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Climate change impact and adaptation pathways for forest dependent livelihood systems in Nigeria

Anthony N. Onyekuru and Rob Marchant

York Institute for Tropical Ecosystems (KITE), Environment Department, University of York, UK.

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Climate change is projected to adversely impact rural livelihoods; especially forest communities dependent on climate sensitive natural resources. Communities within five ecological regions (Mangrove, Rainforest, Guinea savanna, Sudan savanna and Montane forest) in Nigeria were assessed using structured questionnaires to gauge the impact of climate change and adaption responses. Households in the Mangrove, Rainforest, Montane forest, Guinea savanna and Sudan savanna derive 47, 34, 31, 19 and 14% of their livelihood from the forest respectively. More than 75% of households surveyed have experienced impacts of climate change on forest resources, except in the Montane forest zone where only 33% were impacted. In the mangrove and rainforest regions impacts were mostly manifest as excessive rainfall, in the montane forest, Sudan and Guinea savanna, impacts were due to reduced rainfall. Adaptation options in the mangrove and rainforest regions were mainly used for forest conservation and to reduce the impact of excessive rains, while in the montane forest, Guinea and Sudan savannas most strategies are aimed to reduce the impact of aridity such as irrigation, mulching, planting deep and the use of shades. Such community based information can provide a foundation to build an organized, systematic and mitigated approach needed for community-centered adaptive mechanism for sustainable forest resource management. Significantly, this can be used to ensure a steady flow of livelihood support services from a range of ecological regions in Nigeria and across the wider West African sub region.

Keywords: Ecosystem, forest management, forest resources, poverty, sustainability

INTRODUCTION

One of the greatest challenges to livelihoods in the 21st century, particularly in developing countries, is the threat from climate change (UNDP, 2010) that could potentially reverse decades of development gains, such as those focused on achieving the Millennium Development Goals. Africa will bear the major import of climate change due to high population growth, reliance on rain fed agriculture, rapid development trajectories, and high levels of poverty and low level of infrastructure.

Since the last ice age, the climate of the earth has been relatively stable, but in recent years average temperature has been increasing. This is associated with climate change. Climate change is a large-scale, long-term shift in the planet's weather patterns or average temperatures (Met Office, 2014). As a result, annual average temperatures are projected to increase between 1.8 and 4.8°C and annual precipitation will change by between –12 and +25% (seasonal changes range from –43 to +38%)

*Corresponding author. E-mail: nao501@york.ac.uk, chiakatony@yahoo.com

in Sub-Saharan Africa by 2100 (Muller, 2009). Such a climate shift will impact on ecosystem composition (like the forest) and distribution with ensuing resource scarcity (UNFCCC, 2007), leading to ramified socioeconomic effects on those who depend on such resources for their livelihoods.

Forest dependent people are defined by DFID (2000) as those that use forest as a source of water, fuel wood, shelter and a broad suite of non-timber forest products (medicinal plants, culinary herbs, fodder, rattans, gums, resins, latex and oils). Virtually everybody in the West African region is forest dependent at different scales directly or indirectly on a daily basis. Such common pool resources can contribute substantially to livelihoods, particularly of the rural poor (Jodha, 1995; Cavendish, 1999; Kerapeletswe and Lovett, 2001). Resources derived from forested areas are key components of the natural resource base and fundamental to the socio-economic well-being of any community, region or country (Bann, 1997; Inonio, 2009). This is particularly so in sub-Saharan Africa where most countries have large rural populations that depend directly or indirectly on natural resources and agricultural activities for their livelihoods (Ezeani, 1995). With sustainable management, forests have the capacity to provide a perpetual stream of income and subsistence products, while supporting other economic activities through broader regulatory ecological services and functions (Neumann and Hirsch, 2000; Verweij et al., 2009; Watson and Albon, 2011).

