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Analysis of Improved Production Practices in Small holder Natural Rubber Plantation for Sustainable Natural Rubber Industry in Nigeria

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ABSTRACT

The decline in natural rubber production was a consequence of combined effects of the civil war and the oil boom era. Successive governments in the country responded through various policies and programme to address the poor performance of the natural rubber industry. The success of the industry will largely depend on small holder rubber farmers adopting the improved production practices. This study was therefore conducted to examine the Improved Production Practices in Small holder Natural Rubber Plantations for Sustainable Natural Rubber Industry in Nigeria. The specific objectives were to describe the socio- economic characteristics of respondents; identify improved production practices adopted for natural rubber production and examine factors influencing production . Data were collected on 296 small scale rubber farmers and analyzed using descriptive statistics and inferential statistics. Results revealed that respondents are relatively old with the mean age of 48 years with mean family size of 5 people and are smallholder farmers with mean farm size of 1.7 hectares and with mean experience of 16 years. Analysis on improved practices among respondents showed that 72.64% adopted tapping equipment maintenance, slashing of plantation (57.43%), fire traces (65.88%) while 37% of the respondents adopted alternate daily tapping. Furthermore, share arrangement was dominant mode of engagement for latex exploitation among respondents (57.09%). Exotic clones and NIG800/NIG900 series were used as the major planting materials while rubber +cassava, rubber +yam and rubber + plantain were the major rubber based cropping systems adopted by respondents. Cobb-Douglas production function analysis indicated that coefficient of multiple determination (R^2) of 0.6303implied that 63.03% of the variations in output of the respondents were explained by the variables in the model. Farm size, improved planting materials, labour and supervision were factors influencing adoption of improved production among respondents

Keywords: Natural rubber, improved practices, industry, production function, Nigeria

1 Introduction

Natural Rubber (*Hevea brasiliensis*) is an upright tropical deciduous tree. It can grow up to 30 – 40 m tall in the wild, and 15 – 25 m in cultivation due to the effect of tapping. *H, brasiliensis* is cultivated mainly for its product of a milky liquid substance called latex. The genus *Hevea* is native to South America, where it grows wild in the Amazon and Orinoco Valleys. The discovery of *H. brasiliensis (HBK)*

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Muell Arg came about through the action of native Indians who used the latex of various plants for making balls, bottles, crude footwear and waterproofing fabric. One of these plants was *H. brasiliensis (HBK) Muell Arg*, which was later, became the major latex-producing plant based on its desirable qualities since 1495 as reported by Columbus. By 1500, Mr. Austin Coate defined rubber latex as a milk-like juice, which is found in the bark of *Hevea* tree that becomes golden brown and thicker on exposure to air. He called the tree a "CAOUTCHOUC," meaning weeping woodIt was about the same period also that Priestly discovered that the rubber latex could rub off pencil marks, hence the product is named as RUBBER, (Umar *et al.,* 2017).

It was introduced into Nigeria from England around 1895 with the first rubber plantation was established by the Division of Agriculture in Sapele in 1906 in the then Bendel State. The second by Pamol at Ikot- Mbo (Cross- River State) the then eastern region in 1912. The first major Nigerian owned plantation was established at Sapele, between 1909 and 1917. The then Midwestern region (Bendel State) area had 2000 hectares. about 35% were of the over 250,000 hectares of rubber production in the country were established in the Bendel State (Edo and Delta States). The early plantations were raised from unselected seeds with latex yield ranging from 300 to 400 kg/ha/yr.

The predominant property of solid rubber is its elastic behaviour or deformation by compression or tension which gave it diversity of uses in the tyre industry one the major consumers of natural rubber. It is well suited for the manufacture of tyre especially radial, heavy duty and high-speed tyres because of its dynamic qualities such as good tear strength and low heat buildup. Beyond the use of rubber for manufacture of tyres, rubber is used for the manufacture of specific products such as flexible oil resistance pipelines for offshore oil fields, inner tubes of tyres, footwear, bridge pad and building foundation in earthquake prone areas (AbMalek and Basir, 2002). The latex concentrate is used for the production of carpet underlay, adhesives, foam, balloons, condoms, and medical accessories such as gloves and catheters. The rubber seed is also used in the manufacture of rubber seed oil, putty and alkyds resins, which find application in the paint, leather industry and cosmetics (production of soap, skin cream and hair shampoo). Furthermore, rubber seed cake extracted from rubber seeds is valuable in livestock feeds while the rubber wood is used for furniture, particleboards and fuel (Mesike *etal.,* 2010). Rubber is grown in both traditional and marginal areas of Nigeria like Edo, Delta, Ondo, Ogun, Abia, Anambra, Akwa-Ibom, Cross River, Imo, Ebonyi, Bayelsa and Rivers. Southern Kaduna, Taraba and southern parts of Adamawa States are marginal areas discovered during the introduction of the presidential initiatives on natural rubber (Orimoloye, 2011).

