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ASSESSING THE PERCEIVED IMPACTS OF PALM OIL PRODUCTION ON ECOSYSTEM REGULATING SERVICES AMONG DWELLERS OF IPOKIA, OGUN STATE, NIGERIA

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ABSTRACT

The production of palm oil over the years has contributed to food security but its impact on the environment has raised concerns due to the degradation of sustenance of air, water, soil necessary for human survival and wellbeing. Therefore, the study assessed the perceived impact of palm oil production on ecosystem regulating services in Ipokia, Ogun State, Nigeria. A multi-stage sampling technique was used to select 120 respondents. Primary data were collected with a well-structured questionnaire and were analyzed with descriptive statistics and inferential statistics such as Chi-square and Multivariate probit model. The study showed that majority (50.9%) of respondents were male. About 41.7% were below 31 years, 71.8% were married, and 50.9% had secondary education. The findings also showed that majority (about 71.0%) were aware of ecosystem regulating services (ERS) in flood control andwater quality regulation. Further, the findings showed that residents' perceived effect of palm oil production on ecosystem include increase carbon emissions (mean =2.3) which was ranked 1st.The depletion of ground water by oil palm trees (mean =2.2) was ranked 2nd, biodiversity loss (mean= 1.9) was ranked 3rdand deforestation was ranked 4th respectively. A significant association ($p < 0.05$) exists between perceived detrimental effects of palm oil production on the ecosystem and ecosystem regulating services. Multivariate probit estimate showed that respondents' perceived impact of palm oil production on ecosystem, that is, biodiversity loss (ß=0.152; $p<0.05$*), deforestation (ß=0.178; $p<0.05$*), destruction of natural environment (ß=0.137; $p<0.05$*), palm oil effluents increase soil acidity (ß=0.224; $p<0.05$*) have a positive and significant influence on ERS. The study concluded that despite rural dwellers' experience in palm oil production and perceived environmental impacts, their awareness of environmental regulating services (ERS) positively influence ecosystem sustainability in Ipokia, Ogun State, Nigeria.

Keywords: Palm oil Production, Processing, Environmental degradation, Effluents

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a multipurpose tree crop with almost all parts of the tree having one form of socio-economic value or the other, a perennial crop that originated from the tropical rain forest of West Africa (Olagunju, 2008). Oil palm is capable of stabilizing global food security especially in developing countries and has become an increasingly important driver of economic development and poverty reduction in the major producing countries of the world, Nigeria inclusive. Carrere (2001) also pointed out that the crop is indigenous to the Nigerian coastal plain, having migrated inland as a staple crop and to millions of Nigerian people.

The oil palm is a versatile tree crop with almost all parts of the tree being useful and of economic value. The products that emanate from value addition in oil palm processing can be grouped into three: fruit-

based (crude palm oil, fibre, and sludge), nut-based (kernel, palm cake, shell, and empty bunch), and trunk based products (Adeniyi, *et al.*, 2014). It is one of the most important economic crops in the tropics. It is the most important source of vegetable oil in terms of yield among all the oil bearing plants (Odior, 2007). The principal product of oil palm is the palm fruit, which is processed to obtain three commercial products. These include palm oil, palm kernel oil and palm kernel cake.

The establishment of an oil palm plantation begins with clearing the land, either mechanically or with fire. Mechanical clearing often requires heavy machinery in the case of large-scale plantations, which can lead to soil compaction among other soil physical degradations (Murdiyarso *et al.*, 2004). Clearing through slashing and burning removes aboveground biomass, under storey vegetation, and ground litter and thus results in high environmental costs (Schrier-Uijl *et al.*, 2013). Despite laws prohibiting the clearing of land with fire, (since the 1990s in Malaysia and Indonesia), it remains the common practice (Fajrini, 2021). In most situations, adequate and balanced fertilization is essential to realize genetic growth and the potential for palm oil. Yields can also be increased through better quality seeds that have been developed through research (Basiron, 2007).

Palm fruit processing is the set of methods and techniques used to transform the raw palm fruits into palm oil, palm kernel oil, palm kernel cake and other by-products for human and livestock consumption or industrial uses. After oil palm fruit bunches are harvested, they need to be processed in a local mill within 48 hours to prevent fruit deterioration (Vermeulen and Goad, 2006). First, the stalks are separated from the fruits, leaving empty fruit bunches as a by-product. The fruits are then pressed, producing a press liquor that is separated into crude palm oil and palm oil mill effluent (POME). The crude palm oil is refined and separated into solid and liquid fractions (Sheil *et al.*, 2009). The press cake left over from pressing contains fibres, shells, and kernels (the seeds of the palm fruit); the kernels are ground, heated, and treated with a solvent to extract palm kernel oil (Poku, 2002).

