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Original Research Article

Assessment of Key Vulnerability Sectors and Adaptation Strategies to Climate Change in Enugu State, Nigeria

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The assessment of vulnerability areas to climate change and adaptation measures was carried out in Enugu State, Nigeria. Different Participatory Research Approaches (PRA) methods were used, including in-depth interview, focus group discussion and structured questionnaires. Findings revealed that poor farmers in rural communities of Enugu State constitute 85% and the peasant farmers solely depend on the rain-fed agriculture and natural resources for survival; hence they are more vulnerable to climate change and climate variability. The major causes of climate change in the area are deforestation, agricultural activities, changes in the land use system, fossil fuel burning, sand mining and population growth. On the knowledge and level of awareness to climate change in the area, 62.5% of the respondents did not have any knowledge of climate, 53.8% did not know the causes of climate and 66.2% of the respondents could not identify the effect of climate change on their livelihood activities. The key vulnerability areas to climate change identified in Enugu state are water resources, agriculture, health, settlement, ecosystem and gender inequalities. Access to credit facilities, education and training programmes, diversification of their livelihoods and changes in sociocultural practices in Enugu State are necessary to support poor farmers to fully realize their potential for enhanced adaptive capacity to climate change impact in the area and elsewhere in Nigeria.

Keywords Vulnerability Assessment, Adaptation Strategies, Climate Change, Enugu State.

INTRODUCTION

Climate change is one of the most serious environmental threats facing mankind worldwide. It affects agriculture in several ways, including its direct impact on food production. Climate change, which is attributed to the natural climate cycle and human activities, has adversely affected agricultural productivity in the developing countries (Ziervogel *et al.*, 2006). Available evidence shows that climate change is global, likewise its impacts; but the most adverse effects are felt mainly by developing countries, due to their low level of technological development (Nwafor 2007).

Human activities have contributed to an increase emission of greenhouse gases in the atmosphere resulting global warming, rainfall patterns shift, and extreme events such as droughts, floods, sea level rise, crop failures, prevalence of infection of diseases and forest fires become more frequent (Zoellick and Robert 2009). These environmental problems results in poor and unpredictable yields, thereby making farmers, most vulnerable, particularly in Africa (UNFCCC, 2007). In Enugu state of Nigeria, farmers are vulnerable to the

impact of climate change such as crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Robert 2009). It is projected that crop yield in Nigeria may fall by 10-20% by 2050 or even up to 50% due to climate change (Jones and Thornton, 2002), particularly in Enugu state because the farmers practiced rain-fed agriculture and hence fundamentally dependent on the vagaries of weather. As the farmers in Enugu state strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities. Some evidences indicated that Enugu state has already been vulnerable to ecological problems which have been directly linked to climate change (Adefolalu, 2007; Ikhile, 2007).

According to the Third and Fourth Report of Intergovernmental Panel on Climate Change (IPCC), Nigeria is one of the countries in sub-Saharan Africa that would be seriously affected by climate change. Enugu state has a high vulnerability to climate change because of poverty, poor infrastructure and high population pressures (over 5.3 million

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people) (NPC, 2007). Other vulnerability factors that Enugu State is prone to are floods, drought, land degradation and desertification. NEST (2004) reported that over 70% of the populations are engaged in rain-fed agriculture as an occupation. Vulnerability to climate change has been defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

According to the IPCC (2001), vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. The impact of climate change in Enugu State is visible and widespread. The Intergovernmental Panel on Climate Change (IPCC) defines climate change as, any change in climate over time, whether due to natural variability or as a result of human activity" (Parry *et al.*, 2007). Globally, climate change is recognized as a critical phenomenon with strong implications for socio- ecological, biophysical and human systems, and consequently human and structural development.

There have been observed changes in rainfall distribution with increased rainfall expected in the Enugu state (Obiagiele, 2003). Further physical impacts of climate change in the Enugu state include flooding, changes in temperature extremes (such as heat waves) and an increase in the frequency and intensity of storms, gully erosion, late and early cessation of rain and frequent dry spell during farming season. Such impacts combined with high dependence of poor farmers with natural resources and rain-fed agriculture mean that these farmers are at high risk. Poverty, inequitable distribution of natural resources, cultural practices, violent conflict, lack of access to credit facilities, poor health facilities and low educational background mean that farmers in Enugu state lack the adaptive capacity to cope and adjust to climate change impacts (Duncan, 2007).

