CLIMATE SMART AGRICULTURE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

GLOBAL ISSUES & LOCAL PERSPECTIVES volume One

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate Smart Agriculture, Food Security and Sustainable Development** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate smart agriculture (CSA) food security, Sustainable Development issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate smart agriculture, food security, and sustainable development necessary in policy making process that will stimulate increase in food production and environmental sustainability.

Climate Smart Agriculture, Food Security and Sustainable Development: *Global Issues & Local Perspectives* is organized in three parts. Part One deals with The Concept of **Climate Smart Agriculture**, Part Two is concerned with The Concept of **Food Security And** and Part Three deals with the Concept of **Sustainable Development**

Eteyen Nyong; October 2025

CLIMATE CHANGE MITIGATION STRATEGIES ADOPTED BY PALM WINE TAPPERS IN AKWA IBOM STATE NIGERIA

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1.1 Introduction

Agriculture plays important role in shaping the economy of many countries. In Nigeria, it is the highest employer of labor and serves as a major means of livelihood covering 70% of its population (World Bank, 2001). Agriculture provides over 90% of the food consumed locally and contributes 40% of the Gross Domestic Product (GDP) of Nigeria (Ozor, 2009). However, it is a major source of household income and provides raw materials for agro-based industries (Oluigbo, 2012). Agriculture enhances food security and impacts on the overall economic growth of the country. It also provides feed for domestic animals and most of its by-products are of economic importance.

Although the agricultural sector is being transformed by commercialization at the small, medium and large scale enterprise levels, the country is still faced with a number of problems in which addition to these; climate and weather patterns have been changing. (Ziervogel G., A. Nyong, B. Osman, C. Conde, S. Cortes, and T. Dowing, 2006;Nyong, and Nweze, 2014)) observed in their studies that Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa.

Palm wine is very popular for the social life of people living in the coastal States of West Africa (Nyong 2013). It is used in marriages and other festivals in all parts of Nigeria and as well as for the general entertainment and ceremonies. Nigeria is one of the countries that produces palm wine, it is commonly taken as a close local substitute for beer, which is comparatively more expensive (Udo and Nyong 2016).Raffia palm (Raphia hookeri) belongs to the family of Palmea and it is a monocotyledonous tree crop of the fresh water swamp that thrives on soil saturated with continuous presence of water. Due to climate variability, quantity, quality and duration of moisture availability for crop growth and unpredictable development (Nyong, and Nweze,. 2014). Raffia palm trees are grown in the tropical region of Africa (Madagascar, Gambia, Cameroon, Gabon, Congo, Angola

and Nigeria). It is also grow outside Africa in Malaysia, India and Singapore. Of more than 20 species of *raphia*palm that exist in west Africa, eight of them are found in Nigeria (Edet,2018),these include; *Raphiahookeri*, *Raphiavinifera*, *Raphiasudanica*, *Raphiamannu*, *Raphiaragalis Raphiamanbillensis Raphia Africana*, *Raphialongifora.* The *Raphiahookeri*, is ranked highest in palm wine production among all wine producing palm. The raphia palm unlike any other palm flowers once and dies (Nyong and Nweze, 2014); Okolo and Abigor 2016). The palm is beneficial to mankind as almost all the parts of the palm is useful for the production of palm wine, native or local gin, medicinal purposes, building materials, pulp for paper making, fire wood, breeding zone for succulent and edible larvae etc. The lipid components of the exudates ensures that the stigmatic surface is protected from desiccation to enable it trap pollen while the 0.8% sugar possibly serves as a source of energy for initial pollen germination on the stigma (Adinya, I. B and Awoke, M. U et al 2018). The raphia palm reaches maturity for tapping at the stage when the spear leaves become shorter and fan like, indicating the initiation stage of the auxiliary inflorescence, Nyong and Nweze, 2014)

Raphia palm differs significantly in the quantity of palm wine yields per day per tapping duration and the total yields in litres. The tapped palm wine is filled in jars or bottles and sold to costumers according to quantity and on demand while the commercial one is bottled, preserved and sold in supermarkets or exported to other countries (Nyong 2013). Fresh *raphia*palm wine is composed of sugar 8.4gm/100ml, protein 0.37gm/100ml, titrable organic acids 0.28gm/100ml and alcohol 0.79gm/100ml (Esechie, 2012). The quantity of sugar decreases with time while alcohol content increases as the palm wine ferments (Nyong and Nweze.,2014; Faparusi and Bassier, 2018).

Palm wine, a cherished cultural symbol and economic lifeline in many tropical regions, epitomizes the intricate relationship between humans and their environment. Its production, deeply rooted in tradition and heritage, serves as both a source of sustenance and income for communities worldwide. Among these locales, the Eket Agricultural Zone in Nigeria stands out as a prime example, where palm wine cultivation and tapping have been integral to the socio-economic fabric for generations. However, amidst the backdrop of globalization and climate change, the

sustainability of palm wine production faces unprecedented challenges, necessitating a nuanced examination of resource use efficiency and climate change impacts (Ajayi et al., 2020).

This expansive exploration delves into the intricate nexus between resource utilization, climate variability, and the production dynamics of palm wine within the unique ecological context of the Eket Agricultural Zone. By synthesizing empirical evidence, scholarly discourse, and local insights, this study aims to unravel the complexities inherent in palm wine production, shedding light on both its resilience and vulnerability in the face of evolving environmental and socio-economic pressures.

