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Economic Impacts of the Anthropogenic Effects of the Deforestation on the Rural Populations of Mali

Amadou K. dit Amobo Waïgalo

Abstract

Deforestation in rural surroundings in Mali is the main problem determining the deterioration of the quality of the environment with consequent climate change (drought, erosion and decrease in rainfall). More than 70% of the Malian's population is predominantly rural, with a poverty line of 48.7% in 2017. Their main source of energy comes from the consumption of firewood and charcoal. The Mali Sahelian country suffered for nearly two decades, from 1968 to 1985, a long cycle of drought that has weakened its ecosystem. Population pressure in the 1970s and 1980s increased demand for farmland. This has resulted in massive deforestation in favor of cereal and cash crops. Since rural agriculture is extensive and has low productivity, the populations find that wood is used as an alternative to offset the decline in their agricultural income. From the analysis of the results obtained, anthropogenic factors significantly impacting deforestation with negative and positive effects are pasture and firewood consumption. The variable associated with population growth is negative and significant at 5%. Population growth positively affects forest cover regeneration.

Keywords: anthropic, deforestation, economic impacts, firewood, forest, population

1. Introduction

Mali is a vast country of West Africa with a surface of 1,241,238 km². In 2018, its total population rose to 18,338,322 inhabitants¹, that is to say, a low density of approximately 15 inhabitants per km². The essence of its economy rests on agriculture and the breeding including more of the 2/3 of its total population evolving in the sector. More than 70% of the Malian population is rural. The incidence of poverty² of the Malian population which accounted for 46.8% in 2016 knew a fall of 1.9% in 2017. However, this fall of the rate of incidence of poverty would be ascribable in the good crop year of 2017–2018 cereal productions. In 2017, poverty was accentuated in rural medium, with a threshold of 53.6%. At the same period, the

¹ <https://contrymeters.info>

² The INSTAT brings back this rate to the proportion of the population which does not manage to spend 178,000 F CFA to satisfy its basic needs per annum.

real growth rate of the GDP was about 5.4%. On the other hand between 2016 and 2017, the rate of inflation passed from -1.8 to 1.8% , that is to say, a clear increase of 2% [1]. The rate of inflation which results in the impact that the rise in the price of goods has on the purchasing power of the consumers is relatively low. It indicates that apart from the agricultural sector, few economic alternatives are offered to the rural medium in order to easily integrate the nonagricultural market.

Mali Sahelian country knew a long cycle of dryness between 1968 and 1985. For this period, the rains were done rare. It had as consequences the degradation of the grounds, the recurring dryness, a reduction in vegetable cover with a considerable reduction of spaces of grazing ground and a deceleration of the growth of the live-stock. During years 1970 and 1980, the Sahelian countries made considerable great strides of the demographic growth which resulted thereafter in an expansion of the cultivated grounds, less grounds put in fallow and the exhaustion of the grounds. During nearly one century, the essence of the marketing policy of the colonizers rested on the cultures of revenue. The imposition of the cultures of revenue by the colonial capacities more contributed to deforestation with as a corollary the degradation of the not very fertile grounds. Thus, $60-93\%$ of the energy needs of the Sahelians come from wood [2]. Between 1990 and 2005, deforestation passed from 84,000 to 144,000 hectares. It results primarily from the human intervention. During this interval of period, the total surface of artificial afforestation passed from 5000 to 65,000 hectares [3].

The economic activities of the rural populations of Mali are mainly dependent on the agriculture which constitutes their principal source of income. With that the exploitation of the forest resources is added (nonwoody forest products, woodcut, pharmacopeia, etc.) which come to them in complement from incomes for the periods of welding.

With the accentuated effects of the climatic change, these populations are more and more confronted with falls of their mean level of productivity, which impacts negatively on their level of incomes. Consequently, to compensate for the fall of their agricultural incomes and the abuse of the local forest resources, they are increasingly inclined with the expansion of cultivable surfaces with an aim of increasing the agricultural output per hectare. It has as a corollary the excessive firewood cut for the charcoal (domestic consumption and sale on the urban markets), with less afforestation with regard to the local trees. The excessive anthropic pressures on these resources limit their productivities and exacerbate local and community conflicts.

