes increase the likelihood of dependence on forests declines. The probable reason for the positive relationship is the lack of alternatives for fuel wood in the study area due to remoteness. Households have to cover long distances to get cooking gas, or those who cannot get cooking gas make use of firewood more attractive than the households with the capacity to get it.

The results of the study revealed that the education level of household heads also positively and significantly influenced household forest product demand in the study area. This is because the income obtained from other

economic activities could be used by the educated household with a higher education level, to engage in the commercial exploitation of forest products. This was supported by the study of Newton *et al.,* (2016) indicated that the level of education attained by the household head is expected to influence the nature of his/her economic activity and consequently the level of his/her income. However, this study was contrasted by the study of Newton *et al.,* (2016) who assumed that the high level of education of respondents would lead to the extraction of fewer forest products since education opens up alternative employment opportunities and diverts people from subsistence livelihoods activities such as the gathering of NTFPs from the forest reserve. This is because education would make it easier for households to comprehend negative externalities and passive user values of natural resources.

The results of this study indicated that the gender of the household head influenced the use of forest products. This implies that a 1% increase in women household heads would increase forest product demand by 0.2%. This is due more particularly to traditional culture in the study area influencing a high number of women participating in the collection of forest products and daily food cooking. While the collection of woods for timbers, carpenters, woof for making charcoals, and woods for building is exclusively done by men. This was supported by Jagwe *et al., (*2010) reported that male-headed households are more likely to sell farm products because they own more productive resources than female-headed households.

The study findings also reveal that there is a negative and significant relationship between age, timber diversification, distance to the forest, and likelihood of using forest products. The results showed that the closer the location of the forest to the household the more likely respondents would demand forest products than those located far from forest. This implies that a 1km increase in distance to the forest would reduce forest product demand by 1.045%. The results were supported by Tafere (2013) in his study concerning age, household size, and location of the forest showed that age had a positive relationship with participation in forest management. It was also supported by Cavendish (2000) had earlier stated that older people have difficulty carrying out arduous tasks related to NTFP collection activities.

Factors Influencing Deforestation in the Study Area

The data collected from the respondents were analyzed using a logit obit regression model to find out the factors influencing deforestation in the study area. R-square value (R^2) of 0.8925% means that 89.5% of the total variation in factors influencing deforestation explained the dependent variable. The result of the regression analysis in (table 5) showed that eight variables out of nine were positively significant and influenced deforestation in the study area. Agricultural activities, urbanization, forest fires, and overpopulation were statistically significant at the $P \leq 0.01$ level. Livestock ranching and desertification of land were significant at $P \leq 0.05$ level while mining and price of related fuel were significant at 10% level. Moreover, only illegal logging was not significant in influencing deforestation. This was supported by Otum, *et al.,* (2017) state that most of the activities that can lead to deforestation are human-initiated and are for economic purposes. They also add that forest exploitations are done on two levels: firstly, by local people for survival and livelihood, and secondly, on a more commercial level that involves commercial logging, land conversion for agricultural purposes

Table 4. Logit Regression analysis of the Factors Influencing Forest Products demand.

Explanatory variables	coefficient	Standard deviation	p-value
Land size	0.210	0.388	0.001
Family income	0.325	0.182	0.008
Households size	0.018	0.207	0.004
Age	-0.091	0.059	0.007
Gender	0.164	0.150	0.025
Occupation	0.256	0.065	0.000
Education level	0.088	0.058	0.001
Distance from forest	-1.045	0.357	0.000
Distance to market	0.139	0.430	0.037
Timber diversification	-3.961	2.556	0.050
Fodder	0.719	0.410	0.000
Stakes	0.635	4.127	0.045
constant	1.770	2.152	0.000
Number of observations:120	Prob> chi2:0.0000		
Log-likelihood = -83.374	Pseudo R2:0.7407		

The results indicated that agricultural activities had a positive influence and statistically significant on deforestation in the study area at ($p< 0.01$). This implies that a unit increase in agricultural activities will lead to increased deforestation by 0.8 units. As earlier mentioned in the results of forest products demanded in the study area, agricultural activities are one of the significant factors affecting deforestation. This is supported by Karamage F *et al.,* (2004) indicated that agriculture leads to around 80% of deforestation. Due to the overgrowing demand for food products, a huge amount of trees are felled to grow crops, and 33% of agriculture-caused deforestation is because of subsistence agriculture.