Smallholder farmers, who constitute the backbone of the industry in the Eket Agricultural Zone, navigate a complex landscape marked by limited access to capital, fluctuating market prices, and inadequate extension services. Addressing these systemic barriers requires a multi-pronged approach, encompassing targeted interventions such as capacity-building programs, technological innovation, and market linkages to enhance productivity and profitability along the palm wine value chain.

The specter of climate change looms large over the sustainability of palm wine production, casting a shadow of uncertainty over the future viability of this age-old tradition. The Eket Agricultural Zone, like many tropical regions, is already experiencing the impacts of a changing climate, manifested in altered rainfall patterns, rising temperatures, and increased incidence of extreme weather events. These climatic shifts pose a myriad of challenges to palm tree health, sap flow dynamics, and overall productivity, thereby amplifying the vulnerability of local communities reliant on palm wine for their livelihoods (Vermeulen et al, 2012).

Research indicates that rising temperatures and prolonged dry spells may disrupt the delicate balance of palm tree physiology, adversely affecting sap production and quality. Additionally, changes in precipitation patterns can exacerbate water stress, further compromising palm tree health and resilience to pests and diseases. Furthermore, the escalating frequency and intensity of extreme weather events, such as storms and hurricanes, pose immediate threats to palm stands, exacerbating the risks of physical damage and economic losses for palm wine producers (FAO, 2017).

In the face of these daunting challenges, proactive measures are imperative to safeguard the sustainability and resilience of palm wine production in the Eket Agricultural Zone. Mitigation strategies aimed at reducing greenhouse gas emissions and enhancing carbon sequestration in palm forests can contribute to broader climate change mitigation efforts while concurrently preserving ecosystem integrity. Additionally, the adoption of climate-smart agricultural practices, including improved irrigation techniques, agroforestry systems, and crop diversification, can bolster the adaptive capacity of palm wine producers to withstand climatic variability and extreme events

The issue of climatic variability has generated discussions in this millennium among the stake holders in both agriculture and economic development. Climate variability is one of the major environmental problems globally that threatens the entire human survival through temperature rise, drought and frequent flooding in farmlands increasing and it has become a global recurrent subject of concern. In other countries of the developing world, the action of global warming and climate variability is large especially in Africa due to widespread poverty, firewood burning, and erosion. It is a serious threat globally with implication on natural ecosystem, agriculture, health, water supply, atmosphere and soil which all these are elements that support life on earth for a long-term sustainability. Climate variability is a factor which redefines the world food equation through their effects on productions mainly in the agro-based dependent livelihoods. It causes death to crops which leads to crop failure, crop destruction and reduction in productions. Climate can be seen as the average or mean atmospheric elements of a particular place over a period of time.

The sustainability of palm wine production in the Eket Agricultural Zone hinges upon a delicate balance of resource use efficiency, climate resilience, and community empowerment. By embracing a holistic approach that integrates scientific research, policy support, and grassroots participation, stakeholders can chart a path towards a more sustainable and equitable future for palm wine production. Through concerted action and shared stewardship of natural resources, the Eket Agricultural Zone can emerge as a beacon of resilience in the face of evolving environmental challenges, ensuring the preservation of this timeless tradition for generations to come (Achigan-Dako et al., 2015).

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The sustainability of palm wine production in the Eket Agricultural Zone is increasingly threatened by inefficient resource utilization and the adverse impacts of climate change. This dual challenge not only jeopardizes the economic well-being of local farmers but also endangers a cultural heritage that has been preserved for generations.Adaptation to climate change entails the adjustments in the natural or anthropogenic activities in response to the actual or expected climatic changes and their effects which could cause harm or exploit the economic opportunities by the rural farmers (Efe, 2011). It has been predicted that the resultant increase in temperature due to climate change will accelerate physiological development resulting in hastened maturation and reduced yield. Growing seasons are expected to become shorter as temperature increases. It has also been noted that food production in Africa could half by 2020 (IPCC, 2007).

Nigeria is an Agrarian Economy with 75% small farmers accounting for the nation's agricultural output making arable crop farmers to depend largely on rainfall for high level of productivity. According to Sha, Fischer and van Velthuizen (2009) the adverse consequences of climate change will take an irreplaceable toll on food production and food security especially in developing countries which have a low capacity to cope and adapt to these challenges. Temidayo Gabriel Apata (2009) also asserted that climate change in the form of higher temperature, reduced rainfall and increased rainfall variability reduces crop yield and threatens food security in low income and agriculture-based economies like Nigeria. Evidence from Schlenker and Roberts (2009) confirmed the effects of climate change on farm net revenue in different parts of the globe through rainfall and temperature variability.

Observable determinants of adaptation also provide some evidence that institutional and social economic factors play an important part in allowing farmers to adapt. It may also be attributed that access to credit is associated with the decision to adapt. However, it appears that the type of credit affects the propensity to adapt. Whereas informal credit is negatively related to the probability of adapting, formal credit is positively correlated with the probability of adaptation (Ashley Gorstet.al 2018). This underlines the need for a greater reach of formal credit.

The researcher at this point was aimed at digging deep to find the determinants of climate change adaptation among arable crop farmers in Akwa Ibom State.

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Environmental Sustainability: The study aims to identify and promote sustainable practices that minimize resource wastage and conserve the natural environment. This is critical in preventing the over-exploitation of palm trees and ensuring the long-term availability of resources necessary for palm wine production (Ajayi et al., 2020). By integrating climate-smart agricultural practices, the study contributes to broader climate change mitigation efforts. These practices can help sequester carbon, reduce greenhouse gas emissions, and enhance biodiversity in the region.

Climate Resilience: Understanding the impact of climate change on palm wine production enables the development of effective adaptation strategies. These strategies are vital for building the resilience of local farmers to climate variability and extreme weather events, thereby securing their livelihoods against future climatic uncertainties.