Indeed, in front of these factors impacting the standard of living of these populations, they find as alternative the migration, the rural migration, nonagricultural gold washing and other activities (small trade and seasonal work in the large cities). These various factors thus make it possible to compensate for those which would have positive and significant impacts on deforestation. For this study, except the above-mentioned factors, it is also a question of determining the socio-economic and anthropic effects which impact positively and negatively deforestation. It will make it possible to pose a real not very used econometric diagnosis by the engineering departments which primarily focus on the descriptive analysis of the data that they produce.

Considering these various factors, one would be brought to analyse and interpret the bond of dependence between the deforestation and the variation of the economic (macroeconomic indicator determined by the GDP per capita and the poverty line) and demographic (evolution of the size of the population and manpower of the pupils having the level of the second cycle) factors. And a thorough comprehension of the anthropic actions (pasture of the cattle, consumption of the firewood and charcoal, the breeding, the expansion of surfaces of food crops

and production of food crops) in bond with deforestation will make it possible to corroborate the immediate and indirect causes as well as the consequences of deforestation.

For this study, we will use a suitable econometric model which will enable us to determine the explanatory variables which have impacts on deforestation. It will enable us to make recommendations as regards public policy for better apprehending the immediate and indirect causes of deforestation generated by the people.

Moreover, deforestation in Mali appears more and more as a phenomenon which mobilizes the government, local populations, the nongovernmental organizations and international organizations to limit these socio-economic impacts on the populations.

2. Methodology

2.1 Medium of study and data acquisition

From its surface, Mali is the 23^e vastest country in the world. It is located between the 10° and 25° degrees of northern latitude and between the 4° degree of east longitude and the 12° degree of western longitude. The climate is at the same time very dry and very heat for the 3/4 of the country, except in the extreme South, being in part of the area of Sikasso. In the Far North, the Sahara, precipitations' ring average is lower than 250 mm and exceeds 100–150 mm with difficulty. On the other hand, in the extreme North, the rains are quasi non-existent. The Sahel sheltering the semi-desert central areas receives on average less than 500 mm of rain per annum. The South is subhumid with average precipitations lower than 750 mm per annum. The lowest value of the average annual temperature is of 28°C and highest is of 32°C³.

The whole of the data collected for this study is secondary data. They are time series and cover the periods going from 2003 to 2012. The data made up are carried mainly on deforestation and of the macroeconomic and sociodemographic variables. The collected data come from the sources of the National Institute of the Statistics—INSTAT of Mali, the World Bank, the reports/ratios of study and the sites: perspective.usherbrooke.ca and ps://donnees.banquemondiale.org.

2.2 Specification of the model and processing of data

Two models of regression will be used to analyse the direct and indirect bonds between deforestation and the variables from which it would result. The estimate of the first regression will relate to ordinary least squares (OLS) in order to identify the immediate causes of deforestation. The second stage will be specified with the model logarithmic curve in order to explain the relative variations (in %) of deforestation following the variations (in %) of the macroeconomic and sociodemographic variables. The data processing will be made by the Stata software.

First stage of the specification of the model

$$\text{Def} = \beta_0 + \beta_1 \text{ManLi} + \beta_2 \text{FWC} + \beta_3 \text{SFC} + \beta_4 \text{PFC} + \varepsilon \quad (1)$$

Def: annual decline of forest cover (km²).

ManLi: manpower of the livestock (number).

FWC: firewood overall consumption (tons).