Ecosystem services (ES) are all the benefits which human can derive from the natural ecosystems for their physical, social, and economic well-being (MA 2005). Regulating ecosystem services (RES) are defined as “the benefits obtained from the regulation of ecosystem processes” (MA 2005). It comprises the various ways whereby the ecosystems regulate the natural environments. It helps to reduce the impacts and effects emanated from both natural and anthropogenic activities that cause risk to human health and ecosystem quality. RES, therefore, protect the natural environment using mechanisms like water purification and waste treatment, air quality maintenance, soil erosion control, flood protection, climate regulation, pest and disease regulation, pollination, and regulation of frequency and intensity of natural hazards’ flow (Villamagna *et al.*, 2013). Some other is primary or intermediate ES which includes pollination, disease, and pest regulation (Watson *et al*., 2011). Regulation services of natural hazards, for instance, flood regulation, are determined by the hydrological system (Stürck *et al*., 2014). It has large impacts by affecting the provisioning services like crops, plants, and livestock which are the main sources of food for humans (Watson *et al.* 2011). The ecosystem regulation services include water purification and waste treatment, air quality maintenance, soil erosion control, flood protection, climate regulation, pest and disease regulation, pollination, and regulation of frequency and

intensity of natural hazards' flow andso on (Sutherland *et al.* 2018).

As new oil palm plantations and palm oil mills are established based on the demanding population allowing for more rapid production of palm oil and utilization, at the same time, however, destroy the natural ecosystem and the services related to it (Obidzinski *et al.*, 2014). Further pressure is put in remaining forests and land conflicts disrupt plantations and conservation efforts. Almost all of the palm oil produced globally is from plantation agriculture. The conversion of rainforests and forests to oil palm plantations has resulted in losses in biodiversity and ecosystem services. Oil palm plantations have also replaced other forms of agriculture (for examplerubber plantations and rain-fed rice cultivation). Oil palm plantations clearly produce significant economic value in terms of cash income for smallholders, who work their own small plantations and large estates, managed by national and multinational corporations. Therefore, based on this background the study was poised to delve into assessment of gap existing on the impact of oil palm cultivation and palm oil production on ecosystem regulation services in Ipokia, Ogun State, Nigeria. This objectives of the study were to: describe the socio-economic characteristics of residents;determine awareness of ecosystem regulating services among residents; and investigate the perceived effects of oil palm plantation and palm oil production on ecosystem regulation services in the study area.

Materials and Methods

Study Area

The study was conducted in Ipokia Local Government Area, Ogun state, Nigeria. Its headquarters is situated in the town of Ipetumodu in the Northern of the area with geographical coordinates oflongitudes2º51´59´´and2º51´85´´E, and latitudes 6º32´33´´ and 6º32´53´´N. It has an area of 563.8 kilometers square and population of 255,800 (National Population Commission, 2022). In this town, the wet season is oppressive and overcast, the dry season is muggy and partly cloudy, and it is hot year round. Over the course of the year, the temperature typically varies from 18.9°Celsius to 34.4°Celsius with an average annual rainfall between1500mm and 2000mm. The vegetation of the area is more of Savannah as there is not much thick forest through the land and is often flooded during the rainy season. The vast fertile land is available for agriculture and is predominantly known for oil palm production which is their major cash crop and other crops such as cassava, melon, maize and yam are cultivated.

Sampling Procedure

A multistage sampling procedure was used to select the respondents for the study area. The first stage involved selection of Ipokia Local Government because the area was notable for palm oil production in Ogun state. It consists of 12 wards which are Agosasa, Agada, Ihunbo/Ilase, Tube, Mauni 1, Mauni 2, Ipokia 1, Ipokia 2, Ajegunle, Idosa, Idiiroko, Ifonyintedo. The second stage involved purposive selection of four wards in Ipokia LGA which includes Tube, Mauni 1, Ipokia 1, Ajegunle where there were concentration of oil palm plantations. The third stage engaged the simple random selection of 3 villages from each of the 4 selected wards making a total of 12 villages. The fourth stage was 30% proportionate random selection of respondents from the population each of 12 selected villages with following population 50, 30, 60, 26, 40, 20, 20, 26, 20, 40, 40,and 26 respectively. Hence, 30% of these populations gave a sum of the following proportions (15+9+18+8+12+6+6+8+6+12+12+8) equals 120 respondents as a sample size for the study. A total of 120 copies of

questionnaires were distributed but 110 questionnaires were retrieved from the respondents.