The study helps in identifying vulnerabilities within the palm wine production system and suggests measures to reduce risks associated with climate change. This can lead to more stable production systems that can withstand adverse climatic conditions (Vermeulenet al., 2012).

Cultural Preservation: Palm wine is not just an economic commodity but also a cultural heritage. The study underscores the importance of preserving this tradition by ensuring that production practices are sustainable and resilient to changing environmental conditions.

By supporting sustainable palm wine production, the study helps maintain the cultural identity and social cohesion of communities in the Eket Agricultural Zone, where palm wine plays a significant role in social and cultural practices (Achigan-Dako et al., 2015).

Policy and Governance: The findings of the study provide valuable insights for policymakers to develop and implement policies that support sustainable agricultural practices and climate adaptation in the palm wine industry. This can lead to more effective governance and resource management.

The study highlights the need for institutional frameworks that facilitate access to resources, training, and financial support for smallholder farmers. Strengthening these institutions is crucial for the successful implementation of sustainable and climate-resilient practices.

2.1 Concept of Climate Change

Agriculture seems not to be successful without the inclusion of climate change. These terms are mostly used inter-changeably due to fact that agriculture depends fundamentally on weather. So far, negative impacts have been felt adversely by some part of the world as a result of increasing severe weather patterns. The term climate change was proposed by the world meteorological organization in 1966 to encompass all forms of climatic variability on time-scale longer than 10 year, bit regardless of causes. During the 1970s, the term climate change replaced climate change to focus on anthropogenic causes, as it became clear that human activity had a potential to drastically alter the climate. Climate change occurs when changes in the global system result in new weather pattern that usually last for a few decades and probably for a million of years. There are five interacting parts that make up the climate system; they include atmosphere air, hydrosphere water, cryosphere ice and permafrost, biosphere living things and lithosphere earth's crust and upper mantle. The climate system derives its energy predominantly form the sun and a very little from the internal earth cavity. There is a balance between the incoming energy and the outgoing energy which determines the earth's energy budget. When the incoming energy is greater than the outgoing energy, the earth's energy budget is positive and the climate system is warming, but if the energy is going out o the system, the earth's energy budget is negative and the earth is experiencing cooling weather (Wikipedia).

The Intergovernmental Panel on Climate Change (IPCC) (2007) defines climate change as statistically significant variations that persist for an extended period, typically decades or longer, it includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature The World Bank (2008) asserts that climate change is a long term change in the statistical distribution of weather patterns over periods of time ranging from decades to millions of years. This might be changes in weather conditions or changes in distribution of weather events with respect to an average either of a specific region or may occur across the whole earth. It is usually as a result of natural factors, natural processing and human activities. According to Food and Agricultural Organization FAO (2006) Climate change refers to any significant change in the measures of climate change lasting for an extended period in time. This includes the changes in temperature, precipitation and wind patterns among other factors that occur several decades or longer.

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2.2.1 Nature of Climate Change

(Fredrick and Schwarz, 2000), opined that in European countries climate change has lead to temperature rises, shift in rainfall patterns, a rise in sea level, hazardous events such as floods and droughts. According to the Action Aid International (AAI) (2006) Climate change is likely to result in high frequency of drought and floods that is likely to challenge farmers eroding their assets leaving them more vulnerable. Climate change is likely to cause hotter days and more frequent and larger heat waves. It might result in extreme events such as decrease in availability of fresh water and food, interact with health care services and also an enhancement of disease spreads as a result of increased rainfall and temperatures (Kelly and Adger, 2000). Changing climatic conditions cause high temperature, unpredictable rainfall pattern, floods, desert encroachment, excessive drought and depletion of the ozone layer by greenhouse gases. These events have tended to reduce agricultural production, hence affecting the means of livelihood of farmers, (Nkeme K. K, Onyia, C. C. and Ekereuke, H. E).

2.2.2 Climate Change and Agriculture

Ifeanyi-obi (2011) described climate change as a canker worm eating up the efforts made by farmers in Agricultural sector to enhance Agricultural productivity. According to her, the devastating effects of climate change on agricultural productivity are very significant and as such cannot be neglected. It has been estimated that 70% of the world population rely on rain fed agriculture FAO, (2010). According to Kurukulasuriya and Rosental (2003), changes in temperature and rainfall will result in adverse changes in land and water systems that is likely to affect agriculture production. Climate change effects are heterogeneous and region specific.

According to Parry et al (2007) climate variability directly affects agriculture production, as agriculture is inherently sensitive and is one of the most vulnerable sectors to the impacts of global climate change.

According to IPCC (2007) agriculture is considered vulnerable to climate change due to its negative effect on agriculture which in turn worsens the conditions for rural famers. Moreover; this is because they lack assets and adequate insurance to combat the effects. In the short run the effects of climate change on agriculture such as carbon dioxide fertilization of plants could contribute to increasing production and security. However, in the long run climate change is likely to increase water stress, reduce biodiversity, damage ecosystem and increase social conflicts due to increased competition of resources (IPCC 2007).

The increase in temperature as a result of climate change will make agriculture inactive and fertile lands less productive and even make some completely barren (Rosenzweign and Solecki, 2010).

According to IPCC (2001) poorest countries, mostly tropical and sub tropical regions would experience a decrease in crop yield due to decreased water availability, new and changed pest incidence. A 50% decrease in rain fed yield of crops such expected in Pakistan, UKMO, Africa and Latin America. Most crops are at its maximum temperature tolerance thus a slight climate change is likely to result in a sharp decrease with an estimation of up to 31% in the 21C.

