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STOCHASTIC MODELLING OF REFORESTATION PROCESS: A MITIGATION TO THE EFFECT OF DEFORESTATION IN NIGERIA

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Abstract Reforestation, put simply, is the process of restocking the forest for economic purposes. Every year, Nigeria loses about 3500 – 4000 square kilometre of land to deforestation which calls for an urgent attention. This research paper is an application of our earlier research on the effect of deforestation in Nigeria to include reforestation as a mitigation process. The result of the earlier researches shows that if nothing is done to stop or control deforestation, Nigeria will loss her entire land area in about 1120 years. However, the result of this research shows that if trees are planted (Reforestation) to cover about 7559 km^2 (10%) of land lost due to deforestation in a period of 20 years (that is 377.95 km^2 each year) and the trees are maintained, it will take about 60 years to forestall or stop the long term effect of deforestation in Nigeria. Based on the results, the following recommendations are made: The Federal, States and Local Governments in collaboration with relevant forest agencies should carry out regular reforestation exercises to replace extracted tree species in the forests, forest areas which are known to be sensitive to erosion, around slopes and stream edges should be considered for zero or light logging only.

Keywords: Deforestation, Reforestation, Mitigation, Modified Exponential Distribution etc.

Introduction

Reforestation as a very important procedure for protecting our planet is the process of regenerating or replanting forest areas that have been destroyed or damaged for the benefits of mankind. Reforestation is crucial to the sustainability of timber supply and maintenance of environmental stability which positively affects growth of human population, food security and quality of life. The environment within which man lives continues to experience changes due to the exploitation of forest resources (Kalu *et al.*, 2014; Udofia *et al.*, 2011). Reforestation is needful because of deforestation which is the permanent destruction of forest in order to make the land available for other uses. According to Olasupo (2016), Nigeria loses about 3500 to 4000 square kilometre of land every year to deforestation. The effect of deforestation is a serious threat to the existence of mankind hence the need for reforestation. As the saying goes "The best time to plant a tree was 30 years ago – the next best time is now" (Fitzgerald, 2008). Fitzgerald (2008) also noted that reforestation is required when timber harvesting reduces the number of trees below specified stocking levels as contained in Rose and Haase (2006). You must complete reforestation within 24 months after completing a harvest operation. Depending on site productivity, at least 100 to 200 seedlings per acre must be established. In addition, seedlings must be well distributed across the area and free to grow within 6 years (Fitzgerald, 2008).

This research is an application of a modified exponential distribution model proposed by Kwaghkor *et al* (2018) and Kwaghkor (2020) on the effect of deforestation in Nigeria to study reforestation process as a mitigation to the effect of deforestation; assuming that both deforestation and reforestation processes are stochastic in nature and follows the modified exponential distribution. The result of these researches reviewed that there is a gradual loss of land in Nigeria due to deforestation activities and that if nothing is done to forestall it, Nigeria will loss her entire land area in about 1120 years. This is the motivation for this research. This research will help to see how reforestation can be used to forestall the long term effect of deforestation in Nigeria. It will help the relevant bodies or agencies in the handling of reforestation issues.

The Model

The loss of land area in Nigeria as a result of deforestation and the reclaiming of the land through reforestation are considered as stochastic processes. The model used to study the effect of reforestation process in Nigeria is a modified exponential distribution. This distribution was first proposed by Kwaghkor *et al* (2019) to study Nigeria's unemployment rate on the long run. The modified exponential distribution was presented as

$$f(t;\lambda) = \begin{cases} (1-\exp(-J/n))\exp(-(1-\exp(-J/n))t), & t > 0 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

where $\lambda = 1 - \exp(-J/n)$, $J =$ Number of persons entering unemployment state at present and $n =$ Number of persons from the source of entering unemployment state at present.

The Cumulative Distribution Function (CDF) of the modified exponential distribution written as the probability of lifetime being less than some value, t, is

$$F(t;\lambda) = P(T \leq t) = 1 - exp[-(1 - \exp(-J/n))t] \qquad (2)$$

Equation (2) was used to give a probable unemployment rate if J and n are known.

Kwaghkor (2020) used this modified exponential distribution to study the effect of deforestation in Nigerian where he redefined J and n as: $J =$ Average land lost per year due to deforestation in Nigeria, and $n =$ Total land area in Nigeria.

This study used equation (1) and (2) to study the effect of reforestation as a mitigation process in Nigeria by redefining J and n as: $J =$ reforested area (in this case, it is 10 %) of the land lost due to deforestation in Nigeria for a period of 20 years and $n =$ total land lost due to deforestation in Nigeria for a period of 20 years.

Results and Discussion

Results

Table 1: Total land lost in Nigeria per year due to deforestation for a period of 20 years (formed from Olasupo, (2016))

Year	Land lost (Km^2)	10% of Land lost (Km^2)
1	3520	352
2	3600	360
3	4000	400
4	3900	390
5	3700	370
6	3620	362
7	3710	371
8	3810	381
9	3850	385
10	3540	354
11	4000	400
12	3910	391
13	3820	382
14	3630	363
15	3650	365
16	3750	375
17	3920	392
18	3900	390
19	3990	399
20	3770	377
Total	**75590**	**7559**

Table 2: Parameter Values for reforestation based on the modified exponential distribution

Parameter	Value	Source
J	7559 km^2	10% of 75590
n	75590 km^2	Olasupo (2016)

The table generated from fitting the values of Table 2 to equation (2) is presented in Table 3 and the graph obtained from the table is presented in Figure 1.

