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Assessment of Farmers' Awareness and Adoption of Green Innovative Technology in Agriculture for Mitigating Climate Change in Benue State, Nigeria

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Abstract
Recently, Benue state has been bedeviled with environmental hazards like bush burning, deforestation, flooding and soil erosion, prolonged draught leading to the destruction of economic trees, soil structure degradation, volatilization of essential minerals in the soil and emission of carbon dioxides. The study investigated the farmers' adoption of green innovative technology in agriculture for mitigating climate change in Benue state, Nigeria. Three research questions were posed to guide the study and three hypotheses were formulated and tested. to guide the study. The population for the study was 334 made up of 257 registered farmers and 77 extension agents. The sample for this study was 182, comprising 131 registered farmers, and 51 agricultural extension agents from the three geopolitical zones of Benue State. Using Taro – Yamen's formula for sample determination and multistage sampling technique was adopted for the study in arriving at the sample size, the entire population was stratified into (Zone A, B and C agricultural zones of Benue state) using stratified proportionate sampling technique. In each of the 3 zones, three Local government areas were purposively selected. Nine local Government Areas were thus sampled. The instruments used for data collection were a checklist and 47 items structuredquestionnaire. A 47- items structured questionnaire titled 'Green innovative technology questionnaire' (GITQ) was developed from literature and used for data collection. The instrument was face and content validated by three experts. Cronbach alpha method was used to establish the internal consistency of the items which yielded a reliability coefficient of 0.868. Mean was used to answer the research questions and t-test statistics to test the hypotheses at 0.05 level of significance. Findings from the study revealed that Green innovative technology in agriculture has significant influence in mitigating climate change in Benue State. It was recommended amongst others that extension agents should carry out more enlightenment campaign on the use of green innovative technology in agriculture for mitigating climate change.The study further revealed that there was statistically significant difference between the mean ratings of responses of farmers and extension agents in all the hypotheses:

Keywords-: Green innovative, technology, awareness, farmer, adoption, mitigation, climate change.

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I. Introduction

Modern farms and agricultural operations work far differently than those of a few decades ago, primarily because of advancements in technology, including the use of sensors devices, machines and information technology (National Institute of Information Technology 2019). The author further opined that agriculture routinely use sophisticated technologies such as robots, temperature, moisture sensor, aerial images and global positioning system GPS technology to boost productivity. Similarly, National Geographic Society (1996) states that technological innovations have greatly shaped agriculture throughout time from the creation of plough to the global positioning system GPS, driving precision farming equipment; humans have developed new ways to making farming more efficient and grow more food, finding new ways to irrigate crops or breed more disease resistant varieties. The author also noted that technology is key to feeding the ever-expanding global population.

Technologyaccording to Lane (1999) concern itself with understanding how knowledge is creatively applied to organized task involving people and machines that meet sustainable goals. In the same vein, Adam (2021) submitted that technology is the application of scientific knowledge to the practical aims of human life or to the change and manipulation of the human environment. In the context of this study, technology is the application of agricultural knowledge in farm practices that protect the depletion of the ozone layers. (i.e., environment friendly farming). The National Institute of Information Technology (2019) advocates that this advancement in agricultural technology allows farming to be more profitably efficient, safer and more

environmentally friendly, produce crops of higher productivity, decreases use of water fertilizer and pesticides which in turn keeps food prices down, reduced impact of natural ecosystem, less runoff of chemicals into rivers and ground water, increased worker safety, help farmers to monitor and manage natural resources, give farmers greater control over plant and animal production, processing , distribution and storage.

A farmer in the opinion of Sokanu (2017) is a person who works under the umbrella of agriculture, producing a variety of food for human and animal consumption. The author submitted that a farmer's main goal is to produce good crops and healthy animals in order to make a living and to feed the population. Similarly, Adam (2017) states that the responsibility and commitment of farmers goes beyond their farms, crops and livestock, to playing vital roles in their communities and indeed our futures. Butt (2018) opined that most farmers use tractors, trucks, ploughs, combine harvester, milking machines, sprayers and incubator. The use of these machines or implements leads to deforestation, biodiversity loss, accelerated soil erosion, loss of soil organic matter, stalinization of soil, coaster water pollution, acidifications, destruction of soil structures and farming practices like bush burning, continuous farming, clean clearing leads to pollution, escape of certain vital minerals from the soil, leaving the soil volatile for plant and increase carbon concentration in the atmosphere.

