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Women Farmers Use of Indigenous Knowledge in Land and Water Management for Climate Change Adaptation in Flood-Plain Agricultural Areas of Imo State, Nigeria

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Abstract

This study was carried out to analyze indigenous knowledge practices employed by women farmers for climate change adaptation and mitigation in Imo State, Nigeria. A total of 360 women farmers was randomly selected from 7 flood plain areas of the State. Questionnaire and oral interview were used to elicit information from the respondents. Percentages, mean and standard deviation were used to analyze data collected. Results showed the indigenous land and water management practices to include ; mulching (88.8%), use of mounds (80.5%), crop rotation (97.2%), soil fertilization (81.6%), conservation agriculture (97.2%), construction of infiltration pits (83.3%), construction of wells and basins for water storage (94.4%), terrace building (96.9%), planting mangrove trees (92.7%), use of sand bags against erosion (96.6%) among others. The high mean (M) response below showed the benefits of use of indigenous knowledge in land and water management to include; enhanced agricultural productivity (M=3.64), reduced water stress (M=3.25), improve soil air and water quality (M=2.86), improves soil organic matter content (M=2.95), increase soil moisture content (M=2.90), reduces erosion menace in farm (M=2.92) and others. The following challenges were faced – high transaction cost (M=3.04), land tenure problems (M=3.95), insecurity of rights to land (M=3.35), low level of income (M=3.67), lack of education and training (M=3.55) among other challenges. Extension training of women farmers be vigorously pursued to educate and enlighten the rural agricultural population.

Keywords: Indigenous knowledge; Agriculture; Water; Land; Management

Introduction

Agriculture is the economic foundation and pillar of many developing countries of the world. This is true because it employs up to two-thirds of the workforce and contributes between 10 and 30 percent of gross domestic product (GDP) [1,2]. For the poorest people, GDP growth originating in agriculture is more effective in raising incomes than GDP growth originating from other sectors [2]. Food production therefore, must increase by more than 70 percent by 2050 to meet the demands of a world with over 9 billion people and changing diets. In some African countries it must increase by more than 100 percent [2].

Agriculture is highly vulnerable to climate change. Its direct relationship with the environment is more pronounced than any other major economic sector such that it will need to adapt to the changing climate [3]. Under optimistic lower-end projections of temperature rise, climate change may reduce crop yields by between 10 and 20 percent. Increased incidence of droughts and floods may lead to a sharp increase in prices of some of the major grain crops by the 2050s. While agriculture is exceptionally susceptible to climate change, it is also a major contributing cause, accounting for about 14 percent of global greenhouse gas emissions. This proportion rises to about 30 percent when considering land-use change, including deforestation driven by agricultural expansion for food, fiber and fuel [4].

Therefore since, ensuring food security under changing climate conditions is one of the major challenges of our era, agriculture must not only become increasingly productive, but must also adapt to climate change while reducing greenhouse gas emissions. The triple imperatives of increasing productivity, enhancing resilience to climate change, and reducing emissions call for alternative practices which are environment friendly, otherwise the use of indigenous knowledge in land and water management by our women farmers.

Sustainable Indigenous knowledge in Land and water management technologies can benefit farmers by increasing yields and reducing production costs. These technologies include integrated nutrient and water management, mulching and residue management, no-tillage, crop rotation, cover crops, and agro-forestry. The integrated land use systems combine trees and shrubs with crops, and in many settings with both crops and livestock.

Indigenous land management (ILM), is a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management to meet rising food and fiber demands while sustaining ecosystem services and livelihoods. It entails the implementation of land use systems and management practices that enable humans to maximize the economic and social benefits from land while maintaining or enhancing the ecosystem services that accrue from land resources.

Water is a key driver of agriculture productivity and the impact of climate change on its supply, quantity, and distribution requires efficient water management. Currently, insufficient measured data represent a systemic limitation for obtaining an accurate estimation of actual and future water resource availability in Africa. Furthermore, the availability of water in SSA differs widely as a consequence of the great diversity of biophysical and socioeconomic conditions of each country.

Climate projections show that mean annual temperature and evaporation are likely to increase over the African continent, particularly in the most arid regions. A reduction in precipitation is likely to occur over Northern Africa and the Southwestern parts of South Africa, leading to a future decrease in water availability [5,6]. Extreme events, such as droughts and floods are expected to become more frequent, due to the increasing variability of climate [6,7]. Frequent droughts are likely to cause severe water shortages and intensification of stress on groundwater delivery infrastructures [8,9].