Method of Data Collection

Data for this study were collected from primary sources through the use of a well-structured questionnaire and interview section.

Measurement of variables

(A.) For age in years, respondents were asked their age as at the time of the investigation.For gender, respondents were asked indicates if the respondent is either male or female. For marital status; respondents were asked to pick between the listed options of single, married, divorced, and widowed, and so on. (B.) Awareness of Ecosystem regulating services in the study area: Respondents were asked to indicate the Ecosystem regulating services in the study area and it was measured on two point scale of Yes and No. (C.) Perceived effect of oil palm plantation and palm oil production on the ecosystem regulation services among residents in the study area: The respondent were asked the perceived effect of oil palm plantation and palm oil production on the ecosystem regulation services among residents in the study area and was measured on a four point scale with response options of High, Moderate, Low, No.

Analytical Tools

The data collected were analyzed using descriptive statistics such as frequencies, percentages, mean scores and ranking. The descriptive statistics were used to analyze objectives one, two, and three. However, inferential statistics was used to test the hypotheses for the study: hypothesis one; there is no relationship between resident's perceived effect of palm oil production on ecosystem and ecosystem regulating services was tested with Chi square, while hypothesis two; was respondent's perceived impact of palm oil production on ecosystem does not influence ecosystem regulating service was estimated with Multivariate probit model.

Model Specification

i. Chi square

$$\chi^2 = \Sigma\left[\frac{(f_o - f_e)^2}{f_e}\right] \quad \text{..... (i)}$$

Where:

X^2= value of chi square

f_o= value for observed frequency count for ith level of categorical variable

f_e= value for expected frequency count for ith level of categorical variable

ii. Multivariate probit model

$$Y_{ij} = X'_{ij}\beta_j + \varepsilon_{ij} \quad \text{..... (ii)}$$

Where Y_{ij}(j=1,2,3,4 ……..) represent the different perceived effect of oil palm plantation and palm oil production on ecosystem regulating services by the i*th* farmer (i = 1,2,3,4…..).

$X'_{ij}$is a 1 × k vector of observed variables that affect the perception of effect by the farmers

$\beta j$is a k × 1 vector of unknown parameters (to be estimated).

$\varepsilon_{ij}$is the unobserved error term.

Results and Discussion

Respondent's Socio-economics Characteristics in the Study Area

The results in Table 1 shows that about 50.9% were males while 49.1% were females. This indicates that palm oil production and processing is perceived as an energy demanding which gives credence to equal involvement of both male and female gender. This supports the findings of Amuwah *et al.* (2023) that found out that men and women are involved in various stages of production activities and utilization of better palm oil processing techniques. The age group between 31-40

years recorded the highest percentage (41.7%). This implies that most of the respondent are young and active enough to carry out oil palm production and processing and achieve better productivity. This concurs with the submission of Okelola *et al.,* (2014) who stated that age has strong relationship on the output of palm oil production. The study further reveals that most respondents (71.8%) were married.

The implication is that married couples dominate palm oil production business. Apparently, they engage in this economic venture as a means of generating income to meet up with their household responsibilities. Also, the results in Table 1 shows that50.9% of respondents were having secondary education. This means that most respondents have the ability to read and understand information on oil palm production and processing. This result agrees with the finding of Adejoh *et al.,* (2010) reposed that formal education has helped oil palm processors to obtain useful information on activities involved in oil palm production. Furthermore, about 70.9% of respondents had6-15 years of experiencein oil palm production. This suggeststhat most respondents are equipped with reasonable experience which is vital for engaging in palm oil production. This supports submission of Akande *et al.,* (2013) who reported that respondents have gained wealth of experience that enhances their decision making in the adoption of technologies.

