Impacts of deforestation on malaria in south-eastern Nigeria: the epidemiological, socio-economic and ecological implications

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Abstract

Forest resources in Nigeria are undergoing severe exploitation pressure due to demographic growth and socio-economic development. Through the process of forest clearing, deforestation alters the ecology of local malaria vectors. The overall goal of this study was to seek to clarify the mechanisms linking deforestation, economic development and malaria epidemiology and the ecological implications. The research methodology stresses a mix scale approach involving social research in areas of active and non-active deforestation in Ebonyi state Nigeria and the descriptive assessment and analysis of the forest resource exploitation issues, as well as the implication for sustainable forest resource management. Findings indicate that the income status of individuals residing in the areas of active deforestation was lower than those of areas of non-active deforestation. Higher yearly episodes of malaria and the tendency to spend less amount of money for malaria treatment characterized the areas of active deforestation and the inhabitants had higher preference for use of woodfuel and use of forest medicinal herbs for malaria treatment. In the areas of active deforestation, the mosquito night biting/landing rates were considerably higher than those of areas of non-active deforestation. Conservation policies aimed at slowing deforestation will impact malaria and would reduce the increasing incidence of deforestation-dependent malaria epidemics.

INTRODUCTION

Forest biodiversity, and the natural functioning of forest ecosystems, contribute immensely to human health. Indeed, the drastic alteration of forest systems – through large-scale deforestation– can open up opportunities for disease-causing pathogens, such as parasites, viruses or bacteria, to infect other organisms with which they have previously had no contact [1]. In Nigeria as in most tropical regions of the world, deforestation constitutes a major health, environmental, ecological and socio-economic challenge. The land area of Nigeria is 923,768 km2 with mangrove and rain forests in the south which occupy about 20% of Nigeria’s land area. The annual deforestation rate in Nigeria is 5.0%, compared to a global rate of 0.6% [2]. The World Development Indicator estimates an average annual deforestation of 3,984 sq.km per annum for Nigeria for the period 1990-2000. The total area under forest cover is put at 135 sq. km, while the rate of forestland conversion is 2.6 percent [3]. Nigeria has lost more than half of its forest in the past five years and is globally considered as the world’s highest deforested country [4]. .

Between 2000 and 2005 Nigeria lost 55.7 percent of its primary forests -- defined as forests with no visible signs of past or present human activities [5]. Logging, subsistence agriculture, and the collection of fuelwood are cited as leading causes of forest clearing in the West African country. The increase in Nigeria's population estimated to be about 140 million has brought about demand for farmland particularly in the rural areas. As a result of extensive clearing of lands, there is soil degradation with erosion. Some extensive clearings have extended illegally to the forest reserves where the trees have been used as fire wood or fuel woods.

Through the process of clearing forests and subsequent agricultural or other project development, deforestation alters every element of local ecosystems such as microclimate, soil, and aquatic conditions, and most significantly, the ecology of local flora and fauna, including human disease vectors [6]. Of all the forest vector species that transmit diseases to humans, mosquitoes are among the most sensitive to environmental changes because of deforestation: their survival, density, and distribution are dramatically influenced by small changes in environmental conditions, such as temperature, humidity, and the

availability of suitable breeding sites [7, 8, 9]. Changes in mosquito ecology and human behaviour patterns in deforested regions influence the transmission of mosquito-borne diseases such as malaria [10,11].

In Nigeria malaria is the number one public health issue, accounting for 25% of under-5 mortality, 30% of total childhood mortality and 11% maternal mortality [12]. According to recent reports, 20% of the global malaria cases occur in Nigeria, with approximately 110 million people affected annually [13] and majority of outpatient visits being malaria-related [12]. Most Nigerians are likely to suffer at least one episode of malaria in their lifetime but the vast majority experiences multiple bouts. Numerous country and area studies have described the influence of deforestation and subsequent land use on the density of local mosquito vectors. In particular, each incident of deforestation and land transformation has a different influence on the prevalence, incidence, and distribution of malaria directly and indirectly [10].

The overall goal of this study is to seek to clarify the mechanisms linking deforestation, economic development and malaria epidemiology with mosquito ecology, and the environmental implications in order to improve health impact assessments for future forest development projects in south-eastern Nigeria and other parts of sub-Saharan Africa of similar setting. The project is aimed at examining the possibility of predicting potential impacts of future deforestation on socio-economic development, vector density and malaria epidemiology using information on types of planned land use and the ecology of local mosquito species.