According to the World Future Council (2012), agriculture is directly responsible for 14 percent of total greenhouse gas emission and broader rural land use decisions have with even larger impact. The author further submitted that over the last 150 years. 147 billion of tons of carbon have been emitted from farm land due to inappropriate farming and grazing practices with only 270 GT emitted from burning of fossil fuel. Bullis (2019) opined that since the invention of the steam engine kicked off, the industrial revolution, our planet has suffered rapid changes in climate that include increasing severe drought, increased depletion of ground water reserves, seawater acidification, rising water levels, the rapid spread of disease and macro parasite and the extinction of endanger species.

Climate change in the opinion of Davis (2018) refers to significant changes in global temperature, precipitation, wind patterns and other measure of climate that occur over several decades or longer. Similarly, National Geographic Society (1996) states that climate change is a long-term shift in global or regional climate patterns. The author further states that, climate change specifically to the rise in global temperature from mid-20^{th} century to present. Climate change has direct effect on moderate warming and more carbon dioxides in the atmosphere may help some plants to grow faster, however more severe warming, flood and drought may reduce yield, livestock may be at risk, both directly from heat stress and indirectly from reduced quantity of their food supply. Fisheries will be affected by change in water temperature that makes water more hospital to invasive species and shift the range or life cycle timing of certain fish species (United State Environmental Protection Agency, 2017). Bellis (2019) noted that these effects may be irreversible except green technologies are adopted by farmers.

Green technology according to Environmental Magazines (2017) is any technology intended to reduce the impact of humans on the environment. The author further submitted that green technology reverses damages to the environment, through the impact of soil remediation and carbon sequestration technology. Similarly, Bellis (2019) noted that green technology is also known as sustainable technology that takes into account the long- and short-term impact of human activities on the environment. Green technology deals with the use of science and technology in order to breathe life into a damaged ecosystem (Betts, 2016). The author further stated that the main goal of green technology is to conserve nature, and to remedy the negative impact that human activities have on the environment. The opinion ofAccording to the Environmental Magazines (2017), examples of green technology include solar panel, wind turbines, solar heating and recycling. Mash (2021) opined that the types of green technology are recycling bin, solar panel, smart thermostat, rain barrels and smart power strips. Similarly, Tecam (2017) stated that green technology includes waste water treatment, elimination of industrial emission, recycling and waste management, self –sufficient building, waste –to- energy, generation of energy from the waves, vertical gardens and natural gas boiler. In agriculture, green technology includes conservation agriculture, sustainable intensification production, transgenic crops, organic agriculture and agro ecological system (Parvize, Maguel and Eric, 2012). Green technology in agriculture includes farmstead solar panel, coconut and glycerin washing agent instead of toxic washing agent, orange/peppermints oil insecticides, farmstead built with plastic water bottles, solar farm stead changing devices, phones or laptops, wind generator, wind turbine/mill, tractor/implement that doesn't emit gases, hand hydroponic farming. Others may include drip irrigation, cover cropping, tungya farming, alley farming, strip farming, agro forestry, crop rotation, terracing, contour farming and shifting cultivation.

More so, Butts (2019) state explained that green technology helps to manage and recycle waste materials, help purifies water, reduce carbon emission, purify the air, rejuvenate the ecosystem and conserve energy. The author further opined that green technology help in energy saving, slowing down global warming,

reduction of air pollution, less soil pollution, less water pollution, reduction in plastic pollution, save natural resources, feed more people on a global scale, protect the poorest among the poor, waste reduction, effective recycling production new business opportunities, straighten a farming brand and tax advantages. Long (2019) submitted that combating climate change require a total disruption of society including adoption of green technology.