Genetic improvement of *Hevea brasiliensis* commenced in Nigeria in 1960s following the importation of primary and improved exotic clones from Malaysia, Sri – Lanka and Brazil. The research efforts resulted to the breeding of high latex yielding clones of NIG 800 and NIG900 series with yields ranging from 2000 – 3500 kg/ha/yr (Omokhafe and Nasiru, 2004). The long gestation period of natural rubber (five to seven years) before the commencement of tapping and wide spacing of 6.7 m x 3.34 m, which gives about 450 plants/hectare discourages farmers to go into production. These problems were addressed by improved agronomic practices such as rubber based cropping pattern to ensure effective utilization of land and labour when rubber saplings are in the immature phase. Integrated farming (mini livestock, Honey bee production, snailery) and production of shade tolerant crops such as cocoyam and edible mushroom) have also been developed in Nigeria (Esekhade *et al*., 1996).

The Nigerian rubber industry has the potentials for employment opportunity, foreign exchange earnings and provision of raw materials for agro- allied industries in the country. Favourable ecology,

improved production practices and high yielding clones as planting materials can be harnessed for its sustainable growth and development. Sustainable agricultural development is also the ability of the present generation to device a means of improving and using depletible resources such that future generations will not suffer more than the present ones, (Dawson *et al.,* 2019). Thus sustainable agricultural development aims at the creation of sustainable improvement in the quality of agricultural development and other economic sector of the country. Agricultural sustainability in itself is fairness regarding the treatment of present and future generations and contends that for ethical reason exploitation of resources should not leave future generation worse than the current sustainability also requires manage the resources base such that the average quality of life, ensures can potentially be shared by all future generation (Michael, 2017). The agricultural sustainability will help to reduce poverty, hunger, starvation, lack, suffering, untimely death, infection and diseases in Nigeria environment.

The decline in natural rubber production in Nigeria was a combined effects of the civil war and the oil boom era. The discovery of crude oil in commercial quantities changed the agricultural priorities of Nigeria. The effect of the war led to the abandonment of rubber farms and their conversion to arable food crop production and other non-timber industries. Successive governments in the country responded through various policies and programme to address the poor performance of the natural rubber industry. The Agricultural Research Institute Decree of 1973, the abolition of Commodity Board in 1986, National Accelerated Industrial Crops Production Programme ; NAICPP in 1994 and the Presidential Initiative on Natural Rubber PIR in 2006 were the policy interventions to address the problems of the natural rubber industry in Nigeria in areas like smallholder development activities and associated constraints, seedlings production and uptake, processing and alternative uses and local marketing and export. Substantial number of smallholder plantations are older and have passed their economic life span of 25 years and coupled with the fact that most plantations are planted with unselected planting materials. Inadequate information, poor marketing facilities, lack of credit facilities and high cost of credit, low yield and under exploitation due to the inability and unaffordability of vital production inputs and decreased earnings from rubber business (Agwu, 2006).

The adoption of the improved production practices developed over the years by small holder rubber farmers who form the bulk of producers would lead to increase rubber production and sustainability of the rubber industry. The success of the industry will largely depend on small holder rubber farmers. Several studies have been conducted on the natural rubber by scholars in Nigeria; (Esekhade *et al.*, 1996;Adoption of some recommended Agronomic practices of natural rubber in Nigeria Aigbekaen *et al.*, 2000), Polygene inheritance for latex yield in *Hevea brasiliensis*: Muell Arg. (Omokhafe and Nasiru, 2004); an overview of the potentials of natural rubber (Hevea brasiliensis) engineering for the production of valuable proteins(Omo-Ikerodah *et al.,* 2009), Optimum Replacement period for Rubber plantation in Nigeria (Mesike *et al.,* 2010); An overview of world natural rubber production and consumption: An implication for economic empowerment and poverty alleviation in Nigeria(Umar *et al.,* 2011), ; Rainfall variability and rubber production in Nigeria Mesike and Eskhade, 2014) and Evaluation of the Impact of Climatic Factors on Latex Yield of *Hevea Brasiliensis* (Umar *et al.,* 2017) However, many of such studies have not examined improved production practices among small holder rubber farmers in Nigeria. This study was therefore conducted to examine the Improved Production Practices in Small holder Natural Rubber Plantations for Sustainable Natural Rubber Industry in Nigeria. The specific objectives are to: describe the socio- economic characteristics of respondents; identify improved production practices adopted for natural rubber production and examine factors influencing production . The study will recommend important policies for sustainable natural rubber industry in the country and improve livelihoods of the farmers