Therefore Indigenous knowledge in water management means "the management of all the water put into agriculture (crops, tree crops and livestock) in the continuum from rainfed systems to irrigated agriculture. It includes irrigation and drainage, rainwater harvesting, soil and water conservation, agronomy, interventions such as integrated watershed management, and all relevant aspects of management of water and land" [10,11].

Indigenous knowledge systems or indigenous technical knowledge systems have been defined in various ways by a number of researchers over the years. For instance, Warren and Cashman characterize IK systems as the sum of experience and knowledge for a given group that forms the basis for decision making with regard to familiar and unfamiliar problems and challenges. Similarly, Altieri characterize such knowledge as accumulated knowledge [12], skills and technology of the local people derived from the direct interaction of humans and the environment. IKS consist of integrated systems of production and consumption with the following key components: organized technical knowledge, social institutions, decision making, and management of diverse natural resources, technology, and skilled labour. Some IKS are responding creatively to challenges through local adaptation, experimentation, and innovation under diverse and heterogeneous conditions. Successful adaptations are preserved and passed on from generation to generation, through oral and/or experimental means. Thus, indigenous knowledge is dynamic [13,14].

Indigenous knowledge applied to environmental conservation has been described by the Canadian based Dene Cultural Institute as traditional environmental knowledge (TEK) and is defined as a body of knowledge and beliefs transmitted through oral tradition and first-hand observation [15]. It includes a system of classification, a set of empirical observations about the local environment, and a system of self-management that governs resource use.

For centuries, farmers in Africa, Nigeria inclusive and the study area in particular, have planned agricultural production and conserved natural resources with the instruments of indigenous knowledge (IK). The development of IK systems, including management of natural environment, has been a matter of survival to the people who generated these systems. When used in agriculture is capable of providing jobs for the teeming young population in the rural areas, reducing poverty, increasing incomes, encourage the establishments of rural cottage agro industries among others. Such systems are cumulative, representing generations of experience, careful observations and trial and error experiments [16]. IK is stored in people's memories and activities. It is expressed in stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local languages and taxonomy, agricultural practices, equipment, materials, plant species and animal breeds. Indigenous forms of communication are important to local level decision making processes and for the preservation and spread of IK [16]. This body of knowledge has developed over generations through the process of man environmental interaction and its continuity depends on its transmission and the ability of the young generation to acquire and practice it [17]. Indigenous knowledge systems in traditional Africa have been used by communities to protect natural resources from unsustainable exploitation thereby averting disasters that may have occurred from such exploitation.

Climate change will intensify the current water competition between communities (exacerbating internal social conflicts) and countries, in particular in regions that are expected to become drier and that are more dependent on foreign water resources. The capacity of groundwater delivery systems to meet increasing demands for water will acquire increasing importance in the context of prospective scenarios regarding climate change [9]. The main objective of this work is to analyze indigenous land and water management practices used to simultaneously enhance agricultural productivity, profitability and resilience to climate change. These practices comprise a key area of investment for climate-smart agriculture that simultaneously addresses food security and climate change challenge

Objective of the Study

The overall objective of this study was to examine rural women farmers use of Indigenous knowledge in land and water management practices for climate change adaptation in flood plain areas of Imo State, Nigeria.

Specific objectives were:

1. to identify the indigenous land management practices used by the women farmers in responding to climate change;
2. to examine the indigenous water management practices used by the women farmers in adapting to climate change;
3. to identify perceived benefits of use of indigenous knowledge in land and water management by respondents; and
4. to examine the perceived challenges women farmers face in use of indigenous land and water management practices.

Methodology

The study was carried out in flood plain Agricultural areas of Imo State, Nigeria. The flood plain zones were chosen because they are close in terms of distance to water bodies i.e. streams, rivers, and lakes. The areas are most vulnerable to flooding as a result of influences emanating from the water bodies or undulating land forms/topography. These areas have high land use intensity, with low relief areas and nearest to streams and down the slope environment which are prone to high flooding. The annual rainfall is between 1900mm and 2200mm while the mean annual temperature is between 200C with a relative humidity of about 75% annually. The areas are richly endowed with fertile land suitable for growth of arable crops. Areas that fit these descriptions are Ohaji/ Egbema, Oguta, Orlu, Ikeduru, Ahiazu-Mbaise, Onuimo, and Isiala-Mbano. Purposive sampling technique was used to select 7 LGAs which are areas with the most severe flood menace, and 360 women farmers from 14 most affected communities were selected (Table 1).