An increase in temperature has been found to decrease yield and quality of many crops. A decrease in precipitation will affect the semi arid and arid an area in a negative way as there is a decrease in soil moisture but in areas with excess water agriculture is improved (Mano and Nhemachena, 2006). Climate change has also brought about seed varieties that are more resistant to harsh weather conditions and short season varieties allowing for arable crop production to be cultivated all seasons.

2.2.3 Climate Change and Livelihood

According to the United Nations Joint Press Kit for Bali Climate change Conference (2007), climate change is likely to cause;

- an increase in hunger and malnutrition affecting the vulnerable and food insecure,

- New patterns of pests and diseases will emerge;
- Human plants and livestock will be exposed to new pests and diseases that will flourish only at specific temperatures and humidity, posing new risk for food security, food safety and healthy.

The IPCC (2007) also contributed that malaria in particular is expected to change its distribution as a result of climate change.

Shaw, Mendelsohn and Nordhaus, (2007) pointed out that climate change has an effect on the four dimensions of food security**;** availability, stability access and utilization.

- Availability takes into account direct impacts on the yield through crop, pests and disease, soil fertility and holding properties. Indirectly it affects the economic growth, income distribution and agricultural demand.
- Stability point of view focus is placed on the effects of consistent supply of yields and food supplies. Climate change is likely to affect supplies of yields with fluctuating supplies of yield and food supplies.

Climate change is likely to indirectly affect the physical, economic and social access to food. As agricultural production decreases food prices rise and purchasing power decreases (Rosenzweig and Parry, 2005). In this case food security is prone to kiosk, thereby strangling the economic growth of the country (Palmmah Gutu,2014).

According to IPCC, 2017 climate change has led to environmental hazards to human health, weather patterns and biodiversity. Food borne diseases, water borne and animal diseases are likely to emerge at a rapid pace due to the changes in climatic conditions (Kumar and Parikhl, 2001). Floods may lead to the overflow from sewage treatment plants into fresh water reserves. It is believed that a greater percentage of the population is urbanized thus a majority of the nations' population is affected. As temperature increases a range of ticks breeding is promoted and they later expand leading to Lyme disease in animals (Palmmah Gutu,2014).

Maddison (2007) asserts that extreme climate changes lead to floods, droughts and earthquakes thus destroying infrastructure such as hospitals, schools, roads to mention but a few, this would affect the economic performance of the country an increased mortality rate an increased expenditure on the government as buildings need to be restored.

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2.2.4 Climate Change and Adaptation

Adaptation to climate change should be prioritized by African governments as it is the only way to cushion the effects of climate change on food production (International Food Policy Research Institute, 2009). FAO (2011) indicated that to protect livelihood and food security in developing countries adaptation is a key requirement even under moderate climate change.

Although climate change adaptation has been proved to being key effective, numerous factors have been identified as barriers to adaptation. (Reidsma, Ewert, Lansink and Leemans 2009) elaborates that adaptation to climate change depends on technical and economic factors, farmers' attitude and the political framework. Choice of adaptation to a certain strategy depends on the variable positively or negatively affecting a particular adaptation strategy. For a developing country like Nigeria to obtain accurate scientific data, securing funding for agriculture, main streaming adaptation into existing work and communicating nature of the problem depends on the ability of the government and famer inter-relationship so as to perceive the need for climate change adaptation. To cope with the effects of climate changes farmers have adapted to irrigation, drought resistant seed varieties, shifting to other crops, conservation agriculture preserving both soil and water, dry and early planting, varying planting dates and others do nothing (Boko, Niang, Vogel, Githeko, Medany, Osmanelasha and Yanda, 2007).

2.3 Measuring the Impact

Adams and McCarl (2001) opined that in order to access the impact of climate change on agriculture, models can be used which include; Production function, Agronomic Economic Model (AEM), Agronomic Ecological Zone Model (AEZM), Ricardian cross-section Model (RM), Computable General Equilibrium model (CGE) and the Multinomial logit regression models. But more emphasis will be laid on multinomial logit regression model, as it pertains to the main objective of the study.

2.4 Theoretical Framework

The Ricardian Model is theoretically embedded in the theory of economic postulated by David Ricardo (1815) however, is application to climate change land value analysis drawn

extensively from the work of Mendelsohn et al, (2000) examines how climate change in different places affects the net revenue and value of land. According to Soe and Mendelsohn (2006a) the model accounts for direct impacts of climate change on yield of different crops as well as indirect substitution of different input of different activities and other potential adoption by farmers to different climates. The Ricardian Model has an advantage in that it can incorporate changes that farmers would make to adapt in order to combat effects of climate change such as copying strategies (Mendelsohn et al, 2000). But however, the Ricardian model is criticized in that it is not subject to controlled experiments, it also does not take into account for future change in technology and policies. It assumes a constant price which is unrealistic since prices do change in the real world market and if these changes are significant enough they can invalidate the prediction of the model built on constant price (Mendelsohn, 2008) The model fails to account effects of factors that vary across space (Hassan 2008) and also does not recognize the fertilization effects of increased carbon dioxide (Maddison, 2006; Mendelsohn, 2008 and Kurukulasuriya and Rosenthal, 2006). Some crops might benefit from abundance of carbon dioxide and larger growing season. Ignoring such effects may cause an overestimation of climate change impacts.

Ricardian models or hedonic pricing models are used to answer the questions: What is the economic impact of climate change, and in some cases, how is this reduced by adaptation? Hedonic pricing models are used to isolate the price effects of various characteristics, for example, the amount a nearby green space increases the value of a home. For this project, Ricardian analysis would be used to quantify the costs of climate change through lower land values. Farm land values are used to estimate the long-term economic impacts of different climate conditions than those observed in the past.