2 Methodology

2.1 The Study Area

The study was conducted in Edo and Delta States of Nigeria. Edo State is located between Latitudes 5° 44′ and 7° 34′ N of the equator and between Longitudes 5° 04′ and 6° 43′ E of the Greenwich Meridian. It shares boundary to the south by Delta State, in the West by Ondo State and in the East by Kogi and Anambra States. The State covers a land area of about 17,902 km^2 with a population of 3,218,332 and is made up of 18 Local Government Areas. Mangrove forest, fresh swamp and Savannah are the major vegetations of the State. The mean annual rainfall in the northern part is 1270 mm to 1520 mm while the southern part of the State receives about 2520 mm to 2540 mm rainfall respectively. Mean temperature in the State ranges from a minimum of 24 ^{0}C to a maximum of 33^0 C (Emokaro and Erhabor, 2006). Delta State lies between latitude 5^0 00′ and 6^0 30′ N of the equator and longitude 5^0 00′ and 6^0 45′E of the Greenwich meridian. The State has a land area of 17,440 km^2; about one third of this is swampy and waterlogged. The State is bounded in the North by Edo State, in the East by Anambra and Rivers State and in the South by Bayelsa State. It is bordered to the Western part by the Atlantic Ocean while the North West boundary is Ondo State and consisted of 25 Local Government Areas with a population of 4,098,391 people .The State has a tropical climate marked by dry and rainy seasons. The rainy season starts in April and ends in October. The dry season starts in November and ends in March. The rainfall ranges from 1905mm to 2660 mm monthly. The temperature ranges from 24 ^{0}C to 34^0 C with an average of 30^0 C (Ike, 2010). The people of the States are mostly farmers growing a variety of crops such as cassava, rice, yam, plantain, pineapple and tree crops such as rubber, oil palm and cocoa.

2.2 Source of Data and Sampling Technique

Data for this study were obtained mainly from primary source. Panel data were mainly collected on the 2012 and 2013 production activities of the farmers using structured questionnaire in a multi-stage sampling technique. The first stage involved the purposive selection of Ikpoba – Okha, Ovia South West and Uhunmwode Local Government Areas in Edo State and Ndokwa East, Ika North East and Ndokwa West Local Government Areas of Delta State respectively for their prominence in natural rubber production In stage two of the sampling procedure, list of 410 rubber farmers were obtained from Tree Crop Units and Ministry of Agriculture and Natural Resources in Edo and Delta States. The respondents were served with interview schedules. Finally, a total of 300 rubber farmers were randomly selected in proportion to their population out of which 296 were retrieved and used for analysis

2.3 Methods of Data Analysis

The data collected were analyzed using descriptive statistics and inferential statistics.

Empirical Model Specification

The Empirical production function Model

The production function model used is specified as follows:

$$LogY_{1t} = \beta_o + \beta_1 \log X_{1t} + \beta_2 \log X_{2t} + \beta_3 \log X_{3t} + \beta_4 \log X_{4t} + \beta_5 \log X_{5t} + \beta_6 \log X_{6t} + \varepsilon$$

Where:

Y_{1t} = Output (grain equivalent) of the ith farmer (proxy for improved production practices)

X_{1t} = Hectares of immature plantation

X_{2t} = Labour (man days)

X_{3t} = Hectares of matured plantation

X_{4t} = Supervision (man days)

X_{5t} = Improved planting materials (1 improved , otherwise zero)

3 Results and Discussion

Table 1: Summary Statistics of Socio- economic Characteristics of the Respondents

Variable	Mean	Std	Min	Max
Age	47.5	5.16063	20	60
Family size	5.393333	2.501897	1	12
Experience	16.893333	9.937809	2	16
Hectare	1.7926	1.052991	.4	5.5

