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THE IMPACT OF MIXED CROPPING AND BUSH FALLOWING ON CLIMATE CHANGE MITIGATION IN CROSS RIVER STATE, NIGERIA CROSS RIVER STATE

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Abstract

This study investigated the impact of mixed cropping and bush fallowing on climate change mitigation in Cross River State, Nigeria. Two research questions and corresponding hypotheses were formulated to serve a guide for the study. The sample for the study consisted of four hundred and ninety-five (495) registered farmers with the Agricultural Development Programme in Cross River State. Systematic random sampling technique was adopted to select the four hundred and ninety-five respondents used for the study. A thirty-five item four-point Likert scale questionnaire was the instrument used for collection of data. The research instrument was subjected to validity test by relevant authorities. Cronbach alpha method was utilized to establish the reliability of the research instrument. The testing of hypotheses in the study was done with simple linear regression statistical tools. The hypotheses were tested at 0.05 level of significance. The result that was obtained from data analysis and hypotheses testing in the study revealed that there was a significant impact of mixed cropping and bush fallowing on climate change mitigation. Based on the findings obtained in this study, it recommended that the Agricultural extension officers should continue to engage farmers on the benefits of practicing mixed cropping in order to reduce carbon emission that militate against efforts to promote climate change mitigation and Farmers in the study area should be regularly enlightened by trained personnel on the best ways of practicing bush fallowing in order to promote climate change mitigation activities.

Keywords: Mixed cropping, bush fallowing, climate change, mitigation, agricultural practices, Cross River State.

1.0 Introduction

Climate change mitigation will continue to be a major concern for mankind in the forthcoming decades. Part of the mitigation strategy is to store carbon in the forest or in products, or let wood and other biomass substitute major parts of fossil fuels and fossil intensive products. At the same time, the global population and its wealth increase, and the requests for urban and agricultural land

and energy increase as well. This is likely to results in additional conservation of forests. At the same time, there is an increasing demand on forests for recreation and tourism. Altogether, these pressures may jeopardize managed forests' potential to mitigate climate change (Asu, 2017).

It has been observed that measures have been taken to reduce the level of emission and enhance sinks. The sinks that help to absorb carbon dioxide has been improved by several efforts to reduce deforestation and promote reforestation. The enactment of various legislations and policies to reduce greenhouse gases emission is another effort made to mitigate climate change in various parts of Nigeria (Obi, 2018). Nigeria has signed various international agreements and treaties that support a drastic decrease in the volume of carbon and other greenhouse gases emitted through various human activities that promote climate change. Government at various levels have encouraged tree planting campaigns as well as adoption of agricultural practices that are characterized by biological process. A reduction in the use of chemicals and artificial manure has further reduced the rate of emission of greenhouse gases associated with agriculture. The essence of these directives is yet to achieve the desired outcomes with regards to climate change mitigation.

Mixed cropping is another agricultural practice that is believed to promote climate change mitigation. Asu (2019) asserts that mixed cropping is a farming practice that promotes soil conservation and reduces deforestation caused by forest clearing for agriculture. This helps to mitigate the negative effects associated with deforestation and subsequently improve climatic conditions. The cultivation of various crops on the same piece of land at the same time helps to minimize the demand for various plots of land for cultivation of different crops. This reduces the rate of vegetation loss, which provides an avenue for carbon sequestration and regulation of temperature. Mixed cropping can be adopted a sustainable agricultural practice that can significantly contribute to efforts made to mitigate climate change.

Bush fallowing can contribute both positively and negatively to climate change mitigation. Jake (2021) reports that the practice of bush fallowing can be used to promote reforestation and reclaim lost forested areas earlier destroyed through human activities. The process of farming on a particular piece of land for a few years and once the nutrients in the soil are no longer supporting plant growth, the farmers abandons it for another one is complicated. The continuous search for new virgin forest land encourages widespread destruction of vegetation cover and subsequent high concentration of carbon dioxide and methane in the atmosphere. This results in greenhouse effects that causes climate change. On the other hand, the practice of bush fallowing can also promote climate change mitigation depending on how it is practiced. The period of allowing the already cultivated farmlands to recover and regain its lost nutrients also results in reforestation. This can also promote plants that would support carbon sequestration and mitigate climate change effects.