This was also supported by Karamage F *et al.,* (2004) which notes that industrial activities are the principal driver of deforestation and degradation worldwide, but subsistence agriculture and fuelwood consumption remain an important direct driver of deforestation, especially in Africa. Drivers vary on a regional scale. For example, cattle ranching and large-scale agriculture are major drivers of deforestation in Latin America, whereas

palm oil development, intensive agriculture, and pulp and paper plantations are principal drivers in Indonesia.

The results showed that there is a statistically significant association between urbanization and deforestation in the study area at ($p< 0.01$). This implies that a unit increase in Urbanization would increase deforestation by 1.54 units. This is because the construction of for instance houses, bridges, and roads is undertaken; here again, trees are chopped to build roads. Overpopulation too directly affects forest cover, as with the expansion of cities, more land is needed to establish housing and settlements. Therefore, forestland is reclaimed. Ogundele, *et al.,* (2016) also add urbanization, industrialization, infrastructural development, tourism, bush burning, mining, logging and fuelwood collection, corruption, and political causes as some causative factors responsible for deforestation.

The results revealed that there is a statistically significant association between forest fires and deforestation in the study area at ($p< 0.01$). This implies that a unit increase in forest fires would increase deforestation by 4.2 units. This for example would be forest blazes where hundreds of trees are lost each year due to forest fires in various portions of the world. It happens due to extremely warm summers and milder winters. Fires, whether caused by man or nature, result in a massive loss of forest cover (S. M. Jua´rez-Orozco *et al*., 2017) also supported). Forest fires extensively affect vegetation cover, density, structure, composition, diversity, and productivity. They result in deforestation, reduction in population sizes, forest edge effects, changes in the community structure, and the immigration of exotic species.

The results also pointed out that there is a statistically significant association between overpopulation and deforestation in the study area at ($p< 0.01$). This implies that a unit increase in overpopulation would increase deforestation by 0.6 units. This is because overpopulation requires more land to establish housing and settlements. It generates a significant need for food and farmland to grow food and raise livestock. It automatically requires many more roads and highways for transport and communication all these results in deforestation. Logging industries cut down trees for furniture, building materials, and many more products. This was supported by Mfon, *et al., (*2014) in their study in Nigeria who have identified population growth and its resultant effect on deforestation. This is because as the population grows, it increases the pressure on the available forest resources for sustenance and survival. In addition, population growth also increases the demand for housing and construction, which results in a general forest decline.

Increases in human population are likely to increase household size and this could lead to an increase in fuel wood dependence in developing countries. Kapinga (2015) argued that the majority of these households who depend on the forest for their livelihood are from the rural periphery of developing countries and this has led to deforestation as a common feature.

Bamba, *et al.,* (2011*)* opine that deforestation is usually caused by agricultural practices, timber exploitation, and charcoal and firewood consumption, and these factors are exacerbated by population growth. Population growth harms the available forest cover thus deforestation. Economic growth is among the causes of deforestation because it can also result in the expansion of urban areas especially in Nigeria resulting in the need for raw materials needed for construction (Oyetunji Po *et al*.,2020).

The results revealed that there is a significant association between Livestock Ranching and forest degradation and deforestation in the study area at a 5% level. This implies that a unit increase in Livestock Ranching would increase deforestation by 1.1 units. Livestock production compounds the damage to forests. In a few short years, overgrazing, compaction and nutrient loss turn cleared forestlands into eroded wastelands (GGCR,2011). This is because livestock farmers often clear the land by cutting down trees and burning them to raise livestock and grow food and fodders. They continue to use the property until the soil is completely degraded and repeat the same process on new woodland. Livestock especially is believed to be responsible for about 41% of global deforestation (Jagwe, J *et al.,* 2010).

The results also indicated that there is a significant association between desertification of land and deforestation in the study area at a 5% level. It implies that a 1% increase in the desertification of land would increase deforestation by 0.4%. This should occur due to land abuse, making it unfit for the growth of trees. Many industries in petrochemicals release their waste into rivers, which results in soil erosion and makes it unfit to grow plants and trees. This was supported by AGNS (2022) reported that desertification has led to a reduction in agricultural productivity and incomes; it has also contributed to the loss of biodiversity in many dryland regions. It is further projected to cause reductions in crop and livestock productivity, modify the composition of plant species and reduce biological diversity across drylands. In sub-Saharan Africa particularly, crop production may be reduced by 17–22% due to climate change by 2050 AGNS (2022). Desertification amplifies global warming through the release of CO_2 linked with the decrease in vegetation cover. This decrease in vegetation cover tends to increase local albedo, leading to surface cooling (AGNS, 2022).