Source: Field Survey, 2019

Table 1 shows the distribution of respondents based on some selected socio- economic variables. The mean age of the respondents was 48 years with a standard deviation of 5.16 years which implied that they are relatively old. The preponderance of older farmers in rubber production portends serious danger to the rubber industry with declining productivity and likely reduction in hectares of rubber production. This result is in accord with the previous studies that rubber production in Nigeria are by older farmers as a result of rural – urban migration of the youth to the city centres for white collar jobs leaving rubber production to elderly population (Otene *et al.,* 2011). Family sizes of farmers provide sources of labour for production especially in Africa where agriculture is not mechanized. The mean family size was 5 people with a standard deviation of 2.50 which is a reflection of the fact that many of the respondents were married with minimum and maximum family sizes of 1 and 12 respectively. Large family size of respondents could be used as a vital source of labour for rubber production and other productive activities. Large family size can put pressures on family heads in devising means of obtaining income to meet family needs. The mean farm size was 1.7 hectares with a standard deviation of 1.05 implies that farmers operated at different levels of farm sizes which tend to affect their production levels. This result indicates that respondents are small holders. The result is line with several studies conducted which showed that natural rubber production in Nigeria are by small scale farmers who accounted for about seventy percent with the balance by estate holders (Abolagba *et al.,* 2010; Mesike and Esekhade, 2014). Years of farming experience have been reported to provide a measure of managerial ability among farmers in Nigeria. The mean farming experience was 16 years with standard deviation of 9.65 years. This implies that the farming experience varied significantly among the farmers. The result showed that respondents might have perfected their production of natural rubber with years of experience.

Improved Production practices of Natural Rubber

Matured Plantation

Natural rubber production takes a long gestation period (five to seven years) before the commencement of tapping posing disincentive to farmers. Researchers have developed improved production practices to overcome this problem in both immature and matured plantations. Analysis

in Table 2 depicted the various improved practices for the natural rubber in both matured and immature phases of production. The adoption of minilivestock integration revealed that about 14% of the respondents adopted apiary (honey bee keeping). This can provide additional source of income to the farmers thereby sustaining the industry. Intervention by CFC/ RRIN FGN was to promote and develop commercially viable, socially acceptable and ecologically sustainable rubber-based agro-forestry systems for farmers in Nigeria. Integrating medicinal and aromatic plants with Rubber allows the knowledge, wisdom and practices of local rubber farmers to play fuller roles in identifying and finding solutions to problems of Conservation and sustainable development. It also aims at conserving farmers' prioritized indigenous plants, improving productivity of Rubber agro forestry by poor farmers, enhancing sustainability of farming systems, diversifying sources of income of farmers, improving farmers' livelihoods and providing readily available medicinal plant material for primary health care for rural farmers. Rubber harvesting and quality control measures as presented in Table 2 indicated that use of cemented surface (35.47%) was low due to high cost of construction while the use of wooden surfaces for storage of rubber accounted for 72.64%as respondents can easily source materials around their plantation at least cost. The use of bulking container was adopted by about 51% of the respondents whereas auto coagulation and cup lump collection were highly adopted. Auto coagulation is a situation where rubber latex are acted upon by microbes after being collected and put in containers by tappers at the end of tapping activities. The resultant effect of microbial activities is the rubber lump or coagula. Furthermore, 72.64% of the respondents adopted tapping equipment maintenance. Tapping knives, latex cups, buckets must be cleaned before use. Tapping panels should also be cleaned, pieces of barks, leaves should not be allowed into the latex as these introduce impurities. Studies have shown that farmers are involved in sharp practices (adding sticks and stones) all in an attempt to have heavy weight in order to attract prices for local buyers or agents. The consequences of such practices as poor pricing of output and production of inferior automobile products (Aigbekaen et *al.,* 2006). Local buyers and agents have always devised means of checkmating this unwholesome practice by cutting through rubber lump to ascertain quality (figure 1 &2). To ensure that the problem of adulteration is curtailed, a Central Rubber Testing Laboratory was established at the Rubber Institute of Nigeria Benin City Nigeria to certify African rubber quality to meet the international standard.