³ <https://fr.m.wikipedia.org> consulted the 14/02/2019 at 15. 32

SFC: surface of food crops (hectare).
 PFC: production of food crops (tons).
 $\beta_{1, 2, 3, 4}$: coefficients.
 β_0 : constant.
 ε : term of the error.
Second specification of the model

$$\text{LnDef} = \beta_0 + \beta_1 \text{LnPop} + \beta_2 \text{LnTEEFII} + \beta_3 \text{LnGDPC} + U \quad (2)$$

Ln: neperian logarithm.
 Def: annual decline of forest cover (km²).
 Population: population of the inhabitants (number).
 ETPF II: total of the population having the level from Fundamental II (number).
 GDPC: gross domestic product per capita (\$).
 $\beta_{1,2,3,4}$: coefficients.
 U: constant.

3. Econometric estimate, results and discussions

3.1 Anthropic actions

The anthropic actions having impacts on deforestation are caused directly by human activities. Among those we have the pressures exerted by the animals on spaces of grazing ground, the woodcut for multiple uses, the extension of cultivable surfaces for cereals and the production of food crops.

In the model of estimate between the anthropic deforestation and actions, it arises that $R^2 = 0.8789$, which would explain why 87.89% of the causes of deforestation are due to the explanatory variables of the model, that is, to the human activities. There is adequacy of the model. It arises that the model is overall significant since the value of Prob(F-statistic) is associated to be lower than 5%. As a whole, variables ManLi, FWC, SFC and PFC have overall a significant impact on the degradation of forest cover. More specifically, only variables ManLi and FWC have a significant impact on the degradation of forest cover (**Table 1**).

3.1.1 The pasture

The value of the coefficient associated with the variable ManLi is negative and significant to 10%. It indicates an opposite relation between the deforestation and the number of the cattle. It is obvious that the increase in the livestock in rural medium of Mali is one of the causes of the reduction of the level of deforestation. Therefore, the increase in livestock impacts negatively the degradation of vegetable cover (graminaceous grasses, fodder and Graminaceae). It allows a rapid restoration of the forest cover made up of woody species. It appears thus that it is the overgrazing which leads to the abuse of the forest resources.

Space pastorales in rural medium of Mali are sufficiently available, and their rational use allows the reduction of the deforestation which induces an increase in forest cover. The breeding thus appears as an essential factor which impacts deforestation negatively. The elasticity of reduction of the degradation of the forest surface being of 6.66%, which implies that the increase of 1% of animals constitutes the livestock, would reduce the deforestation by 6.66%. It implies that the increase of the livestock through the production of the organic manure enriching the ground improves the agricultural productivity and contributes to the increase of the forest cover of 6.66%.

Variable	Coefficient	Std. error	t-Statistic	Elasticity
C	−17802.08	6641.227	−2.680541	−277.5293
ManLi	−0.000171	6.67E-05	−2.558930 *	−6.661940
FWC	0.004886	0.001659	2.945847 **	26.29780
SFC	0.000105	0.000185	0.566668 ^{NS}	0.255692
PFC	−0.000200	0.000217	−0.922393 ^{NS}	−0.676106
R-squared	0.878947			
Adjusted R-squared	0.757894			
Akaike information criterion	12.71521			
Schwarz criterion	12.82478			
Hannan-Quinn criter.	12.47876			
Durbin-Watson stat	1.879230			
Prob(F-statistic)	0.040414			

Note: *** = significant 1%, ** = significant 5%, * = significant 10%, NS = not significant.

Table 1.
Anthropic factors determining deforestation.

The large stockbreeders in rural medium being mainly wandering have a good perception of the traditional management of the natural resources. Most of the share of the livestock occupies spaces of grazing ground according to the variation of the seasons and the availability of fodder. It allows thus fast reconstitution of the vegetation after one period when space pastorales are almost unexploited [2].

3.1.2 The firewood consumption

The firewood overall consumption is positively correlated with deforestation. Its coefficient is positive and has a threshold of significativity of 5%. The firewood consumption by the households is thus one of the principal reasons of the deforestation in rural medium of Mali. That is means that as the consumption of the firewood increases, the decline of forest cover also increases. Thus, the elasticity of the variation of the firewood consumption with regard to the increase in deforestation is 26.30%. Any increase in the firewood consumption of 1% implies an increase of 26.30% of the forest degradation.