MATERIALS AND METHODS

PROFILE OF STUDY AREA

This research was conducted in the rural and semi urban areas of Abakaliki and its environs. Abakaliki is the capital of Ebonyi State, Nigeria. Ebonyi State is located in the south eastern region of Nigeria. With a land area of about 5,935 sq. km, the State lies approximately within longitude 7°30' and 8°30'E and latitude 5°40' and 6°45'N. There are two distinct seasons-the rainy season (April-October) and the dry season (November to March). The average atmospheric temperature is 30oC and the mean annual rainfall is 2100mm. The vegetation is characterized predominantly by tropical rain forest. Ebonyi State is primarily an agricultural region. It is a leading producer of rice, yams, and cassava.

The study locations were within the semi urban areas (Azugwu and Azuiyiokwu) of Abakaliki and rural communities at the boundaries of Abakaliki and two neighbouring local government area (LGA) known as Ezza North LGA (Umuohara) and Ebonyi LGA (Ndiabor). Although Umuohara and Ndiabor are located on the outskirts of the capital city of Abakaliki, the increasing population growth within the capital and the efforts to decongest the city have led to the exploitation of boundary communities. Massive deforestation is taking place in Abakaliki the State capital and its rural environs to pave way for agricultural activities, logging, fuel wood collection and construction works (including roads, housing estates and other residential buldings, industries and factories, schools and other educational istitutions, health facilities, etc), leading to a rapid expansion of the area.

The study area Abakaliki is an area of stable malaria transmission. The transmission usually approaches the peak towards the end of the rainy season. Anopheles gambiae and A. funestus are the commonest mosquito species found in Abakaliki and its environs and have been implicated in the transmission of malaria in the area (Odikamnoro OO and Uneke CJ, unpublished data).

METHODOLOGY OF STUDY

The research methodology stresses a mix scale approach involving the descriptive analysis of the forest resource exploitation issues, their impacts on malaria and socio-economic status of the affected rural populations and the on the ecosystem, as well as the implication for sustainable forest resource management. The methodology involves a review and presentation of health, socioeconomic and environmental trends based upon secondary data sources. The research methodology also involved quantitative and qualitative survey using structured questionnaire and face to face interview of the study population. The following were conducted:

(a). Mapping of the study sites: Four sites were mapped out for this study. Two of the sites (Ndiabor and Umuohara) have active deforestation activities going on presently while the other two sites (Azugwu and Azuiyiokwu) had active deforestation more than 20 years ago and currently experiencing only minor deforestation activities.

(b). Socio-economic assessment: Assessment of income status and other socio-demographic parameters using quantitative and qualitative survey methods as described

previously [14, 15].

(c). Environmental assessment: Assessment of forest exploitation activities including logging, fuelwood collection and other forest uses; evaluation of government forest conservation policies as described previously [11].

(d). Mosquito ecological assessment: This was conducted as described previously [16]. Assessment of mosquito night landing/biting rate via sampling by night catches on human bait from 6pm to 2am. The collectors aspirated mosquitoes off their own legs and the number of mosquitoes was recorded within the period.

(e). Malaria epidemiological assessment: Assessment of malaria incidence and prevalence via descriptive epidemiological survey method using hospital records; and house-to-house interview to determine number of bouts of malaria among the population within the last 12 months as described previously [15,17].

RESULTS

A total of 235 individuals (57% male, 43% female; aged 16-67; literacy level 52%) from the two areas undergoing active deforestation (Ndiabor and Umuohara) and 290 individuals (52% male, 48% female; aged 17-62; literacy level 67%) from the two areas undergoing minimal deforestation (Azugwu and Azuiyiokwu) provided information via the qualitative and quantitative survey in this study (Table1). The income status of individuals residing in the areas of active deforestation is lower (up to 47.7% and 4.7% earned less than =N=5,000 ($42) and greater than =N=30,000 ($250) respectively) than those of areas of minimal deforestation (41.4% and 12.4% earned less than =N=5,000 and greater than =N=30,000 respectively). Individuals of the active deforestation areas were more likely to have more episodes of malaria within one year (30.2% had greater than 6 episodes) than inhabitants of minimal deforestation areas (14.8% had greater than 6 episodes). Information obtained from the hospital record of a missionary hospital (Mile Four Hospital) serving the areas of active deforestation indicated that a total of 6,709 cases of malaria were identified and treated within 12 months (July 2007-July 2008). The figure comprises 15% adult males, 25% adult females and 60% children.