Garcia-Barrios (2018) reported that in global agricultural practice, various cropping practices or systems have been identified and classified based on their design, composition and management approach. One of such cropping technique is mixed cropping. It involves the cultivation of various crops on

the same piece of land during a planting season. It is a common practice among most subsistence farmers in various parts of the world, especially in developing countries. This cropping system help to maintain the quality of the soil because the residue from one crop usually adds manure to the soil and provide nutrients for other crops with longer maturity periods within the cultivated land. This recycling process helps to maintain soil quality and nutrients as well as reduces pest invasion on farmland, which usually promotes crop yield and ensure profitability in farming operations. Once this is achieved, farmers will demand less fresh agricultural land and this will ensure the conservation of forest resources at all times. The conservation of forests provides carbon sinks for the sequestration of carbon present in the atmosphere. This has a positive impact on climate change mitigation efforts, which secures a healthy environment and ecosystems.

Hobbs and Morton (2017) revealed that intentionally mixing plant species will create new habitats for associated species, mainly when the structure of the system is modified. In sole crop systems, the mutually beneficial functions and natural subsidies that lend stability and sustainability to natural systems are usually destroyed and require energy subsidies. According to Hobbs and Morton (2017), the stability and sustainability of managed systems could be increased by replacing external energy subsidies with the mutually beneficial functions found in nature through biodiversity. Hence, multispecies systems might or might not improve productivity, but might improve sustainability by improving the ability to resist or rebound in the face of disruptive effects, i.e. resilience. Frankie (2016) further maintained that the advantage of a mixture has often been assimilated to a higher yield of the mixture when compared with an equal area divided between monocultures of the components in the same proportion as they occur in the mixture. Advantage may also be considered when the yield of the mixture is higher than the yield of its best components grown in a monoculture over the whole of the same area, a less frequent situation called transgressive deviation. In a study based on published data on 344 binary mixtures, Trenbath (2015) reported that most mixtures were recorded as yielding at a level between the yields of the components' monocultures. A minority of mixtures were recorded as yielding outside the range defined by the yields of the components grown in a monoculture. Mixed cropping promotes soil viability to absorb carbon emission as well as reduce the rate of deforestation associated with agricultural activities. This helps to reduce methane emission and also provide carbon sinks that sequestrate greenhouse emissions from agricultural production. This subsequently contributes to the mitigation of climate change.

Smith (2019) reported that bush fallow farming currently occurs mainly in the humid tropics of Africa, South and Central America, Southeast Asia, and parts of Oceania. In these regions, average temperatures for the coolest month are above 18 °C and annual precipitation exceeds potential evapotranspiration. Temperatures and moisture conditions in turn affect soil and vegetation characteristics. Soils are generally heavily weathered and lacking in basic nutrients, but on these soils grow a great biodiversity of plants in forest and savanna biomes. Bush fallow farming is a response and adaptation of farmers to this environment. It can be defined as an

agricultural land use system and set of practices that is based on the rotation of land between different uses rather than a single permanent use, to achieve several agronomic (Sally, 2017). The fallow periods allow soil to regenerate its lost nutrients and support plant growth. The continuous growth of plants promotes the restoration of deforested areas. The consequences associated with deforestation are minimized through forest regeneration supported by fallow periods. The long-term benefits of regaining lost forests will result improved carbon sequestration and subsequent mitigation of climate change.

Jeffrey (2016) stated that bush fallowing is often perceived to be a threat to forests, but it is also central to the culture and livelihoods of millions of people worldwide. Balancing agriculture and forest conservation require knowledge of how agricultural land uses evolve in landscapes with forest conservation initiatives. Based on a case study from Quintana Roo, Mexico, and remote sensing data, we investigated land use and land cover change (LUCC) in relation to accessibility (from main settlement and road) in search of evidence for agricultural expansion and/or intensification after the initiation of community forestry program in 1986. Intensification was through a shortening of the fallow period. Defining the sampling space as a function of human needs and accessibility to agricultural resources was critical to ensure a user-centered perspective of the landscape. The composition of the accessible landscape changed substantially between 1986 and 2007. Over the 21-year period studied, the local population saw the accessible landscape transformed from a heterogeneous array of different successional stages including mature forests to a landscape dominated by young fallows. This has positive implication for climate change mitigation

2.0 Statement of the problem

This continuous degradation of the environment has resulted in the destruction of plant species and emission of greenhouse gases into the atmosphere. The regular emission of greenhouse gases into the atmosphere has resulted in severe alteration of natural climatic conditions. These changes in climatic condition due to loss of plants in particular have brought about adverse consequences including increasing temperature, reduction of oxygen in the atmosphere, drought, flooding, deforestation, erosion among others. These consequences have brought about varying thoughts, fear and assumptions among people in various locations within the study area on the negative effects of climate change.