Table 1. Respondent's Socio-economics Characteristics

Variables	Frequencies	Percentages
Gender		
Male	56	50.9
Female	54	49.1
Age (in years)		
20-30	14	12.7
31-40	47	41.7
41-50	36	32.7
Above 50	13	11.9
Marital status		
Single	20	18.2
Married	7 9	71.8
Divorced	10	9.1
Widow(er)	1	0.9
Education		
No formal	28	25.5
Primary	37	25.5
Secondary	45	40.9
Monthly income (₦, 000:00k)		
20-34	10	9.1
35-49	42	38.2
50_64	38	34.5
65-79	17	15.5
>80	3	2.7
Years of experience		
< 5	19	17.3

6-15	78	70.9
16-24	7	6.4
25-34	5	4.5
>35	1	0.9
Other livelihood means		
Farming	45	40.9
Artisan	25	22.7
Civil servants	20	18 .2
Trading	14	12.7

Awareness of Ecosystem Regulating Services among Respondents

The results in Table 2shows that majority of respondents (71.8%) are aware of flood control as ERS. This implies that respondents were aware of less occurrence of floods in upstream of ecosystem than the downstream upstream of forests. This agrees with reposition of Rieley (2007) who found that the ecosystem in upland area of forests has strong tendency to regulate flood occurrence. In the same line, 64.5% were aware of air quality regulation and this could be due to air pollution from land clearing fires, increased emissions of volatile organic compounds and processing of oil palm. In addition, 70.9% were aware of water quality regulation and this could be due to the fact the conversion of forest to oil palm plantation generally leads to a decrease in water storage, an increase in annual yield, and a decrease in water quality, but these changes tend to become less extreme as plantations mature which support (Comte *et al.*, 2012) that opined oil palm plantation water quality regulation services was observed in oil palm plantation.

Furthermore, about 62.7% were aware of soil erosion controls alongside (63.5%) that were aware of soil protection service. Also, about 58.7% of respondents were aware of soil retention and formation. This suggest that awareness of ERS is high in the study area which could be due to the fact that most soil losses occur during plantation establishment when land becomes bare and maximally exposed to wind and water erosion. The study further shows that about 60.9% were aware of water purification. This supports Gregory *et al.*, (2006) who identified soil compaction in oil palm plantations reduces the rate at which rainfall infiltrates into the soil leading to surface runoff and reducing groundwater recharge.

Table 2. Awareness of Ecosystem Regulating Services

Ecosystem regulating services	Yes	No
	F %	F %
Climate regulation service: Carbon storage	45(40)	65(59.1)
Habitat quality, i.e measure of biodiversity in terms of ecosystems and their abundance	70(63.6)	40(36.4)
Water purification	67(60.9)	43(39.1)
Provisioning Service: Timber production		
Air quality regulation	71(64.5)	39 (35-5)
Disease control	53(48.2)	57 (51.8)
Pollination	57 (51.8)	53 (48.2)
Water quality regulation	78(70.9)	32(29.1)
Soil erosion control	69 (62.7)	41 (37.3)

Flood control	79(71.8)	31 (28.2)
Microclimate influence	38 (34.5)	72(65.5)
Natural Disaster Mitigation	60 (54.5)	50 (45.5)
Food Production	65(59.1)	45 (40.9)
Soil protection	70(63.6)	40(36.4)
Regulation of frequency and intensity of natural hazards' flow	70(63.6)	40(36.4)
Waste management	68 (61.8)	42(38.2)
Soil formation and retention	64(58.2)	46 (41.8)

Note: F = Frequencies are outside parentheses, % = Percentages are in parentheses

Respondents' Perceived Effect of Palm Oil Production on Ecosystem Regulating Services

The results in Table 3 shows that increasing in carbon emissions (mean = 2.3) was ranked 1st among the effects. This could be attributed to the fact that processing of oil palm generate carbon dioxide which is released into the atmosphere and oil palm plantations usually store less carbon in the soil than forests. This corroborates Zarin *et al.,* (2016) who elucidated that annual carbon emissions from oil palm production contribute nearly 10% of the global total of anthropogenic greenhouse gas emissions. Also, depletion of ground water by oil palm trees (mean= 2.2) was ranked 2nd and this could be due to the process of siltation. This corroborates Cordoba *et al.* (2019) who found that water availability and quality were perceived to be the most heavily impacted ecosystem services by oil palms in the Brazilian Amazon. Loss of biodiversity was recorded to be the 3rd in rank in terms of effect.