The contribution of forests to sustainable livelihoods cannot be over-emphasized; it is estimated that about 500 million people across the world depend on forest resources for their livelihoods (Roper and Roberts, 1999). Forests provide households with income, fuel wood, food security, reduces vulnerability to shocks and adversities and generally increasing wellbeing (Arnold, 1998; Warner, 2000; Fisher and Shively, 2005; Eva and Fred, 2013). More broadly, forestsare vital for ecosystem and regulatory services, such as water and carbon management (Watson and Albon, 2011). Forest products add important variety, vitamins and increase palatability to main food staples (FAO, 2005). Food products such as roots, tubers, rhizomes and nuts are widely used between meals; eaten while working in fields or herding. In addition to these supplementary roles, forest foods are extensively used to meet dietary shortfalls bridging “hunger periods”, when stored food supplies are dwindling and the next harvest is not available (FAO, 2005). Hence, forest products smooth seasonal peaks and troughs in farm production; a role that is particularly important in periods of floods, droughts, famines and wars.

In Nigeria, for example, over 90% of the rural population depends on agro foresting for livelihoods (Federal Government of Nigeria, 1997; UN, 2002; IMF, 2005; FAO, 2008), deriving over 10% of the Gross Domestic Product from the forest sector (FAO, 2003), thus, underscoring the importance of the forest sector to the socio economic lives of the Nigerians. Against this backdrop, DFID (2009) asserts that climate change could result in between 2 to 11% GDP loss globally by 2020 and from 6% to 30% by 2050; costing an estimated US$ 100 to 460 billion. Given the importance of forest resources, it is paradoxical, that in spite of their current and potential value, how individual respond to climate change is relatively under-researched (Aiyeloja and Ajewole, 2006).

This paper aims at quantifying forest dependence and assessing the impact of climate change on forest resources and captures the ensuing adaptation options adopted by the households to cope with the impacts of climate change in managing their forests resources. Although the study is in Nigeria, results are applicable to the wider West African region due to comparable vegetation and communities.

MATERIALS AND METHODS

Data were collected from 450 rural households, sampled from five broad ecological regions in Nigeria, Figure 1, using a structured questionnaire (Appendix 1), interviews were focused on assessing the socio economic attributes of respondents, types of forest, forest governance, access to forest, forest management, forest resource use, level of dependence on forest resources, forms of climate change impacts (Appendix 2) and adaptation strategies adopted by the households (Appendix 3).

Based on the relative size of the population which they support, and the prevalence of forest cover, 150, 100, 100, 50 and 50 households were sampled from the rainforest, mangrove forest, Guinea savanna, montane forest and Sudan savanna zones respectively. For the rainforest zone the Cross River high forest was chosen as this is the only area of surviving lowland rainforest cover, not just in Nigeria, but across West Africa. Communities were selected from the respective states and research assistants in each of the area who understood the local languages were used for the study. Communities were selected based on information from local informants on their reliance on forest resources. Five communities were selected from each of the rainforest and mangrove forest areas, four from Guinea savanna (Appendix 4), three from montane and two communities were chosen from Sudan savanna ecozone.

Communities were chosen using a random draw from all possible communities in the target areas. In each community households were randomly selected using the communities’ roll calls. From the roll call, different households were selected at random intervals until the required number of households per community was reached (this was directly proportional to the total population of the different communities). Structured questionnaires were administered on a one to one basis, with the household heads, or other family members who were familiar with forest resource use by the household and the wider community. To check for interviewer bias and ensure data consistency and compatibility, the addresses and mobile phone numbers of each respondent were collected and information supplied by the interviewer randomly crosschecked in all zones. The data collected were coded and screened for consistency and analyzed using STATA statistical software.