STUDY AREA

Enugu State. Enugu State is particularly vulnerable to ecological problems, especially soil erosion in all forms, uncertainties of existing rainfall and prevalence of diseases due to high temperature (Ofomata, 1985; Oti, 2002). Though some of these climate-related hazards used to have a positive impact on the farmers of the area, but of recent times, the frequency of these events has become alarming (Ekpo and Asuqwo, 2012). The livelihoods of the inhabitants are at high risk due to the extreme climatic induced events. The majority of people in Enugu State are peasant farmers. There have been reports of changes in the early onset or late onset of rainfall and early cessation or late cessation of rainfall in the area. Also high temperatures are noted to have increased over the years (Ibe, 2006).

The changes in the pattern and quantity of rainfall as well as other climate parameters such as temperature, wind storms and relative humidity have a negative impact on the lives of farmers and other vulnerable group's mostly rural people who depend on natural resources for their livelihoods. The environmental degradation of the area as a result of sand mining, deforestation, agricultural activities, population explosion and industrialization has been known to increase the vulnerability level of the farmers in the zones.

MATERIALS AND METHODS

Information on the impacts of climate change, key vulnerability areas and adaptive measures in Enugu State were obtained from farmers, elders, agricultural extension officers in the

zones, women's groups and other opinion leaders that have lived in the rural communities for the past 30 years. In-depth-Interview (IDI), Focused group discussions (FGD) and structured questionnaires were held separately with the various groups. The groups separately provided their views on the impacts of climate change, areas of vulnerability and adaptive measures to climate change on their livelihoods activities in the area. Questionnaires were structured to elicit much information as possible on the climate-related extreme events, vulnerability areas and actions which may be taken for adaptation to climatic hazards in the zones. Information from secondary data were obtained from various sources, including existing data already published on climate related hazards, conferences, journals, national dailies, and workshop proceedings

Vulnerability Assessments

The indices that were used to assess the vulnerability areas as related to climate change in Enugu State include the dependence of climate sensitive occupation, poverty level in a household, extent of access to resources, the land tenure system, poor health care service, level of infrastructure development, level of awareness and education, dependence of natural resources, access to new technologies and access to credit facilities.

Impact Assessment

The indices used to assess climate change impacts in Enugu State include poor yield, homelessness, loss of farmland, migration, malnutrition, long distance to access fuel wood, long distance to access drinking water, sickness and unemployment.

Adaptation/ Coping Measures

Adaptation in this study involves a process of adjusting in relation to the impact of climate change which includes ecological, social and economic adjustments in anticipation or actual changes in climatic conditions. The method used to assess adaptation measures in the communities were structured questionnaires, in depth interviews and focus group discussion with the farmers of the area. The indices used in this assessment included identifying the alternative options that sustained their livelihood during climate disasters like flooding, severe wind storms, late onset of rain and early onset of rain during farming season and new technologies that can be introduced to remedy the situation.

Methods of data analysis

Descriptive statistics and simple percentage were used for data presentations (Seepersad and Henerson, 1984; Shepherd and Roger, 1991) were used to analyze data from questionnaires.

RESULTS AND DISCUSSION

Major Causes of Climate Change in Enugu State

Figure 1 shows the major causes of climate change in Enugu State. About 52% of the respondents reported that deforestation is a major cause of climate change in Enugu State. 43% of respondents agreed that agricultural activities are the cause of climate change in the area. Changes in land use system had 37%. While fossil fuel burning, population

explosion, sand mining and industrialization recorded the following percentage 33%, 28%, 23% and 18% respectively. For decades, deforestation (through the conversion of forest lands to other land uses) has been the second major source of greenhouse gas (GHG) emissions, after fossil fuel combustion (IPCC 2007).

There has been a global increase in deforestation in Enugu State. This accounts for the loss of these forests. The rate of agricultural activities and the changes in the land use system in Enugu State in the last three decades is alarming and this activity does not consider the implication to the environment. Also the increase in population growth in rural communities of Enugu State results in the environmental degradation in these communities. The huge implication of these growths in terms of climate change is not just carbon emissions; more importantly, it is increasing the vulnerability of resources and affects the livelihoods of the poor farmers who depend on these natural resources for their survival.

