OPTIMUM REPLACEMENT AGE FOR OIL PALM FARMS IN EDO STATE, NIGERIA

[1]Abdul-Qadir, M.I., Omofonmwan, E.I., Bankole, A.S., Garba, I.D. & Erumwenbibi, B.O.
Agricultural Economics Division, Nigerian Institute for Oil palm Research, NIFOR, Benin City, Edo State, Nigeria. [1]Abdurauf2007@gmail.com

ABSTRACT

The contributions of the oil palm subsector to employment and income in Nigeria justify the research for empirical evidence on its economic replanting for improved productivity in the industry. However, there is inadequate documentation on the optimal replacement age of Oil palm farms in the country. In this study, an economic replacement age for oil palm farms in Edo State is examined. The concept of profit maximization was used for the construction of the model using Nigerian Institute for Oil palm Research (NIFOR) main station as the study area. The cost of land preparation and planting in the first year of the project was ₦1,350,000 for one hectare (ha). The cost of maintaining immature palms was ₦313,000 per year for three years, while the cost of maintaining mature palms from the fourth year and above was ₦353,000 annually. Harvesting cost increased steadily with an increase in yield. The interest rate of 9% was used for the computation of the present values of invested costs and returns. The optimum replacement age for oil palm farms in the study area was found to be 33 years. Therefore, the application of this model is recommended to oil palm farmers in Edo State, Nigeria.

Keywords: Optimal, Oil palm, Profit Maximization, Cost Minimization and Productivity

INTRODUCTION

The global importance of oil palm is enormous. It provides food, employment, raw materials for industry and foreign exchange to major producers in the world. “Nigeria is one of the leading producers of palm oil worldwide” (Statista, 2025). In fact, it is the largest producer in Africa and fifth largest in the world with annual production figure in 2024 of 1.5 million Metric Tonnes (MMT) (IndexMundi, 2025). This is less than annual National demand of about 2.0 MMT, which led to palm oil importation of 370,000 Metric Tonnes (MT) in 2022 (Statista, 2025). Other major producers in the world are Indonesia - 46.5 MMT, Malaysia - 19.3 MMT, Thailand – 3.7 MMT and Colombia – 1.9 MMT (IndexMundi, 2025). Palm oil is one of the major economic products of the oil palm and is useful for household consumption, industrial use and biofuel production. Policies for the production of biofuel using the country's raw materials are currently being widely discussed in Nigeria. The policy calls for the creation of a Biofuel Energy Commission, a Biofuel Research Agency, and a goal that all bio fuels be used domestically (Munonye *et. al,.* 2023) but very little progress has been made in this regard due to inadequate palm oil production in Nigeria. The feedstock for biofuel production are Cassava, Yam, Millet, Maize, Sorghum, Sugar cane, potato, Rice, Plantain, Cocoyam, Cowpea, Groundnut, Palm oil, Cotton, Coffee and Cocoa. Among all these, palm oil is most feasible and sustainable in terms of production cost, affordability, availability and productivity/yield per unit area.

The industry has capabilities to generate employment opportunities to million Nigerians, more revenue to governments through tax and thus enhance the pace of poverty alleviation and livelihood improvement among oil palm stake holders particularly in rural areas. There are numerous employment opportunities in the Nigerian oil palm industry, which encompass oil palm production, processing and marketing of its products. For instance, Presco oil palm Plc employed 9,078 workers with 1,054 permanent staff and 8,024 contract workers as at January 2024 (Presco, 2024). The same company paid tax of over 17 billion naira to Nigeria governments in 2023 (Presco, 2025). Thus, the industry provides employment for numerous smallholders involved in oil palm production, processing and marketing.

Wicke, *et. al*., (2011) reported that "before the Indonesian government launched the Transmigration Program (TMP) in 1980s, its oil palm cultivation area only covered 1.6 million hectares (Mha). The program involves relocation of volunteers to areas where there are suitable lands for cash crop production particularly oil palm with allocation of two hectare land followed by financial and input assistance for the growing period of oil palm till harvesting. With the success of TMP in Indonesia, the country becomes the largest producer of palm oil in the world (Naylor *et. al,* 2019 and Statista, 2021). The purpose of the TMP was to reduce overpopulation in some regions, generate employment, boost the economy and reduce poverty (Kunz *et. al*., 2017 and Schleicher *et. al*., 2019). These small holders have become prominent in Indonesia palm oil production (Kubitza, 2018) and the cultivation of oil palm has been a success in poverty reduction in Indonesia (Qaim, *et. al*., 2020). Adopting this programme in Nigeria will accelerate the pace of growth and development of the Nigerian oil palm industry.