Local Govt.	Community	No. affected	No Sampled
Isiala Mbano	Anara	205	20
	Amaraku	231	23
Onuimo	Okwelle	245	24
	Obinulo	257	25
Ikeduru	Atta	243	24
	Akabo	277	27
Ahiazu Mbaise	Amuzi	215	21
	Ahiara	283	28
Orlu	Umuna	247	24
	Ogberuru	197	19
Oguta	Orsuobodo	303	30
	Eziorsu	345	34
Ohaji/Egbema	Mmahu	307	30
	Etekuru	319	31

Source: Authors field work, 2019

Table 1: Communities and locations affected by flood.

The primary data were collected from field investigation or survey using structured questionnaires. Secondary data sources were utilized to provide background information and other necessary to achieve some objectives of the study. Percentage was used to achieve objectives 1 and 2 (indigenous knowledge in land and water management). Mean was computed on a 4-point Likert type rating scale of strongly agree, agree, disagree and strongly disagree assigned weight of 4,3,2,1 to capture the perceived benefits of indigenous knowledge in land and water management practices and challenges faced by the respondents (objective 3 and 4). The values were added and divided by 4 to get the discriminating mean value of 2.5. Any mean value equal to or above 2.5 was regarded as a benefit of the management practices and challenges respectively.

Results

Indigenous Land Management Practices	Percentage
Mulching/crop residue application	88.8
Land Fallowing	65.3
Use of mounds/ridges	80.5
Zero-tillage	56.4
Agro-forestry/tree planting	76.4
Knowledge of soil types	58.3
Establishment of sacred bush	88.8
Soil fertilization	81.6
Crop rotation	97.2
Integrated soil fertility management	95.8
Mixed crop-livestock management	91.4
Conservation agriculture	97.2
Farmstead construction	82.7

The table above shows the indigenous land management practices of respondents

Table 2: Indigenous Land Management Practices.

Table 3 revealed the various water management practices of respondents

Water Management Practices	Percentage
Use/preparation of planting pit	68.3
Underground earthen jars/pots/tanks	58.3
Construction of water infiltration pits	83.3
Construction of wells & basin for water storage	94.4
Construction of soil/stone bunds	97.2
Use of large calabashes to store water	77.2
Terrace building	96.9
Drainage/ditches construction	98.6
Earth dams construction	86.1
Local water purification/protection	86.6
Planting mangrove trees	92.7
Regular hand dredging	80.5
Use of sand bags against erosion	96.6
Traditional taboos	72.2

Table 3: Indigenous Water Management Practices.

Benefits of Land/water Management Practices	Mean	SD
Enhance agricultural productivity/profitability	3.64	1.05
Reduced water stress	3.25	1.01
Reduced soil nutrient loss	2.71	1.07
Facilitates crop production	2.56	1.1
Increases cropping intensity	2.89	0.19
Reduces erosion menace in farm	2.92	1.06
Facilitates crop intensification/diversification	3.35	0.58
Reducing excess water use in farmland	2.55	1.03
Improves soil structure	2.65	0.06
Improves soil organic matter content	2.95	1.02
Increases soil moisture content	2.9	0.66
Improves water and air quality	2.86	0.87
Improves biodiversity	2.53	0.57

Mean 2.50 and above accepted

Table 4: Benefits of Indigenous Land/water Management Practices.

Challenges	Mean	SD
High transaction costs	3.04	0.98
Limited access to productive assets	3.25	1.01
Limited access to rural services	2.81	1.02
Limited access to extension services	2.76	1.05
Lack of access to credits and farm inputs	2.59	0.89
Land tenure systems	3.92	1.06
Insecure rights to land	3.35	0.98
Lack of adequate education/training	3.55	1.03
Low level of income	3.67	0.75
Lack of information on improved technologies	3.05	1.06

Mean 2.50 and above accepted

Table 5: Challenges of Use of Indigenous Land/water Management Practices.

Discussion

Land Management Practices for Climate Change Adaptation

The women farmers adapt to climate change by employing a number of indigenous land management measures/practices as shown in table 2. These practices are discussed below:

Mulching/crop residue application with a percentage score of 88.8: Harvested residue in the form of maize stalks, dried bean and nut plants are a good soil stabiliser. The women reported that after harvest, the residue is tilled with the soil to improve moisture retention and fertility of the soil. This indigenous practice, according to Buthelezi et al replenishes depleted soil nutrients [18]. Again, farmers heap soil and trash around the plant while weeding to make bands to reduce soil erosion. Farmers also add crop residues like kitchen waste/refuse and manure from goats, chicken, and cattle to their fields and fallow plots to enhance nutrient status. Farmers mostly use elephant grass and maize stalks to conserve soil moisture and add manure after decomposition when mulching.