The unwholesome practice of agricultural system in these communities pollutes the water bodies, degrade the agricultural land, causes soil erosion and loss of biodiversity. According to Agu, (2014), the livelihoods of the rural people depend on natural resources for their survival such as forestry products and biodiversity. Nzegbule, (2009) reported that deforestation is a major environmental problem facing rural communities of the Southeastern region of Nigeria, with about 3% of forest lost every year.

Also, wood is the most commonly used sources of energy among the rural poor in Enugu State. Poor farmers collect firewood in the rural communities, along river banks, in forest plantations and in the forest reserve for domestic use. Sometimes both women and men in the rural communities collect wood to sell to urban dwellers. The market for wood is strong in the Enugu state because hydro-power is neither reliable nor cheap, and the high cost of kerosene and gas encouraged the poor people who cannot afford these expensive items to patronize the firewood business. Firewood sellers prefer to collect wood from the forest reserve, since buyers demand the superior quality of indigenous hard wood.

The release of greenhouse gases (GHG) such as CO₂, nitrous oxides, chlorofluorocarbon, hydrocarbons such as methane, ozone, aldehydes and water vapor into the atmosphere is another source of climate change in the Enugu State. Some of these gases, especially CO₂ and the oxides of nitrogen are dissolved in rainwater and fall to the earth as acid rain. CO₂ dissolved in water to form carbonate acid while nitrous oxides dissolve in water to form nitric acids. Because of the high level of ionization of these acids, they erode metallic surfaces and destroy biodiversity. Acid rain leads to loss of biodiversity, forests and economic crops and also affect human health.

The dominance of grasses and shrub conditions in Enugu State is an indication of loss of natural forest (NEST, 2004). This may be mainly due to acid rain, although there are other factors that may lead to this such as agricultural activities and mining activities of multinational companies. Some respondents opined that their farmland had been destroyed and is no longer fertile for cultivation of crops, hence they can no longer involve in farming activities.

According to Adeyemi, (2006) human beings, like other living things, relate to their environment in the following ways: the environment provides the resources needed for the existence and survival of human beings; the environment also provides the site for the physical presence of all living things with human being occupying space per capita; and also, the environment serves as the sink for waste and human being

produced the greatest amount of waste. Rapid population growth can push a region beyond its economic and natural resources, "limits-its carrying capacity" or long term ability to support the people who live there without degrading the region's resources (Schuster, 2003). The number of people, the nature and quantity of productions and consumption, and the cumulative impact on resources and the environment are all factors that determine a given areas carrying capacity.

In the rural communities of Enugu State, widespread malnutrition, high level of poverty and loss of farmland, especially if accompanied by environmental deterioration such as rapid loss of soil fertility, gully erosion and flooding may be one indication that the rural communities especially the urban region is exceeding its carrying capacity. The rural community of Enugu State is continually degraded by frequent sand mining. Seismic blasts and the discharge of untreated effluents directly into water bodies, some of which serve as the only source of water for the people. The devastating impacts of these incidents on the farmlands, crops, economic trees, streams, ponds are such that the people can no longer engage in productive farming (Iyayi 2004).

Awareness of climate Change in Enugu State

Table 1 shows the level of awareness of climate change in Enugu State. About 37.5% of the respondents in Enugu state agreed that they are aware of climate change. While 62.5% of the respondents who did have awareness of climate change in the area. The high number of the respondents observed from those that did not have awareness of climate change in Enugu state may be attributed to the fact that the majority of the people in the area, most especially, the rural people do not attach -importance to education. 53.8% of the respondents who were not able to identify the causes and effect of climate on their livelihood activities. While 46.2% of respondents could suggest the possible causes of climate change and the effect on their livelihood activities in the area.

This also increases the vulnerable level of the poor farmers to climate change impact. Most farmers in the area thought the severe flooding, wind storms, erosion menace and prevalence of pest and diseases affecting their crops and their environment are as a result of God punishment to mankind. About 34.5% of respondents could mention some evidences of climate change impact on the livelihoods. Whereas, 65.5% of the respondents could not mention any evidence of climate change impacts in Enugu State. The high percentage of poor farmers and uneducated people in this issue is that their livelihoods are more affected with climate change impact, since they depend on natural resources for their survival. Only 24.3% of the respondents that can relate historical events of climate change hazards in the area.