Adoption in the opinion of Wayne (2019) is the ability of a person to do something differently other than what they have done previously (i.e., purchase or use a new product, acquire and perform a new behavior etc.). The author further submitted that the adoption of a new idea, behavior or product (i.e., innovative) does not happen simultaneously in a social system; rather it is a process whereby some people are more apt to adopt innovation than other. Marcia (as cited by Strauh, 2009) describes adoption as when an individual integrates a new innovation into their life and diffusion as their collective adoption process over time. Adoption of Green Innovation Technology in the context of this study is the ability of Benue state farmers to use agriculture practices that are environmentally friendly to control, monitor, prevent, remedy and restore the ecosystem. Hence the adoptions of green innovation technology in mitigation climate change in Benue state.

Statement of the Problem

Fluctuation of climatic elements and weather conditions in Benue state in the recent time seems to be worrisome. This fluctuating climate and weather condition has posed adverse effects on crop and animal productivity. The problem of herdsmen and adverse weather conditions has affected the glory of Benue state as the food basket of the nation.

In Benue state, the researchers observed that during the onset of the farming season, farmers usually expect rainfall and the months for rainfall have been fluctuating, this has also resulted in fluctuating crop production in the state, Farmers who usually enjoy price hike on the onset of farming season, no longer enjoy that, due to fluctuating rainfall and prolonged draught.

In the same vein, the researchers also observed that during dry season, Farmers and their children hunt for animal and set bushes on fire, destroying trees, soil structure, volatilization of essential mineral in the soil, emission of carbon dioxides and leaving the soil bare, destroying soil micro and macro fauna and flora, making the environment unsafe for human inhabitation.

More so, the researcher also observes that due to the effect of bush burning and other environmental hazards, have resulted to the growth of stubborn shrubs, pests and weeds like Imperatacylindrical spring up which is an indication of poor soil, this is in line with the finding of Handayani, Prawito, and Ihsan, (2012) which state that Soil dominated by *Imperatacylindrica* grass shows lower soil quality than agricultural fields.Similarly, Garrit, soekardi, van-nooordejk, de-la-cruz and pathak (1997)as cited by Handayani, prawito, and ihsan, (2012)) opined that In Asia, the major variety of *Imperatacylindrica*primarily affects the ecology, economy, fertility and productivity of the farm. However, the researchers have observed keenly, that in Benue state, the use of toxic herbicides and fertilizers, bush burning, deforestation, carbon emission through unsustainable intensification production result to climate change in Benue state. This also in line with Climatic Annual Report (2014) which state Burning fossil fuels, in combination with destruction of carbon sinks due to deforestation and other activities, has contributed to more and more carbon dioxide building up in the atmosphere. The researchers felt that if Benue state farmers adopt green innovative technology, it will help them to mitigate climate change. Hence, the study sort to assess farmers awareness and adoptions of green innovative technology in agriculture for mitigating climate change in Benue state, Nigeria.

Objective of the Study

The study seeks to ascertain farmer's adoptions of green innovative technology in agriculture for mitigating climate change in Benue state, specifically the study seeks to:

1. To ascertain farmers' level of awareness of the green innovative technologies available in agriculture for mitigating climate change in Benue state.
2. To ascertain the farmers' level of adoption of green innovative technology for mitigating climate change in Benue state.

Research Questions

1. What is farmers' level of awareness of the green innovative technology technologies available in agriculture for mitigating climate change in Benue state?
2. What is the level of farmers' adoption of green innovative technology in agriculture for mitigating climate change in Benue state?

Statement of Hypotheses

The following null hypotheses were formulated and tested at 0.05- level of significance.

1. There is no statistical significant difference between the mean ratings of farmers and extension agents on the level of awareness of green innovative technology available in agriculture for mitigating climate change in Benue state.
2. There is no statistical significant difference between the mean ratings of farmers and extension agents on the level of adoption of green innovative technology in agriculture for mitigating climate change in Benue state.