Land Fallowing (65.3%): In many instances exhausted fields are left fallow for two to five years. The participants agreed that this practice helps the soil regain fertility. During fallowing, cattle, sheep and goats are driven in the fields to browse course grass and that their droppings should add to soil fertility. Fallowing enables farmers capture the essence of natural processes of soil regeneration typical of ecological succession [19]. The use of "green manures, intensifies the old fallowing technique in areas where long fallow periods are not possible anymore. It is widely recognized that forests play an important role in the global carbon cycle by sequestering and storing C [20,21]. Local farmers are known to have practiced the fallow system of cultivation, which encouraged the development of forests. It may be argued that with the growth in population, lengths of fallow have been reduced to the extent that the practice no longer exists in certain areas. However, forests have been recognized by traditional institutions to the extent that communal forest reserves were very common in traditional societies. Besides the fact that these well managed forests provided food and timber resources to the community, they also served as C sinks.

Zero-tillage (56.4%): Local farmers in the area have been known to conserve C in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques [22,23]. Natural mulches moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture. Before the advent of chemical fertilizers, local farmers largely depended on organic farming, which also is capable of reducing GHG emissions.

Agro-forestry/ tree planting (76.4%), and establishment of sacred bush (88.8%): Agroforestry is another practice that has been very effective in carbon sequestration. Agroforestry is a rational land-use planning system that tries to find some balance in the raising of food crops and forests [24,25]. A practice similar to this has been described in a part of south western part of Nigeria to raise shade tolerant crops such as Dioscorea spp and cocoyam in essentially a permanent forest setting [26], In addition to the fact that agro-forestry techniques can be perfected to cope with the new conditions that are anticipated under a drier condition and a higher population density, they lead to an increase in the amount of organic matter in the soil thereby improving agricultural productivity and reducing the pressure exerted on forests.

K**nowledge of soil types by colour (58.3%):** Knowledge of soil types using colour and texture, and the types of crops that do well on particular soil types, was. According to the respondents, black clayey soil is rich in nutrients and good for cultivation of maize, pumpkin, and gourds. Sandy soil is good for beans, melons, and sweet-reed. Another type of soil is a mixture of sandy and clayey soil which is good for all crops. Farmers expressed reasonable knowledge on soil fertility indicators. This is mainly determined by soil characteristics, types of weeds growing in an area and crop characteristics such as yields, vigor and the general appearance of the plants. Soil types, degrees of soil fertility, and land use categories were also desegregated by farmers. Color, texture and even taste usually distinguish soil types while some classified their soils based on vegetative cover.

Soil Fertilization with response of 81.6%. The respondents agreed that they apply poultry manure to make the soil regain fertility, retain moisture, and avoid pests. This type of soil fertilization mainly improves soil moisture conservation [27]. Again, farmers know that if weeds are left to grow, they cover the soil, prevent it from heating up or drying out excessively, induce a positive competition, which simulates crop growth and reduces erosion during rainfall [28]. Bush fallowing involves the use of natural fallows to regenerate or restore soil fertility by the farmers. In some areas, leguminous plants are used for quick restoration of soil fertility. Example, *Centrosema* spp is used to fix nitrogen into the soil in order to improve its fertility. The application of compost, animal waste and domestic wastes to soil helps to maintain soil microbial activities and promote absorption of nutrients by plants. Farmers use this practice to improve soil fertility. This system has the advantage of conserving the soil because of minimal disturbance [29].

Farmstead construction (82.7%): Indigenous peoples around the world may suffer most from climate change due to a combination of their high dependence on ecosystems, occupation of marginal lands, social pressure and lack of political representation. 'Because of their long dependence on nature they have developed strategies to cope with climate change and extreme natural events which still have as much relevance today as they did hundreds of years ago [30]. Other measures include integrated soil fertility management (95.8%), mixed crop-livestock management (91.4%) and conservation agricultural practices (97.2%). All of these also contribute to improving landscape hydrology, resilience in agro-ecosystems, and livelihoods, and be a response to climate risks.

Indigenous Water Management Practices

Table 3 showed the traditional water management practices used by the respondents - planting pits (68.3%), underground earthen jars (58.3%), construction of infiltration pits (83.3%), construction of wells/basins for water storage (94.4%), construction of soil/stone bunds (97.2%), use large calabashes to store water (77.2%) and traditional taboos for water protection (72.2%). Again, a wide variety of traditional and innovative rainwater harvesting systems is found in sub-Saharan Africa. The technology improves infiltration and increases nutrient availability on sandy and loamy soils, leading to significant increases in yields, improved soil cover and reduced downstream flooding [31]. Some farmers dig infiltration pits along contours. Water collects in the pits during the rainy period, the crops will reach maturity using conserved and harvested water in the pits [32]. Farmers practicing dry season agriculture harvest rain water and conserve it in basins or wells. In the dry season, the water conserved in the wells and basins is used for irrigation.