Whereas, 75.7% of the respondents were not able to relate some historical events of significance in the development of the community to climate change impacts. The result revealed that a lot of poor farmers in the Enugu state do not have any information, and are not aware of the impact of climate change. They thought and believe that the rising temperatures, increasingly erratic rainfall, and more frequent and severe floods, cyclones and loss of species are consequences of God punishment to humanity. Lack of awareness and low educational qualification of poor farmers in the area were observed as major limitations towards understanding the complexity of climate change among the people in Enugu state.

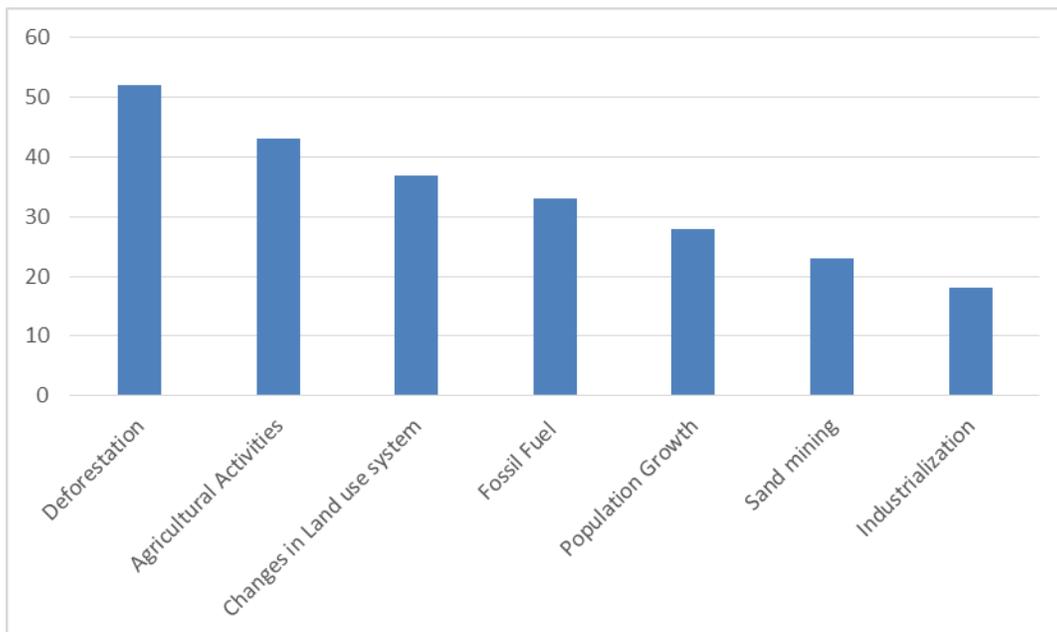


Figure 1. Major causes of Climate change in Enugu State

Table 1. Level of Awareness of climate Change in Enugu State

S/NO	Knowledge and awareness to climate change	Level of awareness	Level of not awareness
1	Level of awareness	37.5%	62.5%
2	Causes of climate change	46.2%	53.8%
3	Identifying effect of climate change on their livelihoods	33.8%	66.2%
4	Relate historical events of climate change impact in the state	24.3%	75.7%
5.	Evidence of climate change in the state	34.5%	65.5%