The recommended Fresh Fruit bunches (FFB)/palm oil yield is 25-30/5-6 MT/ha/year respectively but the yield of ffb/palm oil in Nigeria ranges from 15 -18/3 – 3.6 MT/ha/year to 20 – 25/4 - 5 MT/ha/year respectively (NIFOR, 2022). This exceeds the yields of other vegetable oil sources in productivity per unit area, labour and capital (Abdul-Qadir *et. al*., 2016). Palm oil is a relevant ingredient for most Nigerians' foods (Andem, 2023) and crucial raw material for many foods and non-foods companies. Palm oil is most accessible, affordable, available, and sustainable among all vegetable oils. The overall world populace decides world food consumption and the amount of agricultural production decides food supply (Yohanne, *et. al.,* 2023). Similarly, global palm oil production decides world palm oil supply and it is one of the crops produced in largest quantity globally (Abdul-Qadir *et. al*., 2016).

Replacement models help an organisation to determine when to replace an existing plantation or equipment in a cost-effective manner. In agricultural crops, replacement problems arise when plantations need to be replaced due to reduced efficiency, net revenue and increased maintenance cost. Investor needs to decide when the replacement of an existing plantation with new one would be economical so that the overall productivity of the organisation is not affected (GEEKTONIGHT, 2022).

Replacement problems arise when assets, such as machines need replacement due to reduced efficiency, failure, and breakdown. When more efficient machines are available in the market or the maintenance of the existing machine is incurring prohibitive cost on the company. For tree crops the replacement policy is to replant the old crops with new ones when the "anticipated annual net revenue from the present enterprise equals the amortised present value of net revenue of the incoming plantation" (Ukwuteno *et. al*., 2015).

Adeleke (2015) reported that the Nigerian agricultural sector has performed below expectations for the following reasons; poor implementation and inconsistency of Government policy, poor yield and meagre price during harvest, Mismanagement of subsidy and farmers' incentives, inadequate post-harvest technologies, lack of Financial capital for acquisition of relevant inputs, long gestation period and high risk of capital investment in agriculture, poor marketing system and mismanagement of farmers' cooperative societies. The Nigerian oil palm sub-sector is overwhelmed with similar problems.

The oil palm has numerous potentials in terms of employment and income generation but different problems beset the industry in Nigerian including managing over age palms, high cost of labour, land tenure systems, poor price during peak season, high cost of planting materials, shortage of harvesting labour and difficulty in harvesting tall palms (Abdul-Qadir *et. al*., 2016, Ukwuteno *et. al*., 2015). The problem of managing old palms is the focus of this study. Over aged palms are usually too tall with impaired productivity and increased cost of harvesting. Climbing tall palms is arduous and risky (Ukwuteno *et. al*., 2015). In addition, most Nigerian oil palm farmers have little or no knowledge about the optimum replacement period of oil palm, so they harvest continuously without replacement. This affects the productivity of many farmers in particular and the production potential of the industry in general. Replacement model, replanting old palms with new ones is the solution to the problem of managing old palms. Therefore, it is expedient to develop a model for replanting old oil palm farms for productivity improvement in Edo State.

METHODOLOGY

The study was carried out in the Nigeria Institute for Oil palm Research (NIFOR) main station, near Benin City, Edo State. Secondary data were used for the project. These were collected from NIFOR annual reports, bulletins and research reports. Data collected were analysed by use of descriptive statistical tools. Profit maximization methodology was used for the construction of the replacement model. It is a problem of maximizing the future stream of net revenue from an existing enterprise or asset.

$$NR = TR - TC \qquad 1$$

Where;
NR = Net revenue,
TR = total revenue,
TC = total cost.

The total revenue was realised by multiplying the quantity of palm oil produced in Tonnes per hectare (ha) per year by the unit price per Tonne. Rate per man-day was seven thousand naira (₦7,000), while the farm gate price of palm oil was ₦1,684,000 per Tonne.

$$TC = EC + RC \qquad (2)$$

Where;

EC = establishment cost,

RC = maintenance/Running cost.

For this study, the establishment cost involves: cost of land preparation and planting. Other are interest on loan used, material cost for land preparation and planting and the maintenance of immature palms, 0 – 3 years. Therefore,

$$\mathrm{NR_n} = \mathrm{TR_n} - an - 1 - \mathrm{R_n} - \mathrm{C} \qquad 3$$

Where;

NRn = Net revenue for n years,

TRn = Total revenue for n years

an – 1 = interest on loan,

Rn = Annual running/maintenance cost for n years,

C = establishment cost.