Plantation sanitary practices are another quality control measure which must be observed by farmers. Analysis revealed that slashing of plantation accounted for 57.43% and mostly is manually done by respondents. Plantations must be slashed regularly to the ground level. Wind broken trunks and branches should be removed as soon as they occur. This usually occurs at canopy closure. This is done to create airy and less humid environment. An unkempt plantation predisposes workers to snake bites, stings by insects and impaired movement in carrying out their tasks. Distribution of respondents based on fire traces also indicated that 65.88% practiced fire traces. Effect of fires can destroy rubber plantation thereby hampering production and lost of investment. This findings is in line with Fox *et al.* (2011) that improved agro forestry solutions (e.g., improved planting materials and management practices) are needed to assure secure farmer livelihoods without further endangering ecological and economic conditions In addition to agro forestry, some native vegetation zones can be maintained around rubber plantations to perform functions including windbreaks to protect rubber trees, local biodiversity conservation, and wildlife corridors. Management practices in immature plantation (Table 2) indicated adoption of improved planting materials as 97.97% for exotic clones as against 77.70% for NIG800/NIG900 series. Planting materials and Seedling production in Nigeria has been dominated by

the use of exotic clones such as Gondang Tapen(GT1), Rubber Research Institute of Malaya's 600, 700(RRIM 600, RRIM 700 etc) despite reported high advantage of RRIN developed clones. This was attributed by Aigbekaen *et al.* (2000) to lack of awareness of the high yield potential of NIG 800 and 900 series by farmers. The Presidential Initiative on natural Rubber (PIR) introduced in 2006 was one of the policies to address seedling production and uptake but the initiative could not be sustained due to lack of policy inconsistency by successive governments in the country. Other practices such as planting depth (71.96%), pruning (64.86%) and recommended spacing (56.68%) while fertilizer application was a paltry 9.12%.

Table 2: Distribution of Respondents based on improved Production Practices in mature and immature Plantation (n=296)

Variable	Frequency	Percentage
A: Matured Plantation		
Minilivestock Farming		
Honey bee keeping(Apiary)	40	13.51
Rabbitry	7	2.36
Snail Farming	15	5.06
Grass cutter farming	1	0.33
Rubber harvesting and Quality Control measures		
Use of cemented surfaces	105	35.47
Use of wooden surfaces	190	64.18
Tapping equipment maintenance	215	72.64
Bulking containers for latex collection	150	50.68
Use of Ammonia for latex preservation	2	0.68
Auto coagulation in bulking containers	296	100
Cup lump collection	296	100
Scrap collection	10	3.38
Plantation Sanitary Practices		
Slashing of plantation	170	57.43
Fire traces	195	65.88
B:Immature Plantation		
Improved planting materials		
Exotic Clones	290	97.97
NIG 800/ NIG900 Series	230	77.70
Recommended spacing	150	56.68
Planting depth	213	71.96
Weed control	139	46.96
Fertilizer application	27	9.12
Pruning	192	64.86
Pest control	92	46.86
Disease control	145	48.99
Intercropping		
Rubber + Cassava	291	98.31
Rubber + Yam	285	96.28
Rubber + Maize	197	66.55
Rubber + Plantain	289	97.64
Rubber + Cowpea	15	5.07

Source: Data Analysis 2019



Figure 1: Adulterated produce (contaminants like sticks, stone to increase weight)