The irony of this situation is that, despite the glaring consequences of climate change facing people in the study area, many people still do not seem convinced on the need to carry out sustainable agricultural practices as a means of reducing the adverse effect of climate change. Residents of the study still indulge in farming practices that promote the emission of greenhouse gases into the atmosphere. Government and other stakeholders have made efforts in creating awareness and sensitizing people on adaptation strategies and on the need to consider alternative farming practices that constitute severe climatic problems. These efforts have yielded insignificant results as the incidence of climate change seem to be on the increase in the study area.

These efforts are geared towards raising a citizenry that is aware of and committed to

finding lasting solutions to the increasing incidence of climate change. One of the approaches adopted to mitigate climate change in the study area is the introduction of sustainable agriculture. Agriculture has long been identified as a major contributor to increasing climate change. The need for farmers to adopt farming practices that would consistently contribute to climate change mitigation has become imperative as part of efforts made to change the narrative. This is because the mitigation of climate change will enhance food production, ecosystem sustainability, regulate temperature, and ensure continuity of society. This emphasizes the need to consciously promote climate change mitigation among farmers in the study area. This study is geared towards attempting to find answers to the question, how does mixed cropping and bush fallowing farming practices influence climate change mitigation in Cross River State Nigeria?

3.0 Objectives of the study

Specifically, the general purpose of the study aims:

1. Investigate the influence of mixed cropping on climate change mitigation in Cross River State Nigeria
2. Assess the influence of bush fallowing on climate change mitigationin Cross River State Nigeria

4.0 Research Questions

The following research questions will guide this study:

1. How does mixed cropping influence climate change mitigation?
2. To what extent does bush fallowing influence climate change mitigation?

5.0 Statement of Hypotheses

1 There is no significant influence of mixed cropping on climate change mitigation Cross River State Nigeria

2 Bush fallowing does not significantly influence climate change mitigation Cross River State Nigeria

5.0 Methodology

The population of this study consisted of all farmers in Cross River State, Nigeria that are registered under the Agricultural Development Programmes across various local government areas. The sample for the study consisted of four hundred and ninety-five (495) registered farmers with the Agricultural Development Programme in Cross River State. A descriptive survey research design was adopted for the study. The stratified random sampling technique and proportionate sampling approach were used for this study. The instrument for data collection was a structured questionnaire. It was tagged Agricultural Practices and Climate Change Mitigation Questionnaire (APCCMQ). The local government areas in the state were stratified into three education zones, while proportionate sampling approach was adopted to select the local government areas used for the study. The data collected were analyzed with Simple linear regression analysis at .05 level of significance. The result of the computation of the mean and standard deviation for the main variables of this study is presented in Table 1.

TABLE 1

General description of research variables

Variables	N	$\overline{X}$	SD
Mixed cropping	493	14.9006	.83146
Bush fallowing	493	13.5984	.79949
Climate change mitigation	493	25.6004	1.01841

6.0 Results

6.1 Hypotheses One: There is no significant influence of mixed cropping on climate change mitigation. Mixed cropping is the independent variable in this hypothesis while climate change mitigation is the dependent variable. The statistical tool employed for data analysis was simple linear regression analysis. The result is presented in Table 2.