Table 3: Transition probabilities of the effect of reforestation based on the modified exponential distribution

$t\ (Years)$	$F(t;\lambda)$
0	0
5	0.37862
10	0.61389
15	0.76008
20	0.85092
25	0.90736
30	0.94244
35	0.96423
40	0.97777
45	0.98619
50	0.99142
55	0.99467
60	0.99669
65	0.99794
70	0.99872
75	0.99921
80	0.99951
85	0.99969
90	0.99981
95	0.99988
100	0.99993

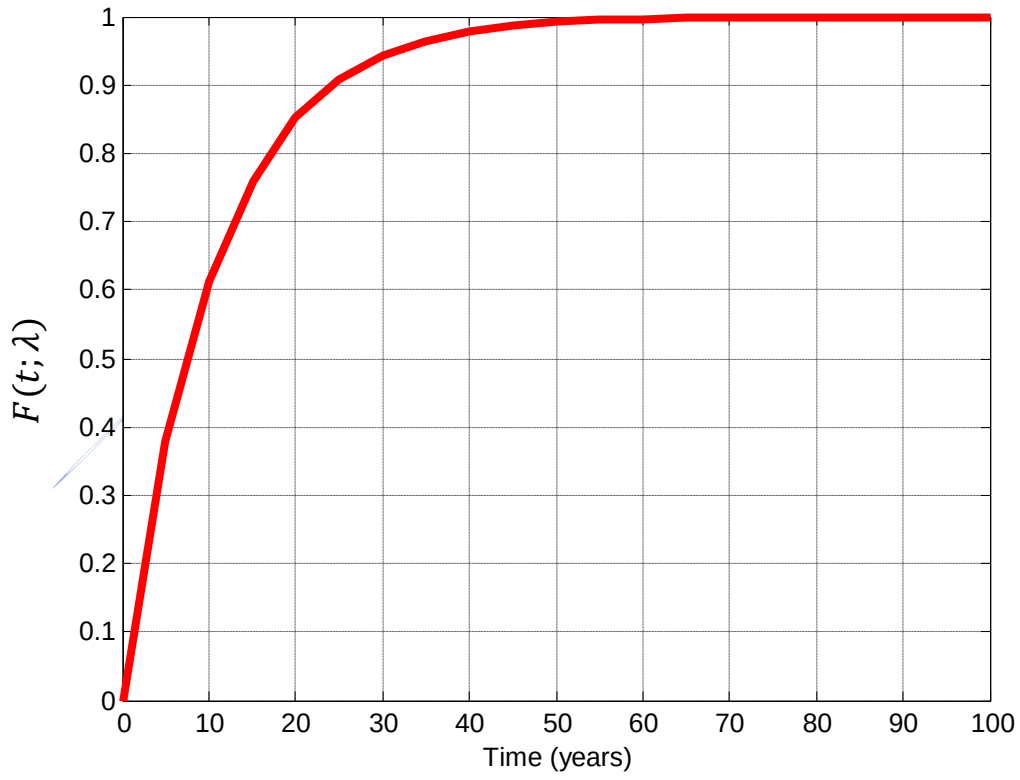

Figure 1: Graph of transition probabilities of reforestation

Discussion

Table 3 and Figure 1 are showing the transition probabilities describing the gradual process of reclaiming and maintaining the Nigeria's land that is lost (due to deforestation) by reforestation. The transition probabilities converges very slowly and can be negligible around 60 years upward from the Figure 1. This result simply indicates that if trees are planted (reforestation) to cover about 10% (7559 km^2) of the total land lost in Nigeria due to deforestation for a period of 20 years (377.95 km^2 each year), it will take about 60 years to reclaim a reasonable land that is lost and probably forestall the future negative effect of deforestation on the Nigeria's land.

Conclusion and Recommendations

This research paper is an application of the model by Kwaghkor *et al* (2018) and Kwaghkor (2020) on the effect of deforestation in Nigeria to study reforestation as a mitigation process. The results of the earlier researches shows that if nothing is done to stop deforestation, Nigeria will loss her entire land area in about 1120 years. But the result in this research shows that if trees are planted (Reforestation) to cover (on the average) about 7559 km^2 (10% of land lost due to deforestation) of Nigeria's land each year for 20 years (that is 377.95 km^2 each year) and the trees are maintained, it will take about 60 years to forestall or stop the long term effect of deforestation in Nigeria. Based on the results, the following recommendations are made: The Federal, States and Local Governments in collaboration with relevant forest agencies should carry out regular reforestation exercises to replace extracted tree species in the forests, forest areas, which are known to be sensitive to erosion, especially around slopes and stream edges, should be considered for zero or light logging only, more forestry personnel should be employed and properly trained to handle reforestation issues.

Conflict of Interest

Author has declared that there is no conflict of interest reported in this work.

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