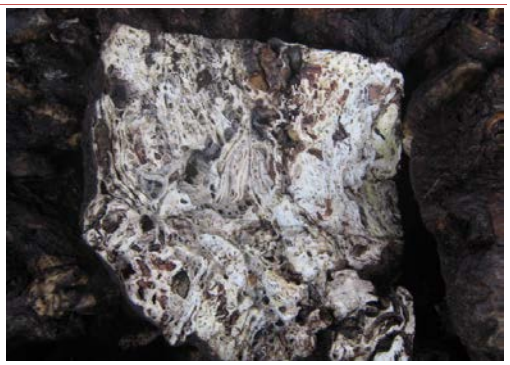


Figure 2: A cut portion of rubber lump to checkmate adulteration

Distribution of respondents based on rubber based intercrop revealed, 98.31%, 97.64 and 96.28% adopted rubber+cassava, rubber+yam and rubber+plantain respectively. The preponderance of cassava, plantain and yam in rubber based cropping system is because these crops are basic food staples in the study area. Monoculture is a land wasted venture and has been found to be a disincentive to farmers who want to adopt rubber and its allied technologies. This finding lay credence to existing literatures where wider adoption of rubber-based intercrops have been reported in many rubber-producing countries of the world (Esekhade *et al*., 1996; Rodrigo *etal.,*2001a; Rodrigo *etal.,*2001b; Rodrigo, *et al.,* 2004; Schroth *et al.*, 2004, IRRDB, 2007). Intercropping during the immature unproductive stage of rubber provides one means of addressing the gaps in income suffered by smallholders after replanting or new planting of rubber. It also ensures efficient management of labour. Effective utilization of the avenues for intercropping has been advocated to put the land under rubber cultivation for maximum benefits. This improved practice can attract small holders to rubber farming as it is economically feasible where the farmer obtains revenue from the sales of the crops while waiting for the maturity of the trees before the commencement of tapping. Rubber based cropping has agronomic compatibility as girth increase is faster in rubber intercrops than in monoculture or sole. However, planting of the inter - crops should be sufficiently away from rubber to minimize competition. Phommexay *et al.* (2011) reported that rubber agro forestry supports rubber trees as well as forest vegetation and edible and useful plants and is the best alternative to monoculture rubber plantations because it reconciles economic and sustainable uses of natural resources and therefore lends itself more readily to biodiversity conservation. Sole rubber production as livelihoods is risky. The vulnerabilities associated with such a production system include the sudden fall of prices, pest and disease damage, productivity decline due to climate change, and loss of biodiversity through forest clear felling. If rubber plantations are meant to improve local livelihoods and conserve natural resources, then a sustainable resource flow is desirable. The rubber cultivation strategy must be subsistence farming based, and must include rubber, other crops, and animals. This kind of farming system can support local livelihoods even when rubber market prices decline. Rubber prices are directly linked to international markets, with fluctuations being common and frequent.

Natural Rubber Tapping Systems

Yields derivable from the *Hevea* tree is controlled by several factors such as the tappers skill, level of field maintenance, clonal characteristics, climate, degrees of exploitation, tapping efficiency and socio-economic factors. Bark consumption and depth of cut is another factor affecting yield/tree. Tapping is the controlled wounding of a matured rubber tree to extract the economic fluid(latex) while at the same time preserving the life of the tree. It is done by making a spiral cut through the bark of

the tree on alternate days. The milky sap or latex which oozes out can be processed into solid rubber or liquid rubber (known as latex concentrate) Tapping cut should penetrate deep enough very near to the cambium layer but should not touch the cambium. If the cambium is damaged, it will result to irregular bark regeneration and frequently lead to bark bursting; hence the need for efficient exploitation as the bark of the rubber tree is the economic reserve of the farmer. Removal of 1 to 1.5 mm is ideal (Delabarre and Serier, 2000). An ideal tapping system is expected to maximize yield, minimize costs, give satisfactory growth, ensure good bark regeneration and reduce incidence of disease attack especially bark burst.

Table 3: Tapping System Adopted (n= 296)

Tapping System (Old)	Tapping System (New)	Frequency	Percentage
d/1 Daily tapping	d1	15	5.06
d/2 Alternate daily tapping (once in 2 days)	d2	109	36.82
d/3 Third daily tapping (once in 3 days)	d3	41	13.85
d/4 Fourth daily tapping (once in 4 days)	d4	35	11.82
d/5 Fifth daily tapping (once in 5 days)	d5	20	6.76
d/6 Sixth daily tapping (once in 6 days)	d6	72	24.32
d/0.5Twice a day tapping	d0.5	3	1.37

Source: Field Survey, 2019

The conventional system of tapping expresses the frequency of tapping as a fraction of daily tapping on a full circumference. Distribution of respondents based on tapping systems adopted (Table 3) revealed that about 37% of the respondents adopted alternate daily tapping denoted by $^1/_2$ S d_2 . This means that half the circumference of the tree is cut during tapping and is done on alternate days and ideal for older plantation. Schroth *et al.* (2004) agreed that the system improves the general health of the trees as compared to tapping all around the trunk, reduces bark consumption and liberate time to tap perhaps 50 percent more trees without any reduction in per-tree yields. Third daily tapping (d3) is represented by about 14% of the respondents was suitable for younger plantation while d6 accounted for 24.32%. Vijayakumar *et al.* (2009) reported a change in tapping notation for latex harvesting as the interval between tapping in days expressed by the letter d followed by Arabic numeral. The implication of this finding is that smallholder rubber plantation are under exploited and the reason may not be farfetched; inadequate labour for tapping. Respondents' inadequacy to financial resources could limit their ability to employ labour for tapping which is very crucial in production and can affect industries depending on productions from small estates.