The development of more sustainable oil palm landscapes containing higher levels of biodiversity is not an alternative to conserving large areas of intact primary forest, as only these forested areas can provide a habitat for many rare and threatened species (Edwards *et al.,* 2010). Also, oil plantation lead to poaching activities in the area was also ranked 3rd and this means due to the conversion of forest to oil palm plantation, animals have been moved out of their habitat and are now being hunted illegally. This corroborates the report of Clements *et al.* (2010) who found out illegal hunting and poaching was a severe effect of oil palm plantation. The problem of health for human populations also ranked 3rd and this means that the health of farmers are prone to emissions of harmful gases due to oil palm plantation and production and also due to reduction in soil and water quality. Environmental degradation (mean =1.8) ranked 4th and this means that most soil losses occur during plantation establishment when land is bare and maximally exposed to wind and water erosion leading to environmental degradation.

Disruption of food chain was also found out to be 4th on the rank and this could be attributed to the fact that forests support many species that oil palm plantations do not, including many species used for food and other raw materials which are especially important during times of crop failure. This concurs with Sheil *et al.* (2006) who reported loss of these forest products and forest agriculture due to conversion to oil palm has negatively impacted many forest-dependent communities.

Table 3. Residents' Perceived Effect of Palm Oil Production on Ecosystem Regulating Services

Parameters	High	Moderate	Low	No	Mean	Rank
	F %	F %	F %	F %		
Depletion if ground water by oil palm trees	54(49.1)	32(29.1)	18(16.4)	6(5.5)	2.2	2nd
Increase carbon emissions	54(49.1)	31(28.2)	25(22.7)	(0.00)	2.3	1st
Loss of timber production	20(18.2)	47(42.7)	39(35.5)	4(3.6)	1.8	4th
Biodiversity loss	27(24.5)	48(43. 6)	26(23.6)	9(8.2)	1.9	3nd
Deforestation	24(21.8)	54(49.1)	22(20.0)	10(9.1)	1. 8	4th
Destruction of habitat	17(15.5)	35(31.8)	56(50.9)	2(1.8)	1.6	6th
Lead to massive fire outbreak	22(20.0)	34(43.6)	48(43.6)	6(5.5)	1.7	5th
Cause health problem for the human population	26(23.6)	53(48.2)	27(24.5)	3(2.7)	1.9	3nd
Nutrient loss	18(16.4)	58(52.7)	26(23.6)	8(7.3)	1.8	4th
Disruption of food chain	17(15.5)	44(31.8)	14(12.7)	14(12.7)	1.8	4th
Forest fragmentation	21(19.1)	34(30.9)	47(42.7)	8(7)	1.6	6th
Lead to air pollution	14(12.7)	35(31.8)	30(27.3)	31(28.2)	1.3	9th
Lead to water pollution	11(10.0)	46(41.8)	42(38.2)	11(10.0)	1.5	7th
Environmental degradation	30(27.3)	43(39.1)	27(24.5)	10(9.1)	1.8	4th
Palm oil effluents increase soil acidity	10(9.1)	47(42.7)	46(41.8)	7 (6. 4)	1.5	7th
Oil palm plantation lead to a illegal hunting or poaching activities in the area	19(17.3)	59(53.6)	29(26. 4)	3(2. 7)	1.9	3rd
Eutrophication which is driven by N- and P- compound	28(25.5)	54(49.1)	19(17.3)	9(8.2)	1.7	5th

Note: F = Frequencies are outside parentheses, % = Percentages are in parentheses

Hypotheses Testing

The results in Table 4 above shows there is significant relationship between provision of timber as ecosystem regulation service and biodiversity loss (x^2= 22.67), massive fire attack (x^2= 37.41), cause air pollution (x^2= 14.94), increase carbon (x^2= 11.42), loss of timber (x^2= 11.42), environmental degradation (x^2= 10.01) and eutrophication (x^2= 3.08). This suggests that residents' perceived effect of palm oil production on ecosystem such as loss of biodiversity, environmental degradation, massive fire attack, loss of timber could choke and hamper the provisioning service of timber production to the sustainability of environment.