RESULTS

Results are presented in three sections: the first section

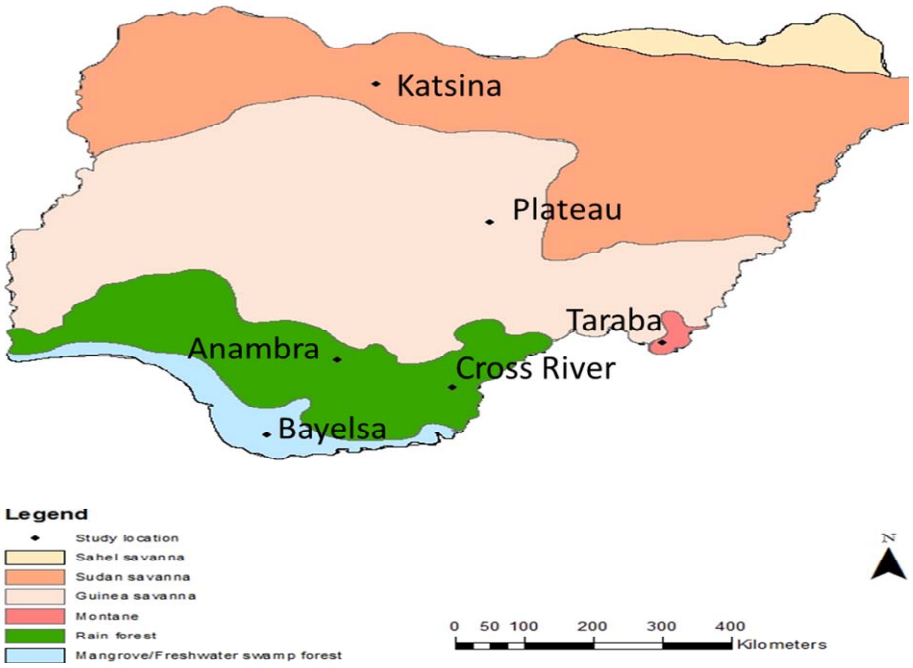

Figure 1. Map of Nigeria; showing areas where the study was carried out.

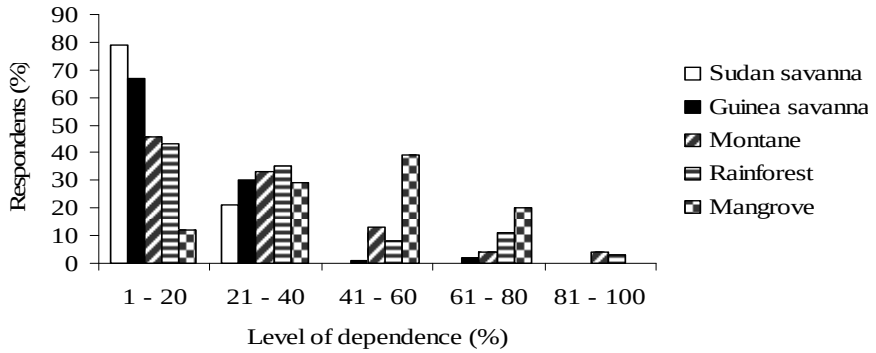

Figure 2. Level of forest dependence across ecological regions.

presents an overview of how forest resources contributes to household livelihoods; the second section assesses how communities perceive climate change impact in their use of forest resources; the third section focuses on the different adaptation options adopted by the households in the face of such climate change impacts across Nigeria.

Forest contributions to livelihood system

Forest resources are important to the livelihoods of the households across Nigeria, Figure 2. Forest resources in the mangrove ecosystem contribute an average of 47% to household income with a range of 10-80%; households depend on both aquatic and terrestrial flora and fauna for food and income. Rainforest communities derive an average of 34% of their livelihoods from the forest with a range of 10-95%. Montane forest contributes an average of 31% to livelihoods with a range of 5-95%. Guinea savanna contributes about 19% with a range of 5-80% (although with a big skew to low dependence), while the Sudan savanna contributes the least, 14%, with a range of 5-30%. On average, forest resources supply about 39% to the livelihoods of rural populations in Nigeria.

Changes in forest resource use and their drivers

Most respondents across ecological zones have experienced changes in their use of the forest resource,

Table 1. Percentage number of respondents experiencing changes in forest resource use due to climate change in the different ecological zones of Nigeria.