Indeed, that who corroborate with the idea according to which more the share of the countries of Africa Subsaharian use like principal energy wood. Nigeria does not make exception since the increase in its forest decline results mainly from the wood consumption due to a demand in increasing. This request results from an increasing population of need for sources of energy and building machineries for the houses [4]. In the Sahel and in Africa, the local wood energy consumption would be one of the principal causes of deforestation. With that the fall of the pluviometry characterized by dryness is added to the Sahel which decimates the population of the woody species [5].

In Mali, the proportion of the households which use the firewood or coal passed from 77% in 2001 to 77.6% in 2016⁴. Also in rural medium as in urban environment of Mali, the use of wood thus constitutes the first source of energy. It is thus used as charcoal for cooking and in the manufacture of boxes and is

⁴ Data resulting from the investigation of the periods active from April 2017 to March 2018, into Consumption, Poverty and Welfare of Households of the National Institute of Statistics—INSTAT of Mali.

used to cover the roofs of the concessions. In rural and urban medium, there are many electric posts which are made containing wood. The mortars, the rammers, the hoe, cart, etc. are also designed containing wood. That who confers on wood multiples uses.

3.1.3 The expansion of surfaces of the food crops

The coefficient determining the expansion of surfaces of food crops is positive and nonsignificant. An increase of 1% of cultivable surfaces increases the deforestation of 0.25%. It shows that compared to the other above-mentioned factors, the increase in surfaces of food crops impacts little on the deforestation in rural medium of Mali. The country has sufficient bottom funds, of arranged plains and irrigated perimeters where cereal culture is made. That is the case of the Office zone of Niger which counts with him only an agricultural potential of 2,458,506 ha including 1,907,406 ha suitable, 1,445,000 ha irrigable by gravity and a surface of 131,000 ha exploited⁵. These great installations were conceived since the colonial period. It would limit the impact of the expansion of surfaces of food crops on deforestation. Another factor not less significant is that the farmers who extend their cultivable surfaces take more and more conscience of the risk which weighs on the environmental pollution through deforestation. The trees resulting from local species are thus protected by the farmers and certain regulations in force.

Many studies highlight the positive impact and the degree of significativity which the increase in cultivable surfaces has on the degradation of forest cover, but the bond established in the Malian context proves the opposite. The models of development of agriculture in Africa, Asia and Latin America, based on rice growing, tend to increase considerably agricultural surfaces which would be the principal cause of the deforestation of the tropical forests [6].

3.1.4 Production of food crops

The coefficient determining the production of food crops impacting deforestation in Mali is negative and nonsignificant. If the agricultural productivity increases by 1%, deforestation decreases by 0.68%. In other words the level of reduction of deforestation decreases less proportionally than the increase in the agricultural productivity. The most of the agricultural productivity, the more high will be the reduction of deforestation but in a less significant way. A high agricultural output ensures a sufficient income and puts the farmer safe from economic and food needs. These factors return to him less vulnerable.

A successful agriculture is that which gives better results in terms of increase in the agricultural productivity through an intensive culture and the safeguarding of the environmental quality leading to less of deforestation [7].

3.2 Economic and socio-demographic determinants of the deforestation

Economic and socio-demographic factors which determine deforestation are estimated by the function neperian logarithm. The model is well specified since $R^2 = 0.9712$, which indicates that 97.12% of the variations of the variable dependent on the model are explained by the explanatory variables. Given that the value of Prob(F-statistic) is lower than 5%, the model is overall significant. The model is thus adequate (**Table 2**).

⁵ Consulted the 18/02/2019 on <https://www.maliweb.net>.

Variable	Coefficient	Std. error	t-Statistic
C	124.4731	20.12615	6.184648
LETPF II	−0.161668	0.223772	−0.722465 ^{NS}
LPOP	−6.083446	0.892867	−6.813383 ^{**}
LGDP	−2.036184	2.714014	−0.750248 ^{NS}
R-squared	0.971229		
Adjusted R-squared	0.928074		
Durbin-Watson stat	2.951644		
Prob(F-statistic)	0.042844		

Note: ** = significant 5%, NS = not significant.