This corroborates Kinyili *et al.* (2020) who reported that forestry ecological practices and sustainable forest management practices have significant effect on natural biodiversity, land use and the environment. Furthermore, there is significant relationship between ecosystem regulating service of soil erosion control and depletion of ground water by plants (x^2= 15.7), loss of timber production (x^2= 14.65), and loss of biodiversity (x^2= 19.99). This indicates that residents' perceived effect of palm oil production on ecosystem could create obstruction to ecosystem provisioning service of soil erosion control as a result of loss of natural plants and reduction in availability of trees. This is similar to

submission of Kalterborn *et al.* (2005) who reported there is a correlation between indiscriminate deforestation, loss of natural environment and environmental issues such as erosion and floods. In addition, the results in Table 4 showcased a significant association between ecosystem regulation service of flood control and depletion of ground water by plants (x^2= 15.7), loss of timber production (x^2= 14.65), loss of biodiversity (x^2= 19.99) and massive fire attack (x^2= 16.61). This implies that residents' perceived effect of palm oil production on ecosystem could cause unnecessary re-occurrence of floods due deforestation and removal of natural environment for various land use change development leading to hampering of ecosystem regulating services of flood control. This corroborates Kalterborn *et al.* (2005) who reported there is a correlation between indiscriminate deforestation, loss of natural environment and environmental issues such as erosion and floods.

Table 4. Ho1: Chi-square Statistic of Association between Resident's Perceived Effect of Palm Oil Production on Ecosystem and Ecosystem Regulating Services

Residents perception of effect of oil palm production	Abundantly habitat quality	Provision service of timber production	Air quality regulation	Water quality regulation	Soil erosion control	Flood control
Depletion of ground water by plants	7.650(0.57)^{ns}	0.64(0.88)^{ns}	15.4(.01)^{ns}	1.19(.75)^{ns}	15.7(.001)*	20.7(.00)*
Increase carbon	14.77(0.25)^{ns}	11.42(0.02)*	2.10(.71)^{ns}	5.54(.06)ns	3.07(2.16)^{ns}	2.71(0.26)^{ns}
Loss of timber	14.77(0.25)^{ns}	11.42(0.02)*	2.10(.71)^{ns}	14.65(.01)*	9.43(0.05)*	8.23(0.04)*
Biodiversity loss	14.34(0.11)^{ns}	22.67(0.00)*	5.81(.12)^{ns}	14.82(.02)*	19.9(0.00)*	8.23(0.04)*
Deforestation	11.7(0.23)^{ns}	4.35(0.23)^{ns}	15.42(.01)*	7.32(.06)^{ns}	3.63(0.30)^{ns}	3.38(0.34)^{ns}
Massive fire attack	23.80(0.01)*	37.41(0.00)*	7.28(.06)^{ns}	24.6(.00)^{ns}	6.86(0.08)^{ns}	16.61(.01)*
Cause health problem	15.26(0.08)^{ns}	2.83(.418)^{ns}	4.27(.23)^{ns}	6.16(.10)^{ns}	6.19(0.10)^{ns}	7.05(0.56)^{ns}
Forest fragmentation	16.63(0.05)*	2.7(0.45)^{ns}	25.3(0.00)*	0.54(.91)^{ns}	5.16(0.16)^{ns}	6.14(0.11)^{ns}
Cause air pollution	12.55(.184)^{ns}	14.94(.002)*	4.92(.18)^{ns}	7.14(.07)^{ns}	6.69(0.08)^{ns}	5.59(0.13)^{ns}
Environmental degradation	15.13(.080)^{ns}	10.01(0.01)*	5.24(.16)^{ns}	12.75(.01)*	1.59(0.66)^{ns}	1.81(0.61)^{ns}
Cause Eutrophication	13.71(.133)^{ns}	3.08(0.38)*	3.77(.29)^{ns}	5.27(.15)^{ns}	2.14(0.54)^{ns}	4.16(0.25)^{ns}

Note: Figures in parenthesis =chi-square value, Figures in parenthesis = * represents significant $p < 0.05$ and ns represents not significant.

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Hypothesis two on Table 5 shows that perceived impact of palm oil production on ecosystem like biodiversity loss (ß=0.152*), deforestation (ß=0.178*), destruction of natural environment (ß=0.137*), palm oil effluents increase soil acidity (ß=0.224*) have a positive and significant influence on the water quality regulating services at $p < 0.05$. This indicates that perceived impact of palm oil production on ecosystems highlights the need for sustainable and responsible production practices that prioritize environmental protection and social responsibility in the study area. This finding agrees with Saswattecha *et al.* (2016) whofound existential significant relationship between environmental impact of oil palm production and water quality. Also, residents' perceived effect of palm oil production on ecosystem such as forest fragmentation (ß=-0.152*) and deforestation (ß=0.160*) have significant influence on air quality regulation at $p < 0.05$. This indicates that perceived effect of palm oil production on ecosystem like forest fragmentation and deforestation could cause air pollution and environmental pollution.