TABLE 2

Simple linear regression analysis of the influence of mixed cropping on climate change mitigation in Cross River State (N = 493)

Model	R	R^2	Adj.R^2	Std error of estimate	
1	.637*	.406	.405	.78545	
Model	**SS**	**Df**	**MS**	**F**	**Sig**
Regression	207.370	1	207.370	336.136	.000
Residual	302.910	491	.617		
Total	510.280	492			

a. Dependent variable: Climate change mitigation
b. Predictors: (Constant), Mixed cropping

The result of data analysis of hypothesis three presented in Table 2 reveals that the independent or predictor variable (mixed cropping) has a significant influence on the dependent or predicted variable (climate change mitigation) among residents of Cross River State. This implied that mixed cropping accounted for 40.6% of climate change mitigation in the study area.

Again, the result of regression ANOVA presented in Table 2 revealed that there was a significant influence of mixed cropping on climate change mitigation, F (1, 491) = 336.136; $p<.05$. The result of this analysis showed that there is a moderate contribution of mixed cropping practice to climate change mitigation. This indicated that mixed cropping is positively influencing climate change mitigation in the study area.

6.2 Hypothesis two: Bush fallowing does not significantly influence climate change mitigation. Bush fallowing is the independent variable in this hypothesis while climate change mitigation is the dependent variable. The statistical tool employed for data analysis was simple linear regression analysis. The result is presented in Table 3.

The result of data analysis of hypothesis four presented in Table 3 reveals that the independent or predictor variable (bush fallowing) has a significant influence on the dependent or predicted variable (climate change mitigation) among residents of Cross River State. This implied that bush fallowing accounted for 46.8% of climate change mitigation in the study area.

Again, the result of regression ANOVA presented in Table 3 revealed that there was a significant influence of bush fallowing on climate change mitigation, $F(1, 491) = 432.372$; $p<.05$. The result of this analysis showed that there is a moderate contribution of bush fallowing practice to climate change mitigation. This indicated that bush fallowing is positively influencing climate change mitigation in the study area.

7.0 Discussion of findings

7.1 Mixed cropping and climate change mitigation

The finding that was gotten from data analysis and testing of hypothesis three in this study showed that the null hypothesis was rejected. The indication of this finding is that there was a significant influence of mixed cropping on climate change mitigation in Cross River State, Nigeria. The finding could be traced to the fact that mixed cropping is considered as a sustainable agricultural practice that because it does not encourage reckless deforestation. The cultivation of several crops on the same piece of land makes it a beneficial agricultural practice because the residue from one crop serves as manure for another crop with a longer maturity period. This help to sustain the viability and fertility of the soil to support crop growth thereby reducing the demand for arable virgin land for fresh cultivation each planting season. The conservation of soil nutrients through the practice of mixed cropping has reduced the rate of deforestation, which promotes carbon sequestration, reduce emission of chemical substances among other services. This is the reason why mixed cropping contributes positively to climate change mitigation in the study area.

The finding of this study agrees with that of Garcia-Barrios (2018) reported that in global agricultural practice, various cropping practices or systems have been identified and classified based on their design, composition and management approach. One of such cropping technique is mixed cropping. It involves the cultivation of various crops on the same piece of land during a planting season. It is a common practice among most subsistence farmers in various parts of the world, especially in developing countries. This cropping system help to maintain the quality of the soil because the residue from one crop usually adds manure to the soil and provide nutrients for other crops with longer maturity periods within the cultivated land. This recycling process helps to maintain soil quality and nutrients as well as reduces pest invasion on farmland, which usually promotes crop yield and ensure profitability in farming operations. Once this is achieved, farmers will demand less fresh agricultural land and this will ensure the conservation of forest resources at all times. The conservation of forests provides carbon sinks for the sequestration of carbon present in the atmosphere. This has a positive impact on climate change mitigation efforts, which secures a healthy environment and ecosystems.

The finding of this study is also supportive of that of Hobbs and Morton (2017) who revealed that intentionally mixing plant species will create new habitats for associated species, mainly when the structure