The results also indicated that there is a significant association between mining deforestation in the study area at 10% level. It implies that a 1% increase in mining would increase deforestation by 0.2%. It is because the mining of gold and wolfram for example requires a considerable amount of forestland. Apart from this, roads and bridges have to be built to make way for trucks and other equipment. The waste that comes out from mining pollutes the environment and affects nearby species, particularly forest degradation. This was supported by REMA (2015). Showed that mining is a non-renewable resource activity with great potential.

However, although it utilizes a small area of the land it can have significant and often irreversible environmental impacts.

Mining can have harmful effects on the surrounding surface and groundwater. If proper precautions are not taken, unnaturally high concentrations of chemicals, such as arsenic, sulphuric acid, and mercury can spread over a significant area of surface or subsurface water (Newton P *et al*, 2016).

The lifecycle of is one of the filthiest cycles that causes deforestation due to the number of toxins, and heavy metals that are released soil and water environment (Oyetunji *et al*, 2020). Although the effects of mining take a long time to affect the environment the burning and fires, which can burn for up to decades can release flying ash and increase greenhouse gasses. Specifically strip mining can destroy landscapes, forests, and wildlife habitats that are near the sites (Oyetunji *et al*, 2020). Trees, plants and topsoil are cleared from the mining area and this can lead to the destruction of agricultural land.

It was also supported by the report of Hosonuma *et al*., (2012) confirmed that indirect drivers of deforestation, including commodity prices, population trends, corruption and poor governance, land tenure, consumption, and government policies. His findings confirmed that economic growth based on the export of primary commodities and an increasing demand for timber and agricultural products in a globalizing economy are critical indirect drivers for deforestation.

Table 5. Logistic Regression Analysis of the Factors Influencing Deforestation.

Variables	Coefficients	Std. Err	P-Value
Agricultural Activities	0.814	0.061	0.000
Livestock Ranching	1.078	0.340	0.035
Illegal Logging	0.032	0.077	0.641
Urbanization	1.549	2.038	0.000
Desertification of land	0.414	3.155	0.042
Mining	0.235	3.686	0.073
Forest Fires	4.149	0.483	0.001
Overpopulation	0.603	3.016	0.000
Price of related fuel	0.971	0.807	0.068
Constant	0.4723	0.313	0.049
Number of Obs=120	Prob > chi2 = 0.0000		
Log-likelihood =-67.565	Pseudo R^2 = 0.8925		

Impact of Deforestation

Forests fulfil far more functions than simply the production of wood and non-wood products. Indeed, they are vital to achieving global sustainable development. They provide solutions to challenges including poverty eradication, environmental sustainability, food security and agriculture, energy, clean water and watershed protection, biodiversity conservation, mitigation of and adaptation to climate change, the combating of desertification and land degradation, and disaster risk reduction (Hannah Ritchie, 2021). Despite the roles provided by forests all over the world as listed by FAO above, the results of this study showed the main effects of deforestation such as climate change, wildlife extinction & habitat loss, decline in life quality of people, loss of biodiversity, food insecurity in the future, soil erosion, increase in global warming, increase in greenhouse gas emissions, floods, and acidic oceans.

The results of the study revealed that deforestation is effective because of climate change, wildlife extinction & habitat loss, decline in the life quality of people (100%). These affects the climate in many ways. Forests are the lungs of our planet. Trees take in carbon dioxide and release oxygen and water vapour in the air. When a forest is cut down, the humidity levels come down and cause the remaining plants to dry out. The drying out of tropical rainforests increases fire damage that destroys forests rapidly and harms wild animals as well as humans. In addition, Forests and climate are linked intrinsically. Forest loss and degradation are both a cause and an effect of our changing climate. At the same time, deforestation is self-perpetuating. Therefore, these occurrences are dangerous and fuel further deforestation. However, the loss of trees allows for flooding, soil erosion, desertification, and higher temperatures to occur more rapidly and exponentially. Due to the massive felling of trees, various animal species are lost. They lose their habitat and are forced to move to a new location where many of them are even pushed to extinction. This should also contribute to social economic conflict and population migration.