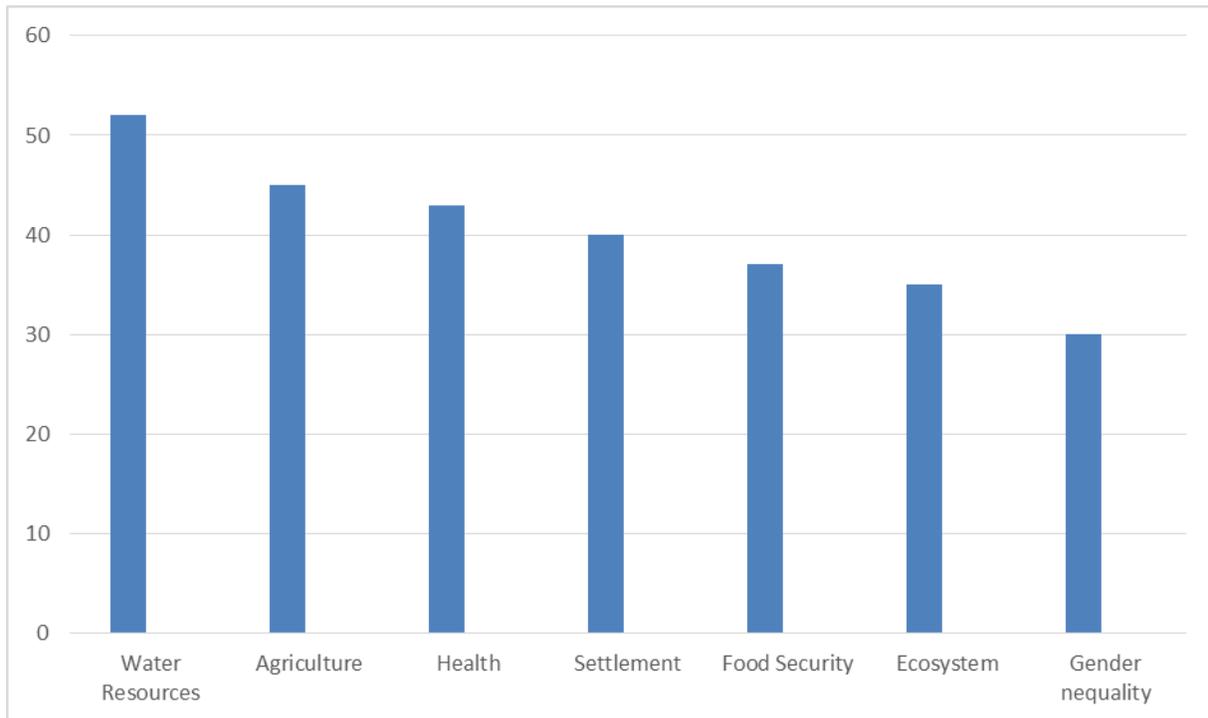


Figure 2. Key vulnerability sectors to climate change in Enugu State

The result was in line with the work of (Abiodun et al., 2000) who reported that educational attainments as well as creating awareness to the rural dwellers are capable of enhancing proper understanding of climate change impacts. The fact that the majority of people living in rural communities of Enugu State are farmers. However, farmers living in rural communities in Enugu State, need some technical knowledge, which is outside their local coping system in order to adapt to climate change impacts and to be able to improve their socioeconomic activities (Ziervogel et al., 2006).

Vulnerability sectors to climate change Enugu state

The key vulnerability sectors to climate change identified in Enugu state is presented in figure 2. Several research reports have consistently noted the vulnerability of the Enugu state to the impacts of climate change. The vulnerability's arises from a combination of physical and social processes and represents the interface between exposure to climatic threats interacting with other non-climatic threats, and the capacity of the threatened systems to cope with those threats.

Although climate change seems marginal compared to the pressing issues of poverty alleviation, hunger, health, and economic development in the study area, it is becoming increasingly clear that the realization of the development goals can be seriously hampered by climate change. The high population growth, rural-rural migration and high urbanization rates in Enugu state interact with climate change to exacerbate her vulnerability to climate change. Sustained rural-rural and rural-urban migration in the area puts undue pressure on land resources, both for farming and pasture, often resulting in communal conflicts between pastoralists and sedentary farmers.

A significant proportion of the population in Enugu state contends with the devastating consequences of diseases such

as malaria, HIV/AIDS, typhoid and meningitis. HIV/AIDS, for instance, affects nearly 13% resource poor farmers, who constitute a disproportionate 65% of the total population living with the virus. (Anyagwa, 2013). Since they are major food producers in the State, the impact of the virus is compounded because it jeopardizes food security by debilitating the agricultural labour force. Poverty is endemic in many states of Nigeria and Enugu State is the number in which people living below the poverty line (one dollar per day).

The economies of most people in Enugu state are largely based on primary products or extraction of natural resources. Enugu state has experienced a 2.8 times decrease in water availability (Okorie, 2006). The average discharge of Enugu Rivers has dropped by 40-60%. It is projected that by the year 2025, the majority of people in Enugu state will experience increases in water stress (Arnell, 2004). A drop in the water level in reservoirs and rivers could adversely affect the quality of water by concentrating sewage and industrial effluents, thereby exacerbating waterborne diseases and reducing the quality and quantity of fresh water available for domestic use (Dixon et al, 2003).