This technique is derived from the writing of David Ricardo (1817), who stated that “net land value is equal to net productivity”. The hedonic pricing technique assumes that land owners will maximize the productivity of their land and the price paid for a piece of land is equal to its productive capacity. The value of land is decomposed into its various components by regressing the price of land on historical climate data, land characteristics and agriculturally significant historical events. For example, the price of land without irrigation may be lower than land with irrigation. The hedonic pricing technique isolates the effect of irrigation on land price, holding all

other characteristics fixed. Alternative regression approaches use farmer profits or net revenue in lieu of land values. Land values are then calculated from profits: they are assumed to be equal to the present discounted stream of rental rates. In other words, land values are the discounted sum of future profits from the use of the land. This technique assumes that farmers are actively adapting to climate change and findings are therefore net of autonomous adaptations. As a result, Ricardian models can be used to assess what would happen in the absence of a government intervention. Adaptations can be difficult to include in these models because they rely on historical information. In analysis of agriculture technology adoption Multinomial Probit (MNP) and Multinomial Logit (MNL) models are commonly used. According to Gujarati (2004) multivariate models are normally used when numbers of choices available to the household are more than two. They allow explaining of combination of choices and take care of self selection and interactions between alternatives. When there is more than one step in decision of choosing a technique then there is need to use models like Heckmans two step models. The MNP assumes the minimum utility using a certain adoption model subject to given factors.

The MNL model has an advantage that it assumes that farmer maximizes perceived utility using a certain adoption model subject to given factors. It also assumes independent from Irrelevant Alterations (IIA) such as the choice of adding a strategy does not change relative probability of existing models. The model seem appropriate for the study as the number of adaptation strategies are more than two and allows explanation of combination choice made by the farmer. The MNL model has an advantage that it assumes that farmer maximizes perceived utility using a certain adoption model subject to given factors. It also assumes independent from Irrelevant Alterations (IIA) such as the choice of adding a strategy does not change relative probability of existing models. The model seem appropriate for the study as the number of adaptation strategies are more than two and allows explanation of combination choice made by the farmer.

Apata, Ogunyinka, Sanusi, & Ogunwande (2010) reported that the MNL is commonly used in adoption studies involving multiple choices because of its importance in analyzing farmers' adaptation decisions, which are usually jointly made, as well as appropriate, in evaluating alternative combinations of adaptation strategies, including individual strategies. The model operates on the assumption that the rural farmers face a set of discrete, mutually exclusive choices

of adaptation measures. Tse (1987) reported that the model has computational simplicity in calculating the choice probabilities that are expressible in analytical form. In addition, the computational burden of the MNL specification is made easier by its likelihood function, which is globally concave (Hausman & McFadden, 1984).

However, the main limitation of this model is the Independence of Irrelevant Alternatives (IIA) property, which states that the ratios of the probabilities of choosing any two alternatives is independent of attributes of any other alternative in the choice set (Hausman & McFadden, 1984; Hassan & Nhemachena, 2008). This is however solved by making each ratio of probabilities a function of the attributes of all the alternatives (Apata et al., 2010). The parameter estimates of the MNL model only indicates the direction of the effect of explanatory variables on the dependent variable, rather the actual magnitude of change is shown by the marginal effect. The marginal effect measures the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Greene, 2000). The signs of the marginal effects and respective coefficients may be different, as the marginal effects depend on the sign and magnitude of all other coefficients (Apata et al., 2010). Furthermore, past studies have argued that adaptation to climate change is a two-step process, which initially requires the perception that climate is changing and then respond to changes through adaptation. Fussel (2007) argues that emphasis should focus on adaptation because human activities have already influenced vagaries in climate fluctuation.

2.5 Empirical Framework

Climate change in agriculture is now a subject of concern globally, evidenced by the number of empirical literature available on the subject. Most of the studies pertaining the adaptation to climate change have been undertaken at a macro level (Jain, 2006) leading to difficulties in generalizing specific household adaptation option. Thus laying a foundation for the increasing number of developing country studies of factors affecting adaptation to climate change at micro level that are emerging (Mendelsohn, 1999).

According to the IPCC (2007) adaptation measures help farmers guard against losses that can be incurred by the farmer due to changes in weather patterns. Different factors affect different

copying strategies at different level. Thus the researcher aimed to look at the factors affecting the dominating strategies in Ikot Ekpene local government area to help increase the adaptive capacity of the farmers so that they guard against losses that they can incur due to climate change. Yusuf et al (2008) confirmed that household wealth, non farm income and livestock ownership increase the likelihood of climate change adaptation. Deressa (2008) identified age, household size, information, social capital and agro ecological settings have significant impact on perception of adaptation.

On a general perspective it seems that adaptation is affected by different factors differently hence it was the aim of this study to analyze the factors that affect adaptation strategies.

2.5.1 Climate Change Adaptation Practices By The farmers

Ina research conducted by (Nyong, et al., 2018), on analysis of climate change adaptation of farmers at Urue-Offong Oruko LGA, of Akwa Ibom State, Nigeria, they found out that from Adaptation practices similarly characteristics into a category, which included; weather management practices, crop management practices, land/soil management practices, water management practices and livelihood diversification. It was found out that off farm employment with 85% in livelihood diversification category was the most predominant adaptation measure used by the rural farmers across all the climate change adaptation categories. It was also added that Agricultural production is seasonal and so, most of the times, rural farmers engage in other economic activities to be active, productive and to earn additional means of living. This could have informed why majority of them where involved in off farm employment activities.