The capacity to spend higher amount of money for malaria treatment was found among those living in areas of minimal deforestation; 29.3% of them could afford to spend more than =N=1,000 ($9) while 37.2% spent less than =N=500 ($4) for malaria treatment (Table 1). In the active deforestation areas, majority of the inhabitants could only afford malaria treatment cost not exceeding =N=500 (59.6%), while only 15.3% of the population could afford to spend more than =N=1,000 for malaria treatment (Table 1). In the areas of active deforestation most people (46.8%) preferred using forest products including herbs either obtained personally or from herbalists/native doctors for malaria treatment. Although a missionary hospital is located at a place where both communities can reach it easily, only 28.1% went there for malaria treatment. The reverse was the case in the areas of minimal deforestation as only 14.1% of the residents used herbs for the treatment of malaria; majority of the residents (52.4%) preferred obtaining antimalarial treatment from patent medicine stores.

Majority of the individuals (66.0%) of the areas of active deforestation make use of woodfuel. A considerable percentage of people (54.5%) in the areas of minor deforestation also make use of woodfuel (Table 1). Considerable rates of illegal logging activities are on-going at Ndiabor and Umuohara areas both at individual and community levels. The situation is compounded by the lack of effective implementation of forest and natural resource conservation laws. No logging activity is presently witnessed at Azugwu and Azuiyiokwu areas. In the areas of active deforestation, the mosquito night biting/landing rate of 7.7mosquitoes/person/hr was recorded at Ndiabor while 6.8mosquitoes/person/hr was recorded at Umuohara. A lower mosquito night biting/landing rate was recorded at the areas of minor deforestation; 3.6mosquitoes/person/hr was recorded at Azugwu while 3.4mosquitoes/person/hr was recorded at Azuiyiokwu.

Figure 1

Table 1. Comparative profile of parameters of areas of active deforestation and areas of non-active deforestation in Ebonyi State south-eastern Nigeria

	Areas of active deforestation			Areas of non-active deforestation		
	Ndibor	Umuohara	Total	Azugwu	Azuiyiokwu	Total
Parameter	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)
Income (Naira)						
<5000	62(44.6)	50(52.1)	112(47.7)	80(38.1)	40(50.0)	120(41.4)
5000-10000	46(33.1)	25(26.0)	71(30.2)	62(29.5)	20(25.0)	82(28.3)
11000-30000	21(15.1)	20(20.8)	41(17.4)	37(17.6)	15(18.8)	52(17.9)
>30000	10(7.2)	1(1.0)	11(4.7)	31(14.8)	5(6.3)	36(12.4)
Total	139	96	235	210	80	290
Episodes of malaria						
<3 times	56(40.3)	34(35.4)	90(11.6)	118(56.2)	53(66.3)	171(59.0)
3-5 times	39(28.1)	35(36.5)	74(31.5)	59(28.1)	17(21.3)	76(26.2)
<6 times	44(31.7)	27(28.1)	71(30.2)	33(15.7)	10(12.5)	43(14.8)
Total	139	96	235	210	80	290
Treatment cost (Naira)						
<500	79(56.8)	61(63.5)	140(59.6)	68(32.4)	40(50.0)	108(37.2)
500-1000	33(23.7)	26(27.1)	59(25.1)	83(39.5)	14(17.5)	97(33.4)
>1000	27(19.4)	9(9.4)	36(15.3)	59(28.1)	26(32.5)	85(29.3)
Total	139	96	235	210	80	290
Sources of treatment						
Patent med store	39(28.1)	20(20.8)	59(25.1)	104(49.5)	48(60.0)	152(52.4)
Use of herbs	56(40.3)	54(56.3)	110(46.8)	33(15.7)	8(10.0)	41(14.1)
Hospital/Pharmacy	44(31.7)	22(22.9)	66(28.1)	73(34.8)	24(30.0)	97(33.4)
Total	139	96	235	210	80	290
Use of woodfuel						
Yes	91(65.5)	64(66.7)	155(66.0)	67(31.9)	17(21.3)	84(29.0)
No	48(34.5)	32(33.2)	80(34.0)	143(68.1)	63(78.8)	206(71.0)
Total	139	96	235	210	80	290

DISCUSSION

This study maintains that mechanisms linking deforestation with malaria epidemiology are extremely complex. Findings from this study suggest that deforestation impacts mosquito density, and consequently the landing/biting rate and obviously the malaria incidence. Deforestation, population growth, human movement, economics, power, environment and malaria are therefore intimately interconnected, but predicting the impact of specific land-cover changes on malaria status will require analysis of specific local conditions [15]. Malaria has varying relationships with deforestation, but in most cases deforestation appears to increase the disease load of local people as can be seen in this study.