Further practices includes terrace building (96.9%), drainage/ditches construction (98.6%), earth dams construction (86.1%), local water protection and purification (86.6%), planting mangrove trees (92.7%), use of sand bags against erosion (96.6%). In the Niger Delta region of Nigeria, water management takes another dimension due to swampy and flooded conditions. Some of the indigenous coping mechanisms for managing soil and water are regular dredging of the drainage system, placing several loads of oyster shells (obtained from the sea), on the land, planting and erection of mangrove trees and planks with a view to enhancing the firmness of the soil [33].

Under this system, in Nigeria, a stream or river is ponded using earthen bunds and sometimes by adding of stones. The water so collected becomes a reservoir, for inundation, for farming purposes. There is usually provision of cluices in the bunds allowing ponded water to be released to the farm plots. Usually, arable crops particularly vegetables and cereals thrive well under this farming system.

Benefits of Use of Land/ water management Techniques

Table 4 revealed the numerous benefits of the use of indigenous knowledge in land and water management in Imo State. The perceived benefits are indicated by the high mean response of 2,5 and above. The following benefits were observed – enhanced agricultural productivity and profitability with a mean (M)response of 3.64, reduced crop water stress (M= 3.25) which is done by water run- off, educed soil nutrient loss (M= 2.71), facilitates crop production (M= 2.56),increases cropping intensity (M=2.89), reduces erosion menace in farm (M=2.92), facilitates crop intensification/ diversification (M=3.35),reducing excess water use in farmland (M=2.55), improves soil structure (M=2.65), improves soil organic matter content (M=2.95), increases soil moisture content(M=2.90), improves water and air quality (M=2.86), improves biodiversity(M= 2.53). While these are good and laudable, increasing food production requires many other things such as change in cultural attitudes, land tenure reforms, use of improved technology and practices in farming, inputs and credit opportunities. These are really endless.

The above agrees with who posited that land management practices typically help to regulate climate change by increasing soil carbon over time [34]. Soil carbon also improves moisture retention capacity and other physical soil characteristics important for adaptation to climate change. Integrated Soil Fertility Management involves combining judicious quantities of chemical fertilizers with organic inputs and improved germplasm) and is especially important because it significantly increases soil carbon [34]. Land management practices that combine crop residues with the use of fertilizer and with manure produce the highest returns, compared to using either of the practices alone. If farmers were making rational economic decisions with full information, one would expect that land management practices with high returns would have corresponding high adoption rates.

Challenges of Use of Indigenous Land/water Management Practices by respondents

While the use of indigenous knowledge in land and water management may be highly beneficial, table 5 showed the challenges associated with it. These include high transaction costs with mean response of (M=3.03), limited access to productive assets(M=3.25), limited access to rural services (M=2.81), limited access to extension services (M=2.76), lack of access to credits and farm inputs(M=2.59), land tenure systems(M=3.92), insecure rights to land(M=3.35), lack of adequate education/training(M=3.55),low level of income (M=3.67), lack of information on improved technologies.

According to Twomlow, et al. Braimoh, Barrett a number of biophysical and socioeconomic constraints limit adoption of Integrated Soil Fertility Management and water management practices [35,36]. These include high transaction costs, limited access to improved technologies, and lack of productive assets are the major constraints that limit farmer participation in agricultural input and output markets. Hence, promoting group marketing and improving access to markets through road construction could facilitate farmers' adoption of land management practices that produce high returns, but require the purchase of external inputs – namely inorganic fertilizer and improved seeds. However, access to extension services reduces the probability of adopting the practice of applying manure in Nigeria, using crop rotations in Uganda, and using alley cropping, mulching and soil conservation in Niger. These results suggest that extension services are generally weak in providing advisory support on organic soil fertility management practices.

Conclusion

The women farmers used the following land management practices - mulching/crop residue application, land fallowing, use of mounds/ridges, zero-tillage, agro-forestry/ tree planting, soil fertilization and crop rotation. To manage water, they use/prepare planting pit, underground earthen jars/pots/tanks, construction of wells & basin for water storage, construction of soil/stone bunds, and use of large calabashes to store water, and terrace building. The benefits of indigenous land and water management practices includes - reduced water stress, reduced soil nutrient loss, facilitates crop production, increases cropping intensity, while the challenges includes high transaction costs, limited access to productive assets and limited access to extension services. Access to land should be improved by the governments through land rights legislation, improve extension services delivery by provision of adequate transportation facilities and proper renumeration, and lastly education of farmers.

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