The optimum replacement period was obtained when the highest amortized present value of accumulated net revenue from the incoming oil palm farm just exceeds the anticipated net revenue from the existing plantation in the year following (Year n + 1) that is, oil palms should be replaced when

$$\frac{Pn(1-v)}{(1-v^n)} > \mathrm{NR}_{n+1} \qquad 4$$

Where, Pn = accumulated present value of net Revenue up to year n

n = Optimum replacement period to be determined,

(1-v)/(1-v^n) = amortization factor,

NR_{n+1} = anticipated net revenue in year n +1,

V = 1/(1+r) = Discount factor,

r = discount rate.

A discount rate of 9 % was used. The net revenue (NRn) which is the same as marginal net revenue (MNRn) for this model is the difference between invested cost and stream of income for the respective years. The present value was obtained by multiplying NRn for each year by the appropriate discount factor, That is PV of (NRn)$1/(1+r)^n$. The accumulation of the present value of net revenue, NR for n years gives Pn. That is,

$$\mathrm{P_n} = \sum_{t=1}^{n} V^{\mathrm{t}-1} NR_t \qquad \left(V = \frac{1}{(1+r)}\right) \qquad 5$$

Equation 5 can be written as

$$P_n = \sum_{t=1}^{n} \frac{NR_t}{(1+r)^n} \qquad (V = \frac{1}{(1+r)})$$

"Pn" takes care of the establishment cost and the cost of running the plantation for n years, which have been deducted from the income. The accumulation of the present value of net revenue for n years serves as Pn for this model.

The amortization factors (AF) i.e. $(1-v)/(1-v^n)$ for n years were obtained by subtracting the discount factor for year one from one, i.e. (1-v) and dividing the result by one minus the discount factor for the appropriate year for n years.
That is

$$AF = \frac{(1-v)}{(1-v^n)} \qquad 6$$

Where;
AF = amortization factor. The cumulated present value of net revenue (NRn) for n years (Pn) multiplied by the amortization factor $(1-v)/(1-v^n)$ gives the annuity "a" (the amortized present value in year n (ANR)). That is "a" is norminal amount which if earned annually for n years will be exactly equals in discounted value to Pn, the cummulated present value of unequal revenue earned during the same period. That is

$$\text{"a"} = ANR_n = (\sum_{t=1}^{n} V^{t-1} NR_t)(\frac{(1-v)}{(1-v^n)}) \qquad 7$$

$$\text{"a"} = ANR_n = P_n\,(\frac{(1-v)}{(1-v^n)})$$

Since Pn $= \sum_{t=1}^{n} V^{t-1} NR_t$

The optimum replacement period "n" was obtained by comparing the annuity "a" for year n from the incoming plantation with anticipated net revenue in the year following (year t+1). The decision rule is to replace when "a" just exceeds NR_{t+1} (a > NRt+1). That is replace when

$$P_n \left(\frac{1-v}{1-v^n}\right) > NR_{n+1} \qquad (a = P_n(\left(\frac{(1-v)}{(1-v^n)}\right) \qquad 8$$

RESULT AND DISCUSSION

Constructed Profit Maximization replacement Period for Oil palms in Edo State

The profit maximization replacement period for oil palm in the study area is presented in Table 1.

