GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL 10, NO. 2, 2011: 135-144

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PROBABILITY DISTRIBUTION OF LONG-RUN INDISCRIMINATE FELLING OF TREES IN ADAMAWA STATE, NORTH EASTERN NIGERIA.

V. B. TARU, S. S. ZIRRA AND J. JOSEPH

(Received 22, July 2011; Revision Accepted 29, September 2011)

ABSTRACT

The study was undertaken to determine the probability distribution of Long-run indiscriminate felling of trees in northern senatorial district of Adamawa State. Specifically, the study focused on examining the future direction of indiscriminate felling of trees as well as its equilibrium distribution. A multi-stage and simple random sampling technique was employed in soliciting respondents for the study. Three out of the five local Government areas that made up the senatorial district were sampled in the first instance; the second stage was the sampling of sixty respondents using a simple random sampling from each of the three local government areas making a total of one hundred and eighty respondents. Structured questionnaires were administered on the one hundred and eighty respondents. Results revealed that there is a dismal reduction in the numbers of trees on various farms. This was indicated by majority, 64% of the farmers in Madagali, 58% of the famer in Maiha and 86% of the farmers in Mubi North Local Government Areas. Conclusively, the study is a wake-up call for all the authorities concern to swing into action before the study area is declared "desert" because by all indication there is desert encroachment. Massive tree planting is encouraged and there should also be strict law against the act of felling of trees

KEY WORDS: Markov chain, Forest, Desertification, Equilibrium

INTRODUCTION

The contribution of forest to national development cannot be overemphasized. Forest supplies the resources for furniture, veneer, plywood, sawn timber, particle board, pulp and paper, paper board, wood for energy (charcoal and fuel wood), gum, resin, ropes, fruits bush meat (Micutta, 1985; Alao, 2003). However, demand for timber far out trips the supply (Alao, 2003). Consequently, wood shortage is imminent in Nigeria and sub-Saharan Africa at large (Gwandu, 1990). Nwokeabia (1983) showed that demand for sawn wood alone on the basis of current consumption is estimated to be 1.2million m^2 per year. This is expected to grow by 6-9% annually as a result of increasing human population vis-à-vis demand for wood especially fuelwood (Ikurekong *et al.,* 2009). It has been estimated that about 50% of the world's population depend on fuelwood or other biomass fuel for cooking, with a daily per capita consumption of about 0.5kg to 1.00kg of dry biomass (Twindel and Wier, 1986) and an average annual per capita consumption of 0.77m3, or 0.18 in Africa (Food and Agriculture Organization FAO, 1995). In Nigeria, fuelwood account for over 80% of national energy consumption (Fuwape, 2000).

Furthermore, United Nations Development Programme (UNDP) (2000) showed that about 25% of the global warming is attributed to the clearing of tropical rainforest at the rate of 17million hectare per year. Centre for Tropical Agriculture (CTA, 2007) reported that Africa lost over 9% of its trees between 1999 and 2005 and this represents half of the global loss. Bigger losers in this regard are Angola, Cameroon, DR Congo, Nigeria, Sudan, Tanzania, Zambia and Zimbabwe.

Many of the challenges we face today (deforestation, soil erosion, desertification, salinization and loss of biodiversity) were problems even in ancient times. What is different now is the scale, speed and long term impact of the problem and civilization challenges to earth's ecosystems. Before the industrial revolutions, environmental degradation was much more gradual occurring over hundreds or thousands of years and relatively localized. The cumulative actions of rapidly growing and industrializing societies, however have given rise to more complex problems. Acids rains, green house gas emissions, ozone layer depletion, toxic waste and large scale industrial accidents are among the major problems that have serious global or regional consequences.

V. B. Taru, Department of Agricultural Technology, Federal Polytechnic P.M.B. 35 Mubi Adamawa State, Nigeria
S. S. Zirra, Department of Mathematics, Faculty of Natural Science, University of Jos, Jos, Plateau State, Nigeria
J. Joseph, Department of Environmental Science Education, University of Abuja, Gwagwalada, Nigeria

Felling of tree/shrubs is a major environmental challenge facing the country. The menace is further accentuated by the fact that, felling of tree/shrubs indiscriminately gives way to erosion which is ravaging areas hitherto considered as safe. The problems are exacerbated by inappropriate human practices as well as natural conditions of the environment, which include the upset of the ecological balance in varying ecological zones in some northern states like Borno and Yobe states (Akinyemi, 2005). This does not ensure environmental sustainability of embracing a target to integrate the principle of sustainable development into country's policies and programmes and reverse the loss of environmental resources.