II. Methodology

The study adopted a survey research design. The area of the study is Benue State. Recently, Benue state has been bedeviled with environmental hazards like bush burning, deforestation, and flooding and soil erosion, prolong draught leading destruction of economic trees, soil structure degradation, and volatilization of essential mineral in the soil and emission of carbon dioxides. Hence, the state was considered suitable for conducting this study. The population for the study was 334 made up of 257 registered farmers and 77 extension agents. The sample for this study was 182, comprising 131 registered farmers, and 51 extension agents from the three geo political zones of Benue State. This was determined using Taro Yamme formula for a finite population (Ministry of Agriculture, Makurdi, 2015). The sampling technique for the study was a multistage technique. In arriving at the sample size, the entire population was stratified into (Zone A, B and C agricultural zones of Benue state). In each of the 3 zones, three Local government areas were purposively selected. Nine local Government Areas were thus sampled randomly. The instruments used for data collection were a checklist and a 47 items structured questionnaire titled 'Green innovative technology questionnaire' *(GITQ)* developed by the researchers from literature reviewed. The response scale for each item were based on a 4 - point rating scale was used for research question 1, 2 and 3, with a corresponding value of 4,3,2,1 respectively. The instrument was face and content validated by three experts, one from the Department of Soil science and two from the Department of Vocational Agriculture and Technology Education, all from the University of Agriculture, Makurdi. Cronbach Alpha method was used to establish the internal consistency of the questionnaire items. A reliability coefficient of 0.868was obtained. The instrument was administered by the researchers to the respondents with the help of two research assistants. One hundred and eight two questionnaires were administered and all 182 were retrieved from the respondents. The data were analyzed using mean and standard deviation to answer the research questions and t-test statistics to test the hypotheses at 0.05- level of significance.

III. Result And Discussion

The results of the study were obtained from the research questions answered and the hypotheses tested through data collected and analyzed.

Research Question 1

What is farmers' level of awareness of green innovative technology available in agriculture for mitigating climate change in Benue state?

The data for providing answers to the above research question are presented on the Table 1: below.

Table 1: The Mean Ratings and Standard Deviation of Respondents on Farmers' level of Awareness of Green Innovative Technology Available in Agriculture for Mitigating Climate Change in Benue State (N= 182).

S/N	ITEMS	MEAN	SD	REMARK
1	Farmstead solar panel	3.26	.817	Highly Aware
2	Coconut washing agent	3.10	.488	Highly aware e
3	Peppermint oil insecticide	1.13	.550	Not aware
4	Farmstead built with plastic bottle	1.29	.820	Not aware
5	Solar farmstead charging devices for laptop/phones	2.80	1.065	Averagely Aware
6	Wind turbines	2.95	.789	Averagely Aware
7	Solar heating panel	3.03	.820	Highly Aware
8	Wind generator	1.54	.949	Not aware
9	season water drainage	2.58	.587	Averagely Aware
10	Hydroponics (farming without land)	2.84	.730	Averagely Aware
11	Sprinkler/Drip irrigation	2.72	.668	Averagely

				Aware
12	zero tillage	2.95	.792	Averagely Aware
13	Organic farming(use of organic manure, like compost/farm yard/green manure)	3.11	.847	Highly Aware
14	Conservative farming (e.g., cover cropping, terracing, strip cropping/ mulching)	2.70	.697	Averagely Aware
15	Sustainable intensification production (farming with use of vinegar herbicides that kill weed/bush instead bush burning that emit carbon dioxide)	1.07	.408	Not aware
16	Agroecosystem farming (e.g., plantation farming, shifting cultivation, tungya farming, alley farming)	2.96	.778	Averagely Aware

N= Numbers of respondent. SD= Standard deviation, A= Agree, DA= Disagree

The data presented in Table 1, revealed that the twelve items have a mean value ranging from 2.58 to 3.26, which are above the cutoff point of 2.50. This shows that the respondents are aware ofsome green innovative technology inclimate change in Benue state. While four item have their mean value ranged from 1.13 – 1.54 which shows that the respondents are not awarethat green innovative technology in agriculture help to mitigating climate change in Benue state. The table further revealed that the standard deviation of the items ranged from 0.448 -1.065, which show that the respondents were not too far from the mean and opinion of one another in their responses on the level of awareness green innovative technology in agriculture to mitigating climate change in Benue state.