In a previous study it was shown that deforestation and land transformation influence the malaria vector anophelines, especially larval survivorship, adult survivorship, reproduction and vectorial capacity, through changing environmental and microclimatic conditions such as temperature (average, variability), sunlight (amount, duration), humidity, water condition (distribution, temperature, quality, turbidity, current), soil condition, and vegetation [17]. Increased ambient temperature caused by deforestation was also shown to shorten mosquito gonotrophic cycle, which implies increased daily biting frequency, thus increased vectorial capacity [18]. This could explain why higher rates of malaria episodes and mosquito night biting rates were observed in the areas of active deforestation compared to areas of minimal deforestation in this present study.

Malaria still remains a major killer and factor in the burden of disease in and near forested areas of Nigeria and this is because forest clearing has allowed populations to enter areas that malaria had previously rendered uninhabitable. Although a simple model is presented in this study, the causal links between deforestation and malaria transmission are difficult to be established [15]. In the two areas of active deforestation there was a higher rate of woodfuel usage and considerable levels of illegal logging activities are on-going; this is in addition to forest clearance for agricultural purposes and construction works. Some logging processes for instance could lead to standing water and increase the mosquito breeding sites. Road building, tree felling, reduced shade and increased pooling of water have been shown to promote breeding and more rapid development of mosquito larvae [18, 19].

In this study most people in the areas of active deforestation preferred using forest products including herbs/medicinal plants either obtained personally or from herbalists/native doctors for malaria treatment. Although rural poverty and low literacy level/ignorance play contributory roles this, the fact remains that most rural dwellers still have faith in traditional medicine. In fact in Nigeria there has been an increasing trend in the use of medicinal plants amongst both urban and rural dwellers [20]. This trend has grave consequences on the survival of some plant species because of the unsustainable manner in which many species are harvested. Malaria control is suffering a setback in many rural southern Nigeria societies because deforestation has led to loss of plants that could provide new treatments for malaria and other diseases. It was demonstrated in Ekiti State, Nigeria how botanicals used by local populations for treating malaria are becoming rarer [21]. The problem arises because of a land tenure system that pushes the boundaries of farms into the forests. Because deforestation is a process that cannot be readily controlled for a variety of political and

economic reasons, investigations and assessments of possible impacts of future deforestation will be crucial to minimize the ecological degradation caused by human activities and to prevent epidemics of malaria and other vector-borne diseases [17].

The findings of this study appear to suggest that there is a higher level of poverty in the areas of active deforestation compared to the areas of minimal deforestation. Apart from recording a considerably lower percentage of people who earn above =N=30,000 monthly (about $250), majority of individuals in the areas of active deforestation could only afford malaria treatment less than =N=500 (about $4). The implication of this is that there is a greater likelihood of obtaining less potent malaria treatment with the consequence of increased morbidity and mortality. Most antimalarial drugs that are effective against resistant malaria parasite (Plasmodium falciparum) in Nigeria cost up to =N=1000 (about $9) [22]. The cost of malaria can therefore be measured in lives lost, in time spent ill with fever, and in economic terms. Treatment costs of malaria for small farmers have been estimated to be as high as 13% of total household expenditure in Nigeria [14].

It was noted in this study that individuals of the active deforestation areas were more likely to have more episodes of malaria within one year than inhabitants of non-active deforestation areas. This was not unexpected since severe deforestation activities obviously created more artificial breeding sites for mosquitoes in the areas with the resultant higher mosquito night biting rate [18]. The most worrisome issue however is that up to 60% of the reported cases of malaria at the hospital in the area were children. Repeated bouts of malaria tend to hinder a child's physical and cognitive development, and may reduce a child's attendance and performance at school. Furthermore, repeated bouts of malaria may expose individuals to chronic malnutrition, anaemia and to increased vulnerability to other diseases [23]. Malaria may have adverse demographic consequences as well and substantially raises the chances of infant and child mortality [24]. Households in rural Nigeria respond to this increased risk by having more children, thereby increasing the overall rate of population growth. In addition, the investments which parents of many children can afford to make in the well-being of each child is limited— so that average levels of health care and education per child tend to be reduced [25]. Moreover, mothers of large numbers of children are less able to participate in the formal labour force, thereby also reducing the household income [26].

In conclusion, it is pertinent to state that the incorporation of deforestation into malaria research in sub-Saharan African countries including Nigeria is very critical, not only because of the obvious potential linkages particularly in rural forest communities, but also because of linkages through the human drivers and consequences of malaria and deforestation. Because deforestation is a process that cannot be readily controlled for a variety of political and economic reasons, investigations and assessments of possible impacts of future deforestation will be crucial to minimize the ecological degradation caused by human activities and to prevent the resultant epidemics of malaria and other vector-borne diseases.

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