In some countries, notably United States of America, forest management, is interpreted in a much wider sense and embraces wild life management, watershed management, protection of soil erosion and provision of recreational and leisure facilities apart from the materials contained in forest (mainly seeds, leaves, fruits, roots) edibles. The remaining woody tissue being inedible is of particular use to humanity (Adedire, 2002; Vanguard Newspaper, 2008). Forests have been the major source of livelihood for most Nigerian. The forestry sector is one of the main pivots on which the nation's welfare was built. The forest is not only important for material goods but also as a valuable ecological and cultural resource. The forestry subsector has over the years contributed immensely to the socio-economic development in the country. It ranks among one of the highest revenue and employment generating sectors.

The demand for wood raw material by the industries in recent times has outstripped the production capacity of the forest. Thus, exploitation of forest resources for domestic and industrial purposes if not well planned may be deleterious to the environment. It is therefore necessary to examine the rate at which indiscriminate felling of trees through the use Markov Chain model in order not to jeopardize the other goods, services and benefits of the forests. These benefits include: amelioration of weather pattern, provision of clean air, protection of biological diversity, protection of watershed, soil and food crops and provision of recreational facilities.

The objective of this paper is to state empirically the percentage distribution of the long-run felling of trees/shrubs so that measures can be recommended appropriately.

Model Specification/Literature Review

Markov Processes

The occurrence of a future state in a Markov process depends on the immediately preceding state and only on it (Taha, 2001; Taru and Mshelia, 2007; Taru, *et al.,* 2009; Idolor, 2010; Ozar *et. al*., 2010).

If $t_0 < t_1 < \ldots tn$ (n=0,1,2,…..) represents points in time the family of random variables $\{\xi_{tn}\}$ is a Markov process if it possesses the following Markovian property.

$$P\{\xi_{tn} = X_n | \xi_{tn-1} = X_{n-1}, \ldots \xi t_0 = X_0\}$$
$$P\{\xi_{tn} = X_n | \xi_{tn-1} = X_{n-1}\}$$

For all possible values $\xi t_0, \xi_{t1}, \ldots \xi_{tn}$.

The probability $P_{xn-1}, X_n = P\{\xi_{tn} = X_n | \xi_{tn-1} = X_{n-1}\}$ is called the transition probability. It represents the conditional probability of the system being in X_n at t_n, given it was in X_{n-1} at t_{n-1} (with X representing the states and t the time). This probability is also referred to as the one-step transition because it describes the system between t_{n-1} and t_n. An m-step transition probability is this defined by

$$P_{xn}, X_{n+m} = P\{tn\text{-}m = X_{n+m} | \xi_{tn} = X_n\}$$ (Idolor, 2010; Ozar *et al.,* 2010).

Markov chains are a special class of mathematical technique which is often applicable to decision problems, named after a Russian mathematician who developed the method. It is a useful tool for examining and forecasting the frequency with which customers remain loyal to one branch or switch to others. Other applications of Markov chain analysis include in manpower planning, production planning, and any other study which may be stochastic in nature. Ozar *et. al.,* (2010) applied Markov chain in the dynamics of rural land use in Lake Chad Basin, and the model presented a stellar result.

A Markov chain is a series of states of a system that has the Markov property. At each time the system may have changed from the state it was in the moment before, or it may have stayed in the same state. This change of state is called transitions. If a sequence of states has the Markov property, it means that every future state is conditionally independent of every prior state given the current state (Obodos, 2005).