Poor water quality, projected to intensify under climate change, would increase water related diseases, reduce agricultural production, and limit economic development options. Poor water supply systems and low infrastructure also will add extra pressures on water availability in the state. This projected future water stress and scarcity, will have serious impacts on the socioeconomic development of the State affected and will likely adversely affect their food production levels. Enugu state has a strong dependence on agricultural production. The food security threat posed by climate change is greatest in the state, where agricultural yields and per capita food production have been steadily declining, and where population growth will double the demand for food, water and forage in the next 30 years (Davidson et al. 2003).

Enugu state is well recognized for its rich and diverse biological resources and these natural systems form the foundation of the economy of most rural farmers, from which the majority of them derive their livelihood. Threatened terrestrial and aquatic ecosystems translate to threatened livelihoods in the State. The economies of Enugu State are often clustered around natural resource rich zones that are very sensitive to climate variability with more than a quarter of the population residing within. These economic activities form the nucleus of settlements, urbanization and development in the state and are associated with high concentrations of infrastructure systems and population.

According to NEST (2008), the recent projected rapid urban growth, rising up to 35% of the population by 2030 in the Nigerian States will lead to extensive land use and land cover changes, especially for largely uncontrolled urban, semi-urban and rural settlements thus altering the existing surface microclimate and hydrology and exacerbate the scope and scale of climate change impacts. Climate change will also impact infrastructure and settlements in area through sea level rise, shortage of water resources, extreme events, food security, health risks and temperature related morbidity in urban centres.

Adaptation Measures

IPCC (2001) defined adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. This means that adaptation would not only deal with reducing vulnerability to climate change, but it might utilize the opportunities provided by changes in hydro-geophysical (natural) system to climate affected communities. Therefore, in order to reduce the vulnerability to climate change and climate variability of the rural farmers in Enugu State, adaptation measures that can be adopted by the farmers were identified and alternative livelihood options that are sustainable under climate change were suggested.

Adopt improved varieties of crops

Developing and using new varieties/species of crop with increased tolerance to flooding, salinity and can survive under declining soil fertility was introduced to the rural farmers in Enugu State. Planting of short-duration crop varieties such as rice, okra, pepper and garden egg, etc. also enhance the ability of women to cope with variable climatic conditions in the area (Ike, 2002).

Diversification of livelihoods

In the rural communities of Enugu State, vulnerability to climate change is influenced by the high level of poverty associated with limited options for coping with economic shocks. This can be reduced by diversifying livelihoods. Poor farmers can combine farming and with livestock rearing such as chickens, rabbits, snails and goats in an integrated manner to enhance their income. They can engage in these activities, particularly during raining season when most of their farm lands are flooded (NEST, 2004).

Accurate and timely weather forecasting.

A major factor contributing to crop failure is poor weather information dissemination in the area. Farmers usually rush to plant their crops with the first rains which may not necessarily

signal the actual onset of the growing season. Better weather forecasting skills and information sharing is needed to assist farmers in this respect.

Responsible agencies such as the Nigerian Meteorological Agency (NIMET) and other relevant research institutes should support the farmers in the area with timely information and in a way they rural women can understand.

Access to education, training

Training programmes on adaptation measures with a special focus on the needs of women (e.g., second season farming or late planting that will not be affected by flood and more resistant crops should be introduced in the area. Training programmes on the use of new technologies (e.g., means of agricultural production, energy-efficient cooking stoves and ovens, renewable energy systems, information and communication technologies). Awareness of existing rights and laying claim to these rights in different spheres of life (e.g., land ownership or land use rights, ownership rights for means of production).

Access to land and ownership rights

Farmers in Enugu State should be allowed to own land and be able to use it according to one's own needs and wishes in order to be active in climate mitigation and adaptation: To procure, own and be able to use the means of production, particularly new technologies, and the related technical know-how to improve their livelihood. To obtain, own, and be able to deploy financial capital for one's own undertakings in order to have investments available for the adoption or development of climate-related work.

Access to services

To (medical) care and childcare services in order to ease the burden on women, stop genital mutilation that reduce time and increase poverty level in the area: To have access to the (agricultural) extension services required, for example, improved seedlings, fertilizer and farm inputs. To have access to loans and credit facilities for the rural farmers should develop strategies to enhance women's access to and control over natural resources, Increase women's participation in decision-making at all levels in climate change. Farmers in Enugu State should have free access

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