Table 1: Constructed Optimum Replacement Age for Oil palm farm in Edo State

Col. **1.** **(S.No)/Year**	**Col. 2. Net Revenue**	**Col. 3. DF V^t (9%)**	**Col. 4. P_n $\sum^n V^{t-1} NR_t$**	**Col. 5. $\frac{(1-V)}{1-V^n}$**	**Col. 6. Pn$\frac{(1-V)}{1-V^n}$**	**Col. 7. NR_{t+1}**
(1) 1989	(2663)	0.9174	(2663)	1.0000	(2663)	(1313)
(2) 1990	(1313)	0.8417	(3868)	0.5218	(2018)	(1313)
(3) 1991	(1313)	0.7722	(4973)	0.3626	(1803)	(486)
(4) 1992	(486)	0.7084	(5348)	0.2833	(1515)	92
(5) 1993	92	0.6499	(5283)	0.2359	(1246)	670
(6) 1994	670	0.5963	(4847)	0.2046	(992)	1,449
(7) 1995	1449	0.5470	(3983)	0.1830	(729)	1,538
(8) 1996	1538	0.5019	(3142)	0.1658	(521)	1,827
(9) 1997	1827	0.4604	(2225)	0.1531	(341)	2,116
(10) 1998	2116	0.4224	(1251)	0.143	(179)	2,261
(11) 1999	2261	0.3875	(297)	0.1349	(40)	2,406
(12) 2000	2406	0.3555	637	0.1282	82	2,550
(13) 2001	2550	0.3262	1542	0.1231	190	2,695
(14) 2002	2695	0.2992	2420	0.1179	285	2,980
(15) 2003	2980	0.2745	3313	0.1139	377	2,984
(16) 2004	2984	0.2519	4132	0.1104	456	2,984
(17) 2005	2984	0.2311	4884	0.1074	524	2,984
(18) 2006	2984	0.2121	5574	0.1048	584	2,984
(19) 2007	2984	0.1945	6207	0.1025	636	2,984
(20) 2008	2984	0.1784	6787	0.1005	682	2,984
(21) 2009	2984	0.1637	7319	0.0988	723	2,695
(22) 2010	2695	0.1502	7760	0.0972	754	2,695
(23) 2011	2695	0.1378	8165	0.0958	782	2,406
(24) 2012	2406	0.1264	8497	0.0946	804	2,420
(25) 2013	2420	0.1160	8802	0.0934	822	2,130
(26) 2014	2130	0.1064	9049	0.0924	836	2,144
(27) 2015	2144	0.0976	9278	0.0915	849	1,855
(28) 2016	1855	0.0896	9459	0.0907	858	1,869
(29) 2017	1869	0.0822	9627	0.0899	865	1,580
(30) 2018	1580	0.0754	9756	0.0893	871	1,594
(31) 2019	1594	0.0692	9877	0.0887	876	1,305
(32) 2020	1305	0.0635	9967	0.0882	879	1,016
(33) 2021	**1016**	**0.0582**	**10031**	**0.0877**	**880**	**726**
(34) 2022	726	0.0534	10074	0.0873	879	438
(35) 2023	438	0.0490	10097	0.0869	877	-

Source: Computed from field survey data, 2024.

The establishment cost, which includes land preparation and planting for one ha in the first year was one million three hundred and fifty thousand naira (₦1,350,000). The immature palms maintenance cost was ₦313,000 annually for three years. Wage rate was ₦7,000 per man-day while annual maintenance cost was ₦353,000.

The oil palm comes into fruiting at the age of four years. Staff salaries and interest on loan used for the project were included in annual maintenance cost. However, building and project vehicle are included in this report as depreciation cost.

The optimum period to replace the oil palm farm is when

$\frac{Pn(1-v)}{(1-v^n)}$ > NR_{n+1} as shown in equation (4)

The anticipated marginal net revenue in year t+1 from the existing plantation (Table 1 column 7) is compared with the highest amortized present value of accumulated net revenue from the incoming enterprise (Table 1 column 6). Thus as long as the anticipated marginal net revenues from the present venture (year 1 – 32 of Table 1 column7) exceed the amortized present value of accumulated net revenue in year t (Table 1 column 6) it is profitable to continue with the existing plantation. However, in row 33, year 2021 of Table 1, the anticipated marginal net revenue becomes less than the highest amortized present value of accumulated net revenue from the incoming plantation. Table 1 column 7 and 6 respectively. Given the law of diminishing marginal returns net revenue (NR) from the present plantation will continue to diminish progressively, over another circle of n years if it is not replaced. Obviously, the comparison is between the marginal net revenue NR from the present enterprise and the average net revenue per annum from the replacement, all converted to their equivalent present value by discounting and compared over another period of n years. Table one presents the constructed optimum replacement age for oil palm farms in Edo State, Nigeria. The optimum time to replace the existing palms with new ones is on the 33rd year (2021) when the condition specified in equation 4:

$$P_n\left(\frac{1-v}{1-v^n}\right) > NR_{n+1}$$

was satisfied. This finding is similar to that of Ukwuteno *et. al*. (2015) who found that the optimum replacement age for oil palm farms in Kogi state was 35 years. The difference might be due to climatic (rainfall and temperature) conditions which affected oil palm growth rate in both regions.

CONCLUSION

The study examined the optimum replacement age of oil palm farms in Edo State, Nigeria using NIFOR main station as the study area. The study applied profit maximization replacement concept. The establishment cost which involves the cost of land preparation and planting was ₦1,350,000. The cost of maintaining immature palms was ₦313,000 per year for three years while the cost of maintaining mature palms four years and above was ₦353,000 annually. Harvesting cost increased with increase in yield and reduced with decline in yield. The interest rate for the project loan was 9%, which was used for the calculation of present value of invested costs and returns. The optimum replacement age for oil palm farms was found to be 33 years. Therefore, application of this model for oil palm replanting is recommended to oil palm farmers in Edo State, Nigeria.

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