Markov chains is a sequence of events or experiments in which the probability of occurrence for an event depend upon the immediately preceding event. It is also refereed to as first-order Markov chain process, for a finite Markov chain, we assume that the sequence of experiments (or events) has the following properties:

i. The outcome of each experiment is one of a finite number of possible outcomes $a_1, a_2, \ldots, a_n$.
ii. The probability of outcome a_j on any given experiment is not necessarily independent of the outcomes of previous experiments but depends at most upon the outcome, chi of the immediately preceding experiment.
iii. There are given numbers P_{ij} which represent the probability of outcome aj on any given experiment, given that

The outcomes a_1, a_2, ... a_n are called states and the number P_{ij} are called transition probabilities. The number of experiments or numbers of movements are sometimes referred to as steps. At times the probability distribution of the initial state is given, but this may not be necessary when determining steady state equilibrium (Agbadudu, 1996). The number P_{ij} which represents the probability of moving from state ai to state aj in one step can be put in the form of a matrix called the transition matrix. This matrix for a general finite Markov chain process with states a_1, a_2, ... a_n is given by:

$$P = P_{ij} = \begin{matrix} P_{11} & P_{12} \ldots\ldots & P_{1n} \\ P_{21} & P_{22} \ldots\ldots & P_{2n} \\ P_{n1} & P_{n2} \ldots\ldots & P_{nn} \end{matrix}$$

Here, the sum of the elements of each row of the matrix is 1. This is because the elements in each row represent the probability for all possible transitions (or movements) when the process is in a given state. Therefore, for state $a_{i,}$ i = 1, 2, ...n the transition probabilities is given as follows:

$$\sum_{j-i}^{n} Pij = 1$$

If we let E_1, $E_{2,}$ ..... E_j (j = 0,1,2,....) represent the exhaustive and mutually exclusive outcomes (states) of a system at any time. Initially, at time t_o, the system may be in any of these states. Let $aj^{(o)}$ (j = 0,1,2...) be the absolute probability that the system is in state Ej at t_o. Assume further that the system in Markovian. The transition probability is defined as:

$$Pij = P\{\xi_{tn} = j \mid \xi_{tn-1} = 1\}$$

This basically is the one step probability of going from state I at t_{n-1} to state at $t_{n,}$ assuming that these probabilities are stationary overtime. The transition probabilities from state Ei to state Ej can be more conveniently arranged in a matrix form as follows:

$$P = \left\{ \begin{matrix} P_{00} & P_{01} & P_{02} & P_{03} \ldots\ldots\ldots\ldots\ldots\ldots \\ P_{10} & P_{11} & P_{12} & P_{13} \ldots\ldots\ldots\ldots\ldots\ldots \\ P_{20} & P_{21} & P_{22} & P_{23} \ldots\ldots\ldots\ldots\ldots\ldots \\ P_{30} & P_{31} & P_{32} & P_{33} \ldots\ldots\ldots\ldots\ldots\ldots \end{matrix} \right\}$$

The matrix P is called a homogenous transition or stochastic because all the transition probabilities P_{ij} are fixed and independent of time. The probabilities P_{ij} must satisfy the conditions.

$\sum P_{ij} = 1$ for all ij

$Pij \geq 0$ for all I and

Indicating that all row probabilities must add to up one, while any single entry in the row or column could have a probability of ≥ 0. The Markov chain is now defined. A transition matrix P together with the initial probabilities $\{aj^{(0)}\}$ associated with the state Ej completely defines a Markov chain (Taha, 2001 ; Onu, 2000; Okpachu, 2006). It is also common to think of a Markov chain as describing the transitional behavior of a system over equal intervals. Situations exist where the length of the interval depends on the characteristics of the system and hence may not be equal. This is referred to as imbedded Markov chain.

Methodology

Source of data and Sampling Procedure

The study employed only primary source of data. A multistage and simple random sampling technique was adopted questionnaires were then administered on 180 respondents. The questionnaires contained items which were forest based.