Table 4: Distribution of Respondents based on mode of Tapping arrangement

Mode of engagement	Frequency	Percentage
Contract tapping	33	11.15
Share arrangement	169	57.09
Owned and tapped by self	94	31.76
Total	**296**	**100**

Source: Field survey, 2018

Transactions with tappers in many rubber producing countries of the world depend on the dry rubber content (DRC) of latex and the true DRC of the latex must be determined to ensure a fairer price. DRC is the percentage of rubber available in any known or given volume of natural rubber. It is the total dry weight (Jayanthy and Sankaranarayanan 2005; IRRDB, 2006). The field production of natural rubber (NR) is a labour-intensive sector involving millions of farmers (mostly women). Tapping and latex collection are normally carried out by paid labourers (estates) or household work (smallholdings). A task is normally 500 – 600 trees which takes 3 – 4 hours to tap by a tapper. Younger trees are simpler

to tap. The same person then returns to collect the still - liquid latex cups emptying it into a bigger container. There is then a residual flow of latex which coagulates on the cut and in the cup; this is secured at the next tapping as scrap and cup lump (International Rubber Research and Development Board, IRRDB, 2006). Rubber tree exploitation is one of the major employers of labour in many rubber-producing countries of the world. Once started, tree exploitation can last for 10 – 20 years, depending on how quickly the accessible bark is consumed. It is a function of girth (reaching a tappable girth of 50cm) where 70 to 75 percent of the trees attaining the recommended 50cm girth for maximum profit. Labour constitutes the largest single cost of production of natural rubber. Considerable variations in the cost of production in estates and smallholdings in many rubber producing countries of the world (IRRDB, 2006; Sasi, 2011). The Nigerian rubber growing ecology is in the oil-producing belt and competes with scarce labour with the oil sector characterized by shortage and high cost of labour where tree exploitation for latex was reported to be very low. The cost of labour to the overall cost of production of natural rubber in Nigeria is estimated at 63 percent. The high cost of labour has forced many smallholder and estate owners to adopting different methods in rubber harvesting.

Table 4 showed modes of engagement of labour sources for rubber tapping by respondents in the study area. From the table, contract tapping accounted for 11.15%. A contract tapping is an arrangement where the contract tapper is a tenant with the right to tap the trees for certain remuneration per quantity tapped. Share arrangement was dominant mode of engagement for latex exploitation among respondents (57.09%). This arrangement is a situation where a share tapper is a tenant contracted the right to tap the trees for a certain terms of agreement based either on percentage dry rubber content (d.r.c.) yield or the number trees based on the sharing formula with the owner. It was found from the study that majority of the farmers used a sharing ratio of 3:1 trees tapped and not based on kilogramme of dry rubber. This translates to owner of the plantation retaining 75 percent while the share tapper has 25 percent of the trees tapped. Schroth *et al*. (2004) reported that the consequence of share tapping arrangement is that the trees are damaged as a result of slaughter tapping to make more money. Natural rubber plantation owners in many rubber producing countries of the world adopted many modes of engaging tappers to overcome problems of exploitation of matured *Hevea* trees as a consequence of financial inability to employ labour. The result is similar to the works of Chew (2001) and Suyanto *et al*. (2001) who reported that rubber harvesting (tapping) were carried out by different parties under share tapping, contract tapping, wage tapping and fixed rent in order to overcome high cost of labour in rubber harvesting in Malaysian and Sumatra rubber smallholdings. Respondents who owned and tapped plantation themselves accounted for 31.76 percent using family members as source of labour for latex exploitation.

Factors influencing Improved production practices

Factors influencing improved practices among respondents were evaluated using the production function analysis where three functional forms were tried and the Cobb - Douglas production function was selected based on economic, econometric and statistical criteria. The diagnostic test results (Table 5) revealed Ramsey RESET test and Breusch-Pagan / Cook-Weisberg test for Heteroscedasticity were not statistically significant. Also, the variance inflation factors(VIF)with respect to all the variables fall within the threshold values of less than 10.The model is not spurious and therefore fit the data. Cobb -Douglas production function result on factors influencing improved production practices among respondents is contained in Table 6. The estimated coefficients for the specified function can be explained as the elasticities of the explanatory variables. The returns to scale parameter was found to

be 1.334, implying increasing return to scale for production among the farmers. This shows that respondents were operating in stage 1 of the production surface. This suggests that a proportionate increase in all inputs would result to more than proportionate increase in output of the respondents. In this case, optimum efficiency of production or resource use has not been attained, but misallocated. The coefficient of multiple determination (R^2) was 0.6303 implying that about 63.03% of the variation in output of the respondents were explained by the variables in the model. F value was statistically significant ($p \leq 0.05$). All the variables carried the expected signs. The coefficient for labour was 0.095 and statistically significant ($p \leq 0.05$).