Table 2.
Anthropic factors determining deforestation.

3.2.1 The level of education

The coefficient associated with education is negative and nonsignificant. An increase of 1% of the level of education reduces the deforestation of a rate of 0.16% in rural medium of Mali. It indicates that the rate of deforestation decreases with the increase in the level of education. This reduction of the level of deforestation in connection with that of education, secondary level, is done in a less significant way since the impact is not considerable. Nevertheless, the level of education is a very significant factor making it possible to understand the stakes related to quality and the environmental pollution. With regard to the secondary school between 2009 and 2014, the net rate of enrolment was 36% for men and 23% for women⁶. So that the impact of the reduction ratio of deforestation is more considerable in rural medium of Mali, it is necessary that the policies adopt a programme of elimination of illiteracy on a large scale. This policy must promote the access for the attack of a minimal level at the secondary school for the adults.

3.2.2 The demographic factor

The negative and significant sign of the demographic growth to the threshold of 5% indicates that it negatively impacts the degradation of forest cover in medium of rural of Mali. In other words, the demographic growth affects the regeneration of forest cover positively. Elasticity relating to the variation of the population is −6.08%. Any increase in the population of 1% reduced the degradation of the forest cover of 6.08%. The rural migration and seasonal worker are the principal reasons of this fall of the destruction of forest cover. With the place that their principal source of income comes only from the wood sale, the rural ones prefer the rural migration towards the urban centres for other remunerative employment. Agriculture principal source of income for the rural young people is forsaken with the profit of gold washing. The migration of the rural young people is also one of the principal causes of fall of the anthropic pressure on the forests. With that the recurrence of the community conflicts between farmers and stockbreeders is added and even sometimes between sedentary farmers who are at the origin of internal displacements. From these factors, cultivable surfaces which shelter many forest resources are thus saved by the extensive agriculture and the extensive pasture.

⁶ Base data of the UNICEF, consulted the 19/02/2019 at 12:01 PM on < <https://www.unicef.org/infobycountry>

That who is explained by this effect regulator the pressure anthropic. The demographic factor, i.e. the number of inhabitants which accounts a country, is quoted in many scientific works as a factor which is positively correlated with deforestation. This assertion is the subject also of controversy on this subject.

Moreover, the rate of deforestation can increase because of the increase in population which induces significant anthropic needs. The growth of the population created enormous food needs, which impacts on the demand for arable lands which results in the deterioration of forest cover. The growth of a population is also accompanied by a keen demand out of firewood, structural timber and woody forest products. Of another share, the demographic growth can induce technological progress and institutional changes which will contribute to reduce devastating effects of the forest [8].

3.2.3 The gross domestic product per capita

Gross domestic product, that is, the income per capita, is negatively correlated with deforestation. But its coefficient is nonsignificant. For any increase of 1% of the annual income per capita, deforestation decreases by 2.03%. The improvement of the living conditions of populations, through the increase in their incomes, is an essential factor of reduction of deforestation. The higher the income per capita, the more the degradation of forest cover is reduced, and the less is the rate of the environmental pollution in bond with deforestation.

Indeed, the gross domestic product per capita significantly affects various manners of restoration of forest cover. That is the Asian case of four countries of which the Philippines, Indonesia and Malaysia, and Brazil. By reducing poverty, the increase in gross domestic product per capita positively affects forest cover and the expansion of the roads. On the other hand, the increase in gross domestic product has a negative influence on forest cover through the expansion of cultivable surfaces. It is the case of the Asian countries where the principal causes of reduction of the forest surface are explained by the economic growth with an elasticity of -0.76% and -0.06% in Brazil [9].

4. Conclusion

With the instar of the other continents, Sub-Saharan Africa is confronted with enormous challenges and more particularly those concerning the climatic changes. The Mali Sahelian country faces the same stakes related to the climatic changes and the deterioration of the quality the environment. Because of the growth of its population, the request for the forest resources is large. This request results from an enormous requirement in consumption for wood which constitutes the first of energy for the households. The consequence is the loss of a woody potential due to anthropic actions which emanate several factors. The level of development of the country with its average income per capita offers few alternatives for the rural and urban populations to use other more accessible sources of energy.