Presentation of Data

Farmers were classified proportionate to the number of trees and shrubs cut as:

i. S_1 is the "state" of numbers of respondents also indicated that there is reduction in the number of trees/shrubs on their farm.
ii. S_2 is the "state" of numbers of respondents also indicated that there is no change in the number of trees/shrubs on their farm.
iii. S_3 is the "state" of numbers of respondents who indicated an increase in the number of trees/shrubs on their farm. To determine the equilibrium vector, the equation $\pi P = \pi$ was used. That is multiplying the initial probability distribution by transition probability matrix.

$$(\pi_1\ \pi_2\ \pi) \begin{pmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{pmatrix} = (\pi_1\ \pi_2\ \pi_3)$$

The probability row vector πi satisfying the equation above is called an initial probability vector for the transition matrix P. Equations above tells us that distribution of states tends towards or approaches the value π which is independent of the original distribution. Hence, π is called equilibrium distribution, that is

$\pi_1 + \pi_2 + \ldots\ldots \pi_n = 1$ after a long time it achieves statistical equilibrium and there exist probabilities $\pi_1, \pi_2 \ldots\ldots \pi_n$ of being in the various states which depend only on the transition probability matrix P.

Table 1: Flow chart for the deforestation in Madagali LGA for the year 2007 and 2008

Year t+1 (2008)

	Size	S_1	S_2	S_3	Total for year t-1 (2007)
S_1		25	12	3	40
S_2		6	2	2	10
S_3		8	2	0	10
Total for year t+1 (2008)		39	16	5	60

Source: Field Survey, 2009

Dividing each row by the row total to obtain P given by:

$$P = \begin{pmatrix} \frac{25}{40} & \frac{12}{40} & \frac{3}{40} \\ \frac{6}{10} & \frac{2}{10} & \frac{2}{10} \\ \frac{8}{10} & \frac{2}{10} & \frac{0}{10} \end{pmatrix}$$

Initial vector $\pi = \begin{bmatrix} \frac{32}{60} & \frac{16}{60} & \frac{12}{60} \end{bmatrix}$

Using the equation $\pi P = \pi . \pi$ is $t$he equilibrium probability distribution vector for the transition matrix P.

$$\begin{bmatrix} \frac{32}{60} & \frac{16}{60} & \frac{12}{60} \end{bmatrix} \begin{pmatrix} \frac{25}{40} & \frac{12}{40} & \frac{3}{40} \\ \frac{6}{10} & \frac{2}{10} & \frac{2}{10} \\ \frac{8}{10} & \frac{2}{10} & \frac{0}{10} \end{pmatrix} = (0.64 \quad 0.26 \quad 0.10)$$

Equilibrium probability distribution = 0.64 0.26 0.10
= 64% 26% 10%

Table 2: Flow chart for the deforestation in Maiha LGA for the year 2007 and 2008

Year t+1 (2008)

Class size	S_1	S_2	S_3	Total for year t-1 (2007)
S_1	26	10	6	42
S_2	4	2	2	8
S_3	6	2	2	10
Total for year t+1 (2008)	36	14	10	60

Source: Field Survey, 2009

Dividing each row by the row total to obtain P given by:

$$P = \begin{Bmatrix} \frac{26}{42} & \frac{10}{42} & \frac{6}{42} \\ \frac{4}{8} & \frac{2}{8} & \frac{2}{10} \\ \frac{6}{10} & \frac{2}{10} & \frac{2}{10} \end{Bmatrix}$$

Initial probability vector $\pi = \begin{bmatrix} \frac{36}{60} & \frac{14}{60} & \frac{10}{60} \end{bmatrix}$

Using the equation $\pi P = \pi . \pi$ is the equilibrium probability distribution vecor for the transition matrix P.

$$\begin{bmatrix} \frac{36}{60} & \frac{14}{60} & \frac{10}{60} \end{bmatrix} \left\{ \begin{matrix} \frac{26}{42} & \frac{10}{42} & \frac{6}{42} \\ \frac{4}{10} & \frac{2}{10} & \frac{2}{10} \\ \frac{6}{10} & \frac{2}{10} & \frac{2}{10} \end{matrix} \right\} = (0.58 \quad 0.28 \quad 0.18)$$

Equilibrium distribution = (0.58   0.24   0.18)

= 58%   24%   18%

Table 3: Flow chart for the deforestation in Mubi North LGA for the year 2007 and 2008

Year t+1 (2008)

Class size	S_1	S_2	S_3	Total for year t-1 (2007)
S_1	40	0	0	40
S_2	8	2	2	12
S_3	4	2	2	10
Total for year t+1 (2008)	52	4	4	60