of the system is modified. In sole crop systems, the mutually beneficial functions and natural subsidies that lend stability and sustainability to natural systems are usually destroyed and require energy subsidies. According to Hobbs and Morton (2017), the stability and sustainability of managed systems could be increased by replacing external energy subsidies with the mutually beneficial functions found in nature through biodiversity. Hence, multispecies systems might or might not improve productivity, but might improve sustainability by improving the ability to resist or rebound in the face of disruptive effects, i.e. resilience. Frankie (2016) further maintained that the advantage of a mixture has often been assimilated to a higher yield of the mixture when compared with an equal area divided between monocultures of the components in the same proportion as they occur in the mixture. Advantage may also be considered when the yield of the mixture is higher than the yield of its best components grown in a monoculture over the whole of the same area, a less frequent situation called transgressive deviation. In a study based on published data on 344 binary mixtures, Trenbath (2015) reported that most mixtures were recorded as yielding at a level between the yields of the components' monocultures. A minority of mixtures were recorded as yielding outside the range defined by the yields of the components grown in a monoculture. Mixed cropping promotes soil viability to absorb carbon emission as well as reduce the rate of deforestation associated with agricultural activities. This helps to reduce methane emission and also provide carbon sinks that sequestrate greenhouse emissions from agricultural production. This subsequently contributes to the mitigation of climate change.

7.2 Bush fallowing and climate change mitigation

The finding that was gotten from data analysis and testing of hypothesis four in this study showed that the null hypothesis was rejected. The indication of this finding is that there was a significant influence of bush fallowing on climate change mitigation in Cross River State, Nigeria. The finding could be traced to the fact that bush fallowing is a farming practice that promotes regeneration of lost soil nutrients, vegetation cover and species. The practice of bush fallowing in the study area has contributed to the sustainability of soil viability, which has resulted in a reduction in the demand for fertile land. The lesser the demand for virgin forest land, the more environmental benefits accrue to individuals and the ecosystems of the earth. This has direct link with the mitigation of the effects associated with climate change. This could be the reason why bush fallowing relates positively with climate change mitigation in the study area.

The finding of this study agrees with that of Smith (2019) who reported that bush fallow farming currently occurs mainly in the humid tropics of Africa, South and Central America, Southeast Asia, and parts of Oceania. In these regions, average temperatures for the coolest month are above 18 °C and annual precipitation exceeds potential evapotranspiration. Temperatures and moisture conditions in turn affect soil and vegetation characteristics. Soils are generally heavily weathered and lacking in basic nutrients, but on these soils grow a great biodiversity of plants in forest and savanna biomes. Bush fallow farming is a response

and adaptation of farmers to this environment. It can be defined as an agricultural land use system and set of practices that is based on the rotation of land between different uses rather than a single permanent use, to achieve several agronomic (Sally, 2017). The fallow periods allow soil to regenerate its lost nutrients and support plant growth. The continuous growth of plants promotes the restoration of deforested areas. The consequences associated with deforestation are minimized through forest regeneration supported by fallow periods. The long-term benefits of regaining lost forests will result improved carbon sequestration and subsequent mitigation of climate change.

The finding of this study is also in support of that of Jeffrey (2016) who revealed that bush fallowing is often perceived to be a threat to forests, but it is also central to the culture and livelihoods of millions of people worldwide. Balancing agriculture and forest conservation require knowledge of how agricultural land uses evolve in landscapes with forest conservation initiatives. Based on a case study from Quintana Roo, Mexico, and remote sensing data, we investigated land use and land cover change (LUCC) in relation to accessibility (from main settlement and road) in search of evidence for agricultural expansion and/or intensification after the initiation of community forestry program in 1986. Intensification was through a shortening of the fallow period. Defining the sampling space as a function of human needs and accessibility to agricultural resources was critical to ensure a user-centered perspective of the landscape. The composition of the accessible landscape changed substantially between 1986 and 2007. Over the 21-year period studied, the local population saw the accessible landscape transformed from a heterogeneous array of different successional stages including mature forests to a landscape dominated by young fallows. This has positive implication for climate change mitigation.

8.0 Conclusion

From the analysis of data and testing of hypotheses in the study it was found that there was a significant influence of mixed cropping, and Bush fallowing on climate change mitigation in the research area. In conclusion, mixed cropping, and Bush fallowing covered in this study positively influence climate change mitigation in Cross River State, Nigeria**.**

9.0 Recommendations

On the basis of the findings of this study, the following recommendations were made:

1. Agricultural extension officers should continue to engage farmers on the benefits of practicing mixed cropping in order to reduce carbon emission that militate against efforts to promote climate change mitigation
2. Farmers in the study area should be regularly enlightened by trained personnel on the best ways of practicing bush fallowing in order to promote climate change mitigation activities.

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