Indeed, the results obtained show that the increase in population is accompanied by a significant level of reduction of deforestation. The principal reason of the negative effect that the increase in population has on deforestation is the rural migration and the migration. These two factors reduce the effects of the anthropic pressure on deforestation. While migrating and urbanizing the rural populations, find other alternatives to compensate for their sources of income primarily coming from agriculture and the wood sale. It has as a corollary the reduction in the exploitation of the cultivable surfaces and that of the woodcut for domestic uses.

Indeed, the rural populations by changing life mode adopt other more suitable means of power consumption induced by institutional measurements. It causes the decrease in the demand out of firewood, structural timber and woody and nonwoody forest products. Political, lawful and legislative measurements quite suitable would encourage the rural and urban populations with a moderation in wood consumption.

However, the level of education affects deforestation negatively but in a non-significant way. Thus, significant challenges are to be raised in order to increase the rate of elimination of illiteracy in rural medium. Education is thus a powerful means making it possible for the populations to understand the consequences related to the environmental pollution.

The abundance of the cultivable ground and pastoral space availability makes Mali a country with potential strong agro-pastoral. The majority of nomads being large stockbreeders have ways of life very related to nature and the forest. It enables them to put methods and traditional techniques into practice favorable to the nature conservation, thus inducing a rational use of spaces of grazing ground. Therefore, the breeding appears as determining which impacts deforestation negatively. It wants to say that the mode of breeding as practised by the rural stockbreeders supports the restoration of forest cover.

However, the principal cause of deforestation in rural medium of Mali results from the wood consumption. It constitutes the principal source of energy for the rural and urban populations since the level of their average incomes offers few alternatives for the use of other sources of energy (solar, wind and thermal). Wood is also used for multiple uses, the coating of the roofs of house, construction of boxes and manufacture of farm equipments.

Deforestation in rural area of Mali is the result of several institutional and regulatory factors. The inadequacy of these measures makes their implementation difficult. Mali is weakened in a sociopolitical context marked by insecurity due to the presence of several armed groups in a large part of the country. The state is therefore unable to implement an effective strategy to combat deforestation and, moreover, mitigate the devastating effects of forest cover. Suddenly, rural populations become direct actors in the preservation of their forest resources. If the state wants to put in place long-term effective environmental policy measures, the involvement of rural people would be fundamental.

However, the implementation of certain institutional, that is, legislative and regulatory, measures is not followed by a policy of large-scale application. Stakeholders involved in the use of forest resources must be made aware of the strict application of these laws and regulations in order to minimize the excessive cutting of wood. As more than half of Mali's rural population is not literate, it is necessary to convey the message of the content of the laws governing forest resource management policy in the local language. Several communication channels, such as rural radio broadcasting and sensitization sessions on the importance of preserving forest resources with local people, should be explored as alternatives. As a result, environmental issues may be better understood by an uninformed population regarding the consequences of climate change. This will have a positive impact on the behaviour of rural populations in terms of wood consumption and reduced destruction of forest cover.

In addition, other more appropriate policy measures need to be taken to significantly reduce the use of wood for domestic purposes. These measures concern the limitation of exploitation rates of forest resources so that the rate of use or exploitation does not exceed the rate of recovery of forest resources. To limit the impact of deforestation, the public authorities, in particular the Malian State, must grant property rights to individuals in certain protected forest areas. The granting of marketable permits and negotiable access rights to forest resources to loggers would be an alternative to significantly reduce deforestation.

In fact, to reduce the consumption of wood as a source of energy, the State must promote the use of substitutable energy. This is to convince rural households of the utility of improved stoves and solar cookers for more economic and environmental purposes. This would allow rural households and loggers to devote a good deal of their time to other more profitable income-generating activities.

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