The results of the study also pointed out that deforestation significantly causes loss of biodiversity, food insecurity in the future, soil erosion, and an increase in global warming respectively as shown in Figure (2) below. This is because deforestation leads to a huge loss of biodiversity. About 80% of the global biodiversity is located in tropical rainforests. Forests not only provide habitats for wildlife but also foster medicinal conservation (FOA, 2016). The forest acts as a critical medium to preserve a wide variety of species. It also destroys the microbial community that is responsible for the production of clean water, the removal of pollutants, and the recycling of nutrients (Muhammad Aqeel Ashraf *et al*., 2014).

Deforestation for food may result in food insecurity in the future. Currently, 52% of all the land used for food production is moderately or severely impacted by soil erosion. In the long term, the lack of fertile soil can lead to low yields and food insecurity (Tiziano Gomiero, 2016). Trees are also crucial for our local water cycles as they keep on returning water vapour to the atmosphere. With the clearance of tree cover, the land is directly exposed to the sun, making it dry. Without trees, erosion often occurs and sweeps the land into nearby rivers and

streams. Forests serve as nature's water purification plants. Soil erosion makes soil exposed to contaminants that leach into the water supply, which damages the quality of our drinking water (CGIS-NUR/PAREF/RNRA, 2012). Trees play a major role in controlling global warming. The trees utilize greenhouse gases, restoring the balance in the atmosphere. With constant deforestation, the ratio of greenhouse gases in the atmosphere has increased, adding to our global warming woes.

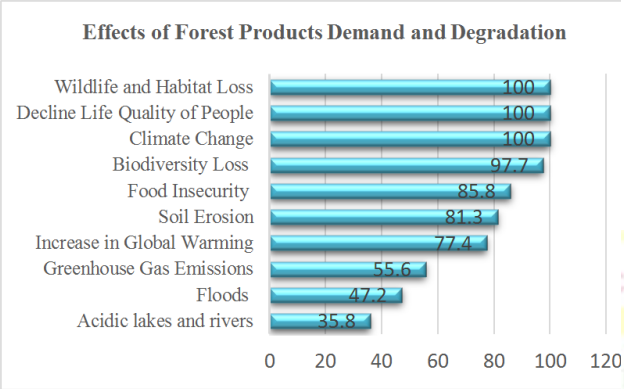

Figure 2. Effects of Forest Products Demand and Degradation on Human Livelihood.

CONCLUSION

The results of the study indicated that the forest products used by the households were firewood, stakes, timbres, charcoal, building scaffolds, fodder, poles, and medicine (table 3). The findings of the logit model showed that land size, family income, household size, occupation, education level, and fodder were statistically significant and positively influenced forest product demand in the study area at ($p< 0.01$). The result of the regression analysis in (table 5) also revealed that eight variables out of nine were positively significant and influenced deforestation in the study area. Agricultural activities, urbanization, forest fires, and overpopulation were statistically significant at the $P \leq 0.01$ level. Despite the roles provided by forests all over the world, the results of this study showed deforestation effectively causes climate change, wildlife extinction & habitat loss, decline in the life quality of people (100%). After these results of the study, the following recommendations were listed as well as to overcome the problem of deforestation:

The best solution to deforestation is to curb the felling of trees by enforcing a series of rules and laws to govern it. Deforestation in the current scenario may have reduced; however, it would be too early to assume.

Land-skinned tree cover for urban settlements should be urged to plant trees in the vicinity and replace the cut trees. In addition, the cutting must be replaced by planting young trees to replace the older ones that were cut.

Livestock rearing has become one of the leading causes of deforestation. The cut-off trees due to the need for fodder significantly increase deforestation. However, cultivating other grasses replacing trees like agroforestry trees, nipper grasses, and Kikuyu grasses will also have an extreme impact on environment management and ecosystem conservation.

There is a need therefore to invest in both formal and informal education of households in the study area where formal education raises awareness of the benefits of conserving the environment while informal education should importantly change households' attitudes towards forest conservation at a large scale.

Timber diversification activity that can help generate income in the study area may also act as an incentive to reduce reliance on forest products. Therefore, to lower the dependence on forests there is a need to improve sensitization and training on commodity value chains that could help to increase household income.

Policymakers and the private sector to invest in activities that will generate other sources of income as an important issue that will significantly reduce forest product use and empower environmental conservation.

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CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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