This could be attributed to the fact that loss of trees that should absorb harmful gases and greenhouse gases have been indiscriminately felled without proper reforestation or planting of trees which have resulted to air contamination. This result corroborates the findings of Seif *et al.* (2021) who reported that most rural communities actively benefited from the physical presence of community trees and their proper conservation management.

Table 5. H_O 2: Multivariate Probit Estimate of Respondent's Perceived Impact of Palm Oil Production on Ecosystem and Ecosystem Regulating Service

Respondent's perception of effect of palm oil production	Abundant habitat quality		Provision service of timber production		Air quality regulation		Water quality regulation		Soil erosion control		Flood control	
	ßcoef.	**S.E**	**ßcoef.**	**S .E**	**ßcoef.**	**S.E**	**ßcoef.**	**S.E**	**ßcoef.**	**S.E**	**ßcoef.**	**S.E**
Depletion of ground water by palm trees	0.015^{ns}	(0.07)	-0.112*	(.045)	0.152*	(.049)	0.019^{ns}	(.047)	0.137*	(.045)	0.060^{ns}	(.048)
Increase carbon emission	0.187*	(0.09)	-0.024^{ns}	(.057)	.0025^{ns}	(.063)	0.056^{ns}	(.059)	-0.08^{ns}	(.060)	0.037^{ns}	(.061)
Loss of timber production	0.059^{ns}	(0.06)	-0.062^{ns}	(.038)	0.102^{ns}	(.042)	-.0152^{ns}	(.040)	0.058*	(.009)	0.198^{ns}	(.041)
Biodiversity loss	0.089^{ns}	(0.09)	0.134^{ns}	(.056)	-0.216^{ns}	(.061)	0.152*	(.058)	0.009^{ns}	(.006)	0.198*	(.060)
Deforestation	-0.17^{ns}	(0.10)	0.024	(.062)	0.160*	(.068)	0.178*	(.064)	0.010^{ns}	(.064)	0.038^{ns}	(.066)
Destruction of natural environment	0.084^{ns}	(0.11)	-1.192*	(.067)	0.054^{ns}	(.073)	0.137*	(.069)	0.207*	(.064)	0.032^{ns}	(.071)
Massive fire out break	0.027^{ns}	(.094)	-.182^{ns}	(.057)	-0.089^{ns}	(.063)	-0.021^{ns}	(.059)	-0.062^{ns}	(.059)	0.065^{ns}	(.061)
Cause health problem	-.205^{ns}	(.111)	-0.153^{ns}	(.068)	0.020^{ns}	(.074)	-0.059^{ns}	(.070)	0.061^{ns}	(-.071)	-0.028^{ns}	(.072)
Forest fragmentation	-.095^{ns}	(.097)	0.023^{ns}	(.059)	-0.152*	(.065)	-0.007^{ns}	(.061)	-0.159*	(.062)	0.065^{ns}	(.061)
Cause of air pollution	-0.021^{ns}	(.111)	-0.159*	(.048)	-0.016^{ns}	(.053)	-0.095^{ns}	(.050)	0.024*	(.050)	-.105*	(.051)
Environment	0.131^{ns}	(.190)	0.197*	(.055)	-0.027^{ns}	(.060)	-0.005^{ns}	(.057)	-0.097^{ns}	(.057)	0.112^{ns}	(.058)

degradation												
Palm oil effluents increase soil acidity	-0.021^{ns}	(.111)	0.050	(.068)	0.060^{ns}	(.074)	0.224*	(.070)	0.126^{ns}	(.070)	0.006^{ns}	(.072)
Causes eutrophication	0.190^{ns}	(.087)	0.146*	(.053)	-0.057^{ns}	(.058)	0.152^{ns}	(.055)	0.172*	(.055)	-.025^{ns}	(.057)

Note:ß coef. = Beta coefficient, S.E = Standard error, * represents figures significant at p < 0.05 and ns represents not significant

Conclusion

Based on the findings, palm oil production in the study area involves both male and female with considerable experience, who perceive significant environmental impacts, yet demonstrates awareness of ecosystem regulating services. Congruently, awareness positively correlates with ecosystem regulating services (ERS) sustainability in Ipokia Local Government Area, Ogun State, Nigeria. The study recommends policy implementationand enforcement forecosystem management, along with stakeholders' support for eco-friendly palm oil processing technologies.

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