According to (Nyong, et al., 2018), other predominant adaptation measures practiced by the rural farmers were multiple cropping of 96% and crop diversification of 85% in crop management category; mulching of 93%, making of ridges across the farm of 85% and cover cropping of 88% in water management category; as well as organic manure application 84% and making of mounds in farms 69% in land/soil management category. They went on to find out that Most of these measures are routine traditional agronomic practices and involves no new innovation or technology, and may therefore have been responsible for their high rate of usage by the rural farmers to adapt to climate change. All the adaptation practices in the weather management

category had a general low usage below 3 percent consisting of: use of weather forecast 4%, change in harvesting dates 24% and change in planting dates 33%. Weather management practices involves state of the art technology for accurate studying, understanding and prediction of the weather, most of which are lacking in the rural areas. Also, most of the rural farmers have limited formal education to understand and appreciate the importance of weather management in agriculture. These may have accounted for the low frequency of their use of these adaptation practices. In the same vein, the least used climate change adaptation practice was migration 3% which is in livelihood diversification category. Most of the rural farmers are in their native environment with very low level of education, and in some cases, with no formal education at all. As such, labour mobility is very limited or absence resigning them to faith in their ancestral homes.

In a study conducted by (Rashid H., C. Nhemachena) on determinants of farmers' actual adaptation decisions, the various combinations of measures and practices were grouped into the following adaptation options: diversifying into multiple crops and mixed crop-livestock systems, and switching from crops to livestock and from dry land to irrigation. It is clear from the study that multiple cropping mixed with livestock rearing under dry land conditions is the dominant system in Africa (52% of farms). Multiple cropping with livestock under irrigation is the second most common strategy (14%), and multiple cropping without livestock under dry land (13%) comes third. Mixing livestock with crops is by far the most common practice of African farmers (79%), whether under irrigation or dry land. Also note that while about 24% of African farms irrigate, using irrigation to support specialized livestock production is rare.

2.5.2 Climate change adaptation and age of farmers

Literature has it that there has been a mixed influence of the age of household head on the adoption of a strategy, its influence varies. Some studies found that age had an influence on farmers' decision to participate in forest, soil and water management activities. A study in the Eastern Highlands of Ethiopia by Wegayehu and Drake (2003) found out that age had an influence on farmers' decision to participate in soil and water conservation activities.

But however, Bayard, Jolly and Shannon (2007) and Okoye (1998) found that age is negatively related to adoption of conservation agriculture. From the empirical evidence mentioned age seem

to have mixed influence depending on copying strategy that is being employed, country and the norms and values. Therefore, age also has an effect on adaptation strategy, as an individual grows there are some strategies that they can easily accept, some may find it difficult to adapt to certain strategies basing on the socio-economic barriers. Thus the researcher was to find out the influence of age of household head on the dominating strategies in climate change adaptation.

2.5.3 Climate Change and Farm Size

According to Nhemachena and Hassan (2008) a larger farm size paves way for farmers to take labor intensive adaptation strategy. Nyangena (2007) objected this and concluded that farmers with small land are the ones that are likely to invest in soil conservation practices. Other studies found out those farmers with larger farms to allocate for the construction of soil bund (Anim, 1999). The researcher postulates that the effect of farm size is also dependant on the availability of cheap labor to the farmer. If the farmer has a larger piece of land and at the same time has readily available cheap labor there is a high probability of adaptation to labor intensive strategies and in contrary if there is no readily available cheap labor then the farmer is likely to shun labor intensive strategies. It is therefore seen that farm size can also have an independent influence on the adaptation of certain strategy.

Thus the researcher seeks to analyze the effect of farm size on the dominating strategies being employed by rural farmers.

Empirical evidence seem to base more on household size reflecting labor readily available to a farmer and that one can adopt to labor intensive adaptation strategy. The researcher suggested that the household farm size can affect adaptation strategy given the level of education of the households. Since Ikok Ekpene Local Government Area consist of the business areas and rural areas, some literate family members may look for other income generating projects reducing dependence on farming activities. The researcher also suggested that adaptation to a strategy is based on the availability of labor when most needed rather than it's readily availability. Thus the researcher seeks to analyze the effect of household farm size on adaptation strategy.

2.5.4 Gender Impact and Climate Change

Gender of the household head was seen as an important variable affecting adaptation decision at farm level (Deressa, Hassan, Teike, Mahmud and Ringler, 2009). According to Nhemachena and Hassan (2008) male headed households adapt more readily to climate change. But however Aymone (2009) found out that gender had an impact on the probability of choosing an adaptation technique. Females tend to adapt to resource management and conservation practices (Bayard et al, 2007; Dolisca et al., 2006; Burton et al., 1999). A study by Bekele and Drake (2003) found that gender was not a significant factor influencing farmers' decision to adopt to soil conservation measures. Literature has it that gender has a mixed influence at different level but the researcher hypothesizes that there are certain adaptation strategies that males are likely to adapt more rapidly compared to women and the opposite being true for women. Thus the researcher seeks to identify the influence of gender on the adaptation strategies being employed by rural farmers to observe if gender of the household head was to change what effect would that have on a given strategy, identify if there is going to be a change in strategy or one would continue using the strategy at hand.

2.5.5 Climate Change and Education of Farmers

According to Reardan and Kangasnieum (1998) education is an insignificant determinant in influencing adaptation measures to climate change. Okoye (1998) found out that education was negatively correlated with adaptation to climate change. Basing on these two studies, education's influence depends more on the type of education which may be formal, non formal and informal.