Hypotheses 1:

There is no statistical significant difference between the mean ratings of farmers and extension agents on the level of awareness of green innovative technology available in agriculture for mitigating climate change in Benue state.

The data for providing answers to the above research question are presented on the Table 2: below.

Table 2: The Mean Ratings and Standard Deviation of Respondents on the Level of Awareness of Green Innovative Technology Available in Agriculture for Mitigating Climate Change in Benue State (N= 182).

Responded	Mean	Standard Deviation	N	DF	Standard Error	t-cal	t-tab	Decision
Farmers	38.8244	3.50270	131	180	.30603	-5.612	.000	S
Extension Agent	43.1373	6.79417	51	60.633	.95137	-4.315		

N= Number of responded, DF=degree of freedom, t-calculated, Sig. =P-value; P>0.05.

The result from Table 2 revealed that the t-cal of 0.00 is less than P- value of 0.05, which shows that there is a statistical significance difference between the mean ratings of responses of the respondents on the level of awareness of green innovative technology in agriculture for mitigating climate change in Benue state. Therefore, the hypothesis was rejected.

Research question 3

What are is the farmers' levels of adoption of green innovative technology in agriculture for mitigating climate change in Benue state?

The data for providing answers to the above research question are presented on the Table 3: below.

Table 3: The Mean Ratings and Standard Deviation of Respondents on the farmers' Levels of Adoption of Green Innovative Technology in Agriculture for Mitigating Climate Change in Benue State (N= 182).

S/N	ITEMS	MEAN	SD	REMARK
32	Farmstead solar panel	2.80	.611	Adopted
33	Coconut/glycerin washing agent	3.41	.815	Highly adopted
34	peppermint oil insecticide	1.16	.652	Not adopted
35	Farmstead built with plastic bottle	1.07	.349	Not adopted
36	Solar farmstead charging devices for laptop/phones	3.01	.740	Highly adopted
37	Wind turbines	1.12	.473	Not adopted
38	Solar heating panel	2.93	.526	Averagely adopted
39	Wind generator	1.00	.000	Not adopted
40	season water drainage	3.53	.532	Highly adopted
41	Hydroponics (farming without land)	1.15	.593	Not adopted
42	Sprinkler/Drip irrigation	3.30	.918	Highly adopted
43	zero tillage	3.19	.846	Highly adopted
44	Organic farming(use of organic manure, like compost/farm yard/green manure)	2.98	.980	Averagely adopted
45	Conservative farming (e.g., cover cropping, terracing, strip cropping/ mulching)	3.15	.949	Highly adopted
46	Sustainable intensification production(farming with use of vinegar herbicides that kill weed/bush instead bush burning that emit carbon dioxide)	1.13	.550	Not adopted

47	Agroecosystem farming (e.g. plantation farming, shifting cultivation, tungya farming, alley farming)	2.93	1.120	Averagely adopted

N= Numbers of respondent. SD= Standard deviation, A= Agree, DA= Disagree

The data presented in table Table 5, revealed that the ten items had have mean values ranged ranging from 2.80 to 3.53 which were above the cutoff point of 2.50. This shows that green innovative technology in agriculture is adopted for mitigating climate change in Benue state. While six items have their mean value ranged from 1.13 – 1.54 which shows that the respondents are not awarethat green innovative technology in agriculture help to mitigating climate change in Benue state. The table further revealed that the standard deviation of the items ranged from 0.00 - 0.980, The respondents were not too far from the mean and opinion of one another in their responses on the level of adoption green innovative technology in agriculture to mitigating climate change in Benue state.

Hypothesis 3

There is no statistical significant difference between the mean ratings of farmers and extension agents on the level of adoption of green innovative technology in agriculture for mitigating climate change in Benue state.