Table 5: Diagnostic Test Results

Type of Test	Value	Probability level
Ramsey RESET test	1.73	Prob > F = 0.1758
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	chi2(1) = 0.09	Prob > chi2 = 0.7670
Variance inflation factors(VIF)		
Variable		
Ln X_4 Supervision (man days)	2.70	
Ln X_2 Labour (man days)	2.68	
Ln X_1 Hectares of immature plantation	2.32	
Ln X_3 Hectares of matured plantation	1.23	
Ln X_5 Improved planting materials	1.17	
Mean VIF	2.02	

Source: Data Analysis 2019

Mesike *et al.* (*2009*) reported that labour has been a critical factor in rubber production in Nigeria where production is done manually. Inconvenient working conditions (unattractive wages, inadequate medical and housing facilities) may be repulsive factors. The effect of this on the rubber industry are likely to manifest in the reduction of hectare of rubber cultivation, plantations may not be tapped resulting to low yield and income to the farmers and a reduction in foreign exchange earnings. The estimated coefficient for hectares of matured plantation was 0.5105 and statistically significant ($p \leq 0.05$) and has a positive effect on rubber latex production. The varying conditions of rubber plantations especially number of tappable trees (natural capital) when properly tapped provide income (financial capital) and will have different impacts on participants' livelihoods. Mustapha (2011) reported a significant relationship between cultivated area of rubber smallholdings in Malaysia and increase in the production of latex. Farm size has been found to be one of the most important factors in natural production in Nigeria (Mesike *et al.,* 2010).

The coefficient for supervision was 0.4983 and was statistically significant ($p \leq 0.01$) probability level. Output of the farmers increases with increase in supervisory roles. Regular supervision of rubber plantations workers ensures proper management of rubber plantations. This result is in tandem with Tapan *et al.* (2013) that emphasized the need for supervision as reflection accountability in many rubber producing countries of the world. The production elasticity with respect to improved planting material (0.0086) is statistically significant ($p \leq 0.05$).The basic component of any crop production enterprise is the planting material. Improved planting materials with potentials for high yield, wind and disease resistance. Spore (2007) reported that rubber farmers need more productive varieties or clones of natural rubber that are adapted to community conditions. Njukeng *et al.* (2011) reported higher yields from rubber plantations where improved clones were used as planting materials. Farmers who adopted the use of improved rubber clones are likely to have increased yields from their plantations leading to the earning of more income.

Table 6: Cobb - Douglas production function Result on factors influencing improved production practices among Respondents

Variable		Coefficient	Standard error	T. value
Constant		1.607726	.5854648	2.75**
Ln X_{1t}	Hectares of immature plantation	.2208018	.1313246	1.68
Ln X_{2t}	Labour (Mandays)	-.0958397	.0375771	2.55**
Ln X_{3t}	Hectares of matured plantation	.5105711	.1774559	2.88**
Ln X_{4t}	Supervision (man days)	.4983057	.0989076	5.04**
Ln X_{5t}	Improved planting materials	.0086017	.0039778	2.16**

Source: Data Analysis 2019 R-squared = 0.6303 Adj R-squared = 0.5883 SE = 0 .11569 F= 15.01**

4 Conclusion and Policy Implication

Natural rubber production was dominated by older, experienced and mostly smallholder farmers. Adoption of some of the improved production practices was higher in planting materials; rubber based cropping systems and quality control practices. Farm size, labour, supervision and improved planting materials exerted positive influence on the adoption of improved production practices

Ensuring the sustainability of the Nigerian rubber Industry will require consistent policies by the Nigerian government that will promote and encourage youth participation in natural rubber production by the provision of infrastructural facilities in the rural areas. Also, industrial policy should encourage capacity building for rubber based industries and provide incentives such as loans, tax holidays and to revitalize the moribund rubber processing industries in Nigeria to enable them remain in the business.

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