- Formal education is where one learns the basic, academic or trade skills,
- Non formal being maybe due to own study or from job skills, skills that are taught outside formal sector.
- Informal education involves information and teachings from magazines, other colleagues and from the mass Medias.

These levels of education have different influence on adaptation strategy; the increase in non formal and informal education might positively influence adaptation. Thus the researcher seeks to identify the effect of level of formal education on adaptation strategy employed by rural farmers.

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Other studies have also found income as a factor that affects adaptation strategies. Income can be grouped into off farm income and farm income. Smallholder farmers' access to off farm income source increases the probability that they will invest in farming activities. Ownership of livestock is negatively related to adaptation, the marginal impacts are not significant (Aymone 2009).

2.5.6 Climate Change and Level of Information

Some farmers can rarely note the differences in amount of rainfall and temperature, access to agricultural services is a vital source of information on climate change and agricultural practices. Research conducted by Bekele and Drake (2003), Tizale (2007) showed that extension education is a motivating factor on the use of soil and water conservation. Other studies however found out that extension was not a significant factor affecting adaptation of soil conservation measures (Pender et al 2004; Nkanya et al 2005). Madison (2006) also contributed that lack of information was a barrier to adaptation to climate change. According to Kandlinkar and Ribsey (2000) access to climate and agricultural information help farmers make cooperate decision to help farmers better cope with changes in climate.

Awareness of the problem and potential benefits of taking action is another important determinant of adoption of agricultural technologies. Maddison (2007) found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. Studies from (Gould et al., 1989; Traoré et al., 1998; Anim, 1999; Araya & Adjaye, 2001), have found that farmers' awareness and perceptions of soil erosion problems positively and significantly affected their decisions to adopt soil conservation measures. Therefore the researcher seeks to identify the level of awareness of climate change adaptation among farmers in the area of study.

3:1 Conclusion

It is absolutely very important to know the factors that affect climate change adaptation. This can help in the formulation of policies and investments strategies cushioning the effects of long term climate change. Since most rural farmers depend on rain-fed agriculture as their

source of livelihoods and have a low capacity to adapt to changes in climate change, policies to help farmer adopt are of great importance. An understanding of the adaptation measures employed by the household will enhance policy towards tackling the effects of climate change. Adaptation strategies employed by households in Eket Agricultural Zone included; Change planting and harvesting time , Prevent bush burning , Plant legumes, Practice crop rotation , Treatment of soil, Use improved /drought resistant variety, Control erosion.

3:2. Recommendation

- Based on the findings of this study, it was recommended that palm wine tappers should be provided with access to credit and inputs to be able to address the challenges of climate change. Adequate education and training should be encouraged among the palm wine tappers. Furthermore, government should make meteorological information on climate change available and accessible to palm wine tappers to guide them in their adaptation strategies on the farm.
- Government of akwa ibom state and other agricultural related bodies in the state should work to ensure that farmers have increased access to functional extension services, as this will provide less educated farmers with up-to-date information needed for better productivity and improved techniques.
- The state government, farming communities and farming households and other agricultural stakeholders should encourage and promote the formation of social group among farmers to strengthen interaction among practicing farmers. This will give them more access to relevant information on climate change adaption.
- There is need for multidisciplinary approach of extension so that there is an increased and strengthened adaptive capacity of the households. There is need to bring together farmers all stakeholders to develop common understanding of different perceptions to facilitate a better and acceptable strategy.

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- To strengthen and increase adaptive capacity there is also need to improve the social and infrastructure and institutions dealing with climate related issues.
- Policy making, it appears that education would do most of the hasten adaptation and increase household decision regarding the key adaptation techniques. There is need to teach individuals the essence of agriculture and the contribution of rural farmers to the nation. There is also need to promote non formal and informal education to help farmers cope with climate change.
- In policy making there is need to include the elderly as they are well vested with weather patterns hence having an influence on adaptation and may increase the acceptability of a strategy by households.

References

Achigan-Dako, E. G., N'Danikou, S., Assogba-Komlan, F., & Ambrose-Oji, B. (2015). Indigenous knowledge and traditional conservation of fonio millet (Digitaria spp.) in Togo. Human Ecology, 43(5), 763-773.

Agrios, G. N. (2005). Plant Pathology. Elsevier Academic Press.

Ajayi, O. A., Oyedepo, J. A., & Jolayemi, O. S. (2020). Vulnerability of oil palm production in Nigeria to climate change: A review. Environmental Challenges, 1, 100004.

Awe, F., Ayeni, L. S., & Adeyemo, A. J. (2012). Comparative study of traditional and improved palm wine production in Nigeria. Journal of Food Agriculture and Environment, 10(1), 66-70.

Bernard, H. R. (2017). Research Methods in Anthropology: Qualitative and Quantitative Approaches. Rowman & Littlefield.

Bryman, A. (2012). Social Research Methods. Oxford University Press.

Campbell Scientific. (2021). Soil Moisture Measurement. Retrieved from https://www.campbellsci.com/soil-moisture

Cochran, W. G. (1977). Sampling Techniques (3rd ed.). John Wiley & Sons.

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.

Creswell, J. W., & Creswell, J. D. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method (4th ed.). John Wiley & Sons.

Dixon, J., Taniguchi, K., Wattenbach, H., & Tanyeri-Arbur, A. (2004). Smallholders, globalization and policy analysis. FAO.

Duke, J. A. (1983). Handbook of Energy Crops. Unpublished. Available online: https://hort.purdue.edu/newcrop/duke_energy/palm_wine.html

Eakin, H., & Lemos, M. C. (2010). Institutions and change: The challenge of building adaptive capacity in Latin America. Global Environmental Change, 20(1), 1-3.