The data for providing answers to the above research question are presented on the Table 4: below.

Table 4: The Mean Ratings and Standard Deviation of Respondents on the Level of Adoption of Green Innovative Technology in Agriculture for Mitigating Climate Change in Benue State (N= 182).

Respondents	Mean	Standard Deviation	N	DF	Standard Error	t-cal	t-tab	Decision
Farmers	38.6489	4.74086	131	180	.41421	3.333	.001	S
Extension Agent	35.8431	5.93421	51	76.127	.83096	3.022		

N= Number of responded, DF=degree of freedom, t-calculated, Sig. =P-value; P>0.05.

The result from Table 6 revealed that the t-cal of 0.001 is less than P- value of 0.05, which shows that there is no statistical significance difference between the mean ratings of responses of the respondent on the level of adoption of green innovative technology in agriculture for mitigating climate change in Benue state. Therefore, the hypothesis was rejected.

IV. Discussion of findings

The findings of this study are discussed as follows:

The result of the study on Table 1 showed that the respondents are aware of green innovative technology in agriculture such as: farmstead solar panel, coconut washing agent, solar farmstead charging devices for laptop/phones, wind turbines, season water drainage, hydroponics (farming without land), sprinkler/Drip irrigation, zero tillage, organic farming (use of organic manure, like compost/farm yard/green manure), conservative farming (e.g. Cover cropping, terracing, strip cropping/ mulching), and agro-ecosystem farming (e.g., plantation farming, shifting cultivation, tungya farming, alley farming). This finding was further confirmed from a test of corresponding hypothesis in Table 2, which shows that there is no statistical significance difference between the mean ratings of responses of agricultural extension agents, and farmers on green innovative technology in agriculture for mitigating climate change in Benue state. This finding was in conformity with the study of Uprety, Dhar, Hongmin, Kimball, Garg,& Upadhyay, (2012).Who studied Technologies for Climate Change Mitigation in Agricultural Sector? The findings of the authors cited above helped to add validity to the result of this study.

The findings of the study on Table 5 revealed that the respondents adopted ten (10) green innovative technologies in agriculture. These are:include farmstead solar panel, coconut/glycerin washing agent, solar farmstead charging devices for laptop/phones, solar heating panel, season water drainage, Sprinkler/Drip irrigation, zero tillage, Organic farming(use of organic manure, like compost/farm yard/green manure), conservative farming (e.g., cover cropping, terracing, strip cropping/ mulching) and agro-ecosystem farming (e.g., plantation farming, shifting cultivation, tungya farming, alley farming). The above finding was supported by corresponding hypothesis in Table 6, which revealed that there is statistical significant difference between the mean ratings of the level of adoption green innovative technology in agriculture for mitigating climate change in Benue state. The finding was in consonance with Martins, Tobias, Spyros, Christian and Michael (2017) who studies the adoption of green energy technologies, the role of policy in Austria, Germany and Switzerland. The findings of the authors cited above helped to add validity to the result of this study.

V. Conclusion

Green innovative technology in agriculture cannot be overemphasis in the quest for solution to the environmental hazard like bush burning, deforestation, flooding and soil erosion, prolong draught leading to the destruction of economic trees, soil structure degradation, volatilization of essential mineral in the soil and emission of carbon dioxides that have bedeviled Benue state. Hence the study is to assessed farmers' adoption of green innovative technology in agriculture for mitigating climate change in Benue state.

VI. Recommendations

Arising from the findings are the following recommendations:

1. Stake holders in agriculture should organize workshop and symposia to create more awareness of the needs for farmers to take advantage of the green innovative technology in agriculture to help mitigate climate change in Benue state, Nigeria
2. Government and agricultural stake holders should provide adequate facilities for green innovative technology in agriculture to help mitigate climate change in Benue state, Nigeria
3. Government and through environmental agency agencies should implement law that will provdent the bush burning, deforestation and other farming method result to carbon dioxide emission, thereby causing environmental hazard.

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