Source: Field Survey, 2009

Dividing each row by the row total to obtain P given by:

$$P = \begin{Bmatrix} \frac{40}{40} & \frac{0}{40} & \frac{0}{40} \\ \frac{8}{12} & \frac{2}{12} & \frac{2}{12} \\ \frac{4}{8} & \frac{2}{8} & \frac{2}{8} \end{Bmatrix}$$

Initial probability vector $\pi = \begin{bmatrix} \frac{40}{60} & \frac{12}{60} & \frac{8}{60} \end{bmatrix}$

Using the equation $\pi P = \pi . \pi$ *is t*he equilibrium probability distribution vecor for the transition matrix P.

$$\begin{bmatrix} \frac{40}{60} & \frac{12}{60} & \frac{8}{60} \end{bmatrix} \begin{Bmatrix} \frac{40}{42} & \frac{0}{40} & \frac{0}{40} \\ \frac{8}{12} & \frac{2}{12} & \frac{2}{12} \\ \frac{4}{8} & \frac{2}{8} & \frac{2}{8} \end{Bmatrix} = (0.86 \quad 0.07 \quad 0.07)$$

Equilibrium distribution is therefore = (0.86 0.07 0.07)

= 86% 7% 7%

RESULT AND DISCUSSION

The result from Table 1, 2 and 3 revealed that 64%, 58% and 86% of farmers in Madagali, Maiha and Mubi North respectively indicated that there is reduction by cut in the numbers of trees/shrubs on their farm, increase in the numbers of trees on their farms. Table 1, 2 and 3 have therefore revealed that the direction of the future indiscriminate felling of tree in the study area is hazardous, because majority of the respondents 64% in Madagali Local Government Area, 57% in Mubi North encroachment and global warming, this has been indicated in an independent studies by UNDP (2000), Fuwape (2003) and Ikurekong *et al.,* (2009) that felling of trees is detrimental to the environment. This finding also confirms those of Nash and Cecelia (2006) and Edmund (2005) who separately reported that there is an increase in felling of trees indiscriminately in Nigeria due to the increasing demand for fuelwood and other industrial wood needs, partly as a result of increasing cost of the kerosene. Oronsaye (2003) estimated that 94% of the energy consumed comes from the forest mainly in the form of fuelwood. At this rate of destruction of the natural vegetation, there was no doubt that the loss of biodiversity is evident. Habitat destruction/modification caused by this level of time goes into extinct.

Although, the entire cause of deforestation may not be credited to fuelwood exploitation, there is strong indication that it is a prime factor. The forest provide habitat for two-thirds of all identified terrestrial species (Myers 1992).These plant and animal species serve as source of food, medicine and fuel in most rural communities in developing countries. Tree harvesting adversely affects the population and variety of plant and animal species in the forest. The removal of forest cover during logging has in some instances resulted in the scarcity or out-right extinction of many important plant and animal species. Some wild animals have also been observed to migrate from areas where tree cover was removed to undisturbed vegetation. Some plant and animal genetic resources that could be used in producing new pharmaceuticals or traditional medicine are lost as a result of the destruction of forest cover.

CONCLUSION/RECOMMENDATIONS

Adopting aggressive reforestation strategy could solve the problem of reduced forest cover. Technology that aids forest productivity and efficient utilization of forest resources on sustainable basis should also be employed during forest operations. The use of appropriate tree harvesting and logging techniques will reduce destruction of forest ecosystem. A well planned skidding and haulage of logs will reduce instances of soil compaction. Indiscriminate felling of trees in water catchment areas should be prevented in order to guide against disruption of the hydrological cycle.

The problem of the clear felling and destruction of forest vegetation due to fuelwood scarcity can be solved by planting fast growing tree species and establishing rural community wood lot. The example of fast growing species, which have been recommended for fuelwood plantation, includes *Gmelina arborea. Leucaena Leucocephala, Terminilia spp. Albizia lebbeck Gliricidia sepium, Sesbania grandifolia, Cassia siamea* and *Acacia albida.* These species coppice very well and have good combustion characteristics (Lucas and Fuwape, 1984).

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