Easterling, D. R., Meehl, G. A., Parmesan, C., Changnon, S. A., Karl, T. R., & Mearns, L. O. (2000). Climate extremes: observations, modeling, and impacts. Science, 289(5487), 2068-2074.

Essien, E. B., & Bassey, A. E. (2012). Agricultural activities in Eket Local Government Area of Akwa Ibom State, Nigeria. Journal of Environmental Issues and Agriculture in Developing Countries, 4(1), 47-53.

FAO. (2013). Climate-smart agriculture sourcebook. Food and Agriculture Organization of the United Nations.

FAO. (2017). Climate-smart agriculture sourcebook (Vol. 3). Food and Agriculture Organization of the United Nations.

Fowler, F. J. (2009). Survey Research Methods (4th ed.). Sage Publications.

IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK

IPCC (2008) Annual Report. Rome: Food and agriculture organization.

IPCC. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Kothari, C. R. (2004). Research Methodology: Methods and Techniques. New Age International.

Krueger, R. A., & Casey, M. A. (2014). Focus Groups: A Practical Guide for Applied Research (5th ed.). Sage Publications.

Nair, P. K. R. (1993). An Introduction to Agroforestry. Springer Science & Business Media.

Nwachukwu, M. I., Obiefuna, J. C., & Ugochukwu, U. C. (2016). Climate variability and change: Perceptions, challenges and coping strategies among arable crop farmers in Anambra State, Nigeria. Journal of Agriculture and Environmental Sciences, 5(2), 106-119.

Nwankwo, C. F., Offem, B. O., & Nwachukwu, M. I. (2017). Sampling techniques and research design in applied sciences. International Journal of Applied Research and Technology, 6(2), 30-45.

Nyong, E. E and Obi, E. O (2014)Effect of Climate Change on Output of Periwinkle Harvesters in Oron Local Government, Akwa Ibom State; European Journal of Conservation and Management, Vol.6. No.9, March, 2014.

Nyong, E. E**.** and Nweze,N.J. (2014) Cassava Value Chain and Gender Role: Resource Use Efficiency in South-South;Asian Journal of Economics and Sociology; Vol.5. No2, April, 2014, P201-207.

Nyong, E. E.(2013) "Socio-EconomicAnalysisofFadamaFarmersinOron Local GovernmentAreaofAkwa IbomState,Nigeria" American Journal of Humanities and Social Sciences; Vol.1, No. 1,2013, 10-17

Nyong,E. E. and Nweze,N.J. (2014) Consumers' Satisfaction Compromise in Raphia Wine and Value Addition Supply Chain in Akwa Ibom, Nigeria International Journal of Agriculture and Food Science SSSN: 1597-1789 ; Vol. 3,No.1. 5, Dec. 2014; p234

Okafor, N. (1975). Microbiology and biochemistry of oil-palm wine. Advances in Applied Microbiology, 19, 237-256.

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 447-465.

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. (2012). Climate change and food systems. Annual Review of Environment and Resources, 37, 195-222.

WCED. (1987). Our Common Future. World Commission on Environment and Development. Oxford University

DEFINITION OF TERMS

Palm Wine:

A traditional alcoholic beverage produced by fermenting the sap of various species of palm trees, such as the oil palm (Elaeis guineensis) and the raffia palm (Raphia spp.).

Palm wine is a significant cultural and economic commodity in the Eket Agricultural Zone, providing livelihoods for many smallholder farmers and being central to various social and cultural practices (Okafor, 1975).

Climate Change:

Long-term alterations in temperature, precipitation, wind patterns, and other aspects of the Earth's climate system, primarily driven by human activities such as fossil fuel combustion, deforestation, and industrial processes.

Sustainability:

The ability to maintain or improve the productivity and utility of resources over time without causing long-term degradation to the environment or compromising future generations' ability to meet their needs. In palm wine production, sustainability involves practices that ensure continuous

production without depleting natural resources, harming the environment, or jeopardizing future production capacities (WCED, 1987)

Smallholder Farmers:

Farmers who operate small plots of land, typically less than two hectares, relying predominantly on family labor for agricultural activities.

Climate-Smart Agriculture (CSA):

An integrated approach to managing landscapes—cropland, livestock, forests, and fisheries—that addresses the interlinked challenges of food security and climate change.

CSA practices in palm wine production may include agroforestry, improved water management, and soil conservation techniques that enhance resilience to climate variability and extreme weather events (FAO, 2013).

Agroforestry:

A land-use management system in which trees or shrubs are grown around or among crops or pastureland, combining agricultural and forestry technologies to create more diverse, productive, and sustainable land-use systems.

In palm wine production, agroforestry practices can help maintain soil fertility, conserve water, and provide additional sources of income and resources (Nair, 1993).

Extreme Weather Events:

Severe or unseasonal weather phenomena, such as hurricanes, floods, droughts, and heatwaves, that can cause significant damage to the environment, infrastructure, and human life.

Extreme weather events pose direct threats to palm wine production by damaging palm trees, disrupting sap flow, and affecting overall agricultural productivity in the Eket Agricultural Zone (Easterling et al., 2000).

Pests and Diseases:

Organisms (insects, fungi, bacteria, viruses) that can cause harm to plants by feeding on them or infecting them, leading to reduced growth, yield, and quality of agricultural produce. Pests and diseases affecting palm trees can significantly reduce sap production and quality, thereby impacting the volume and economic viability of palm wine production (Agrios, 2005)

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