Ecological Zone	Change in forest resource (%)
	Yes
Mangrove forest	75
Rainforest	84
Guinea savanna	82
Sudan savanna	94
Montane	33

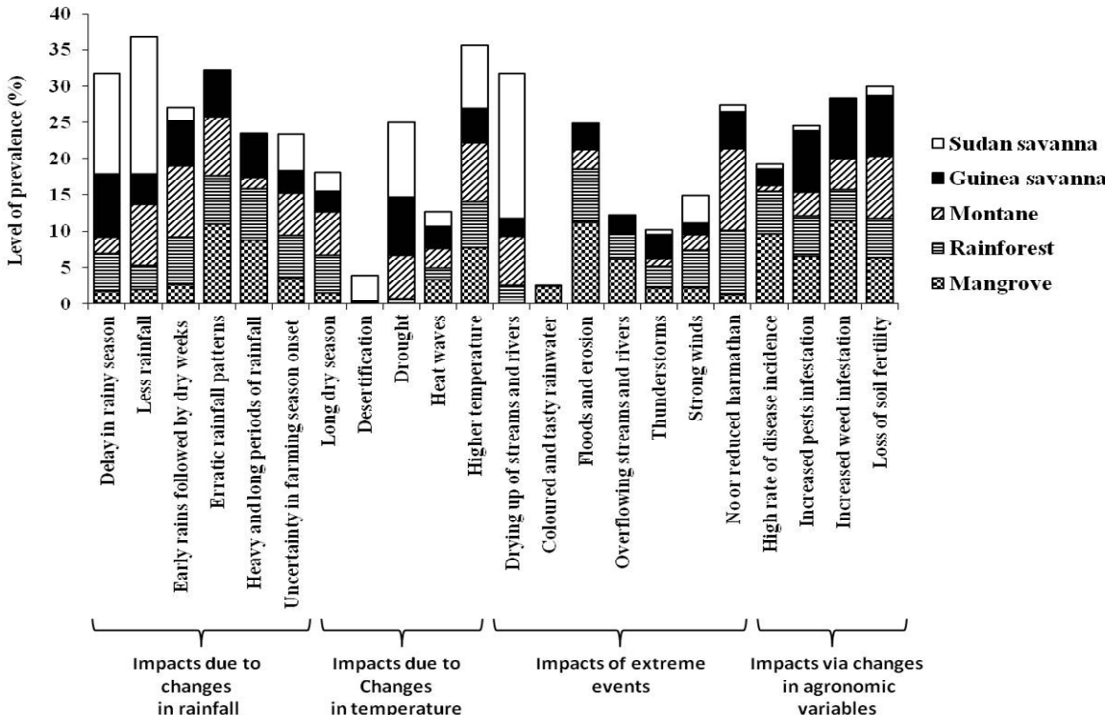

Figure 3. Climate change impacts in the different ecological regions.

Table 1. Perceptions of climate change, and how these impact through forest resource availability and use in the different ecological zones, were determined, Figure 3, and the general consensus was that climate change is predominantly responsible for the changes, Figure 4. In the mangrove ecosystem, some of the key impacts are increased weed infestation, floods and erosion and increasingly erratic rainfall patterns. In the rainforest ecosystem, the most serious impacts are floods and erosion, heavy and long periods of rainfall, high temperature, uncertainties in the onset of farming season, increased disease incidence and weed infestation.

In the Montane ecosystem, impacts are characterized by delayed onset of rain, reduced harmattan, less rainfall, higher temperature and erratic seasons. In the Guinea savanna ecosystem, the major climate change impacts are a delay in the onset of rainfall, increase in pests and weed infestation, drought, erratic rainfall and higher temperatures. In the Sudan savanna, the most important impacts of climate change are reduced rainfall, drying up of streams/river, delayed onset of rainfall, uncertainty in the onset of farming season and increased incidence of wind, Figure 3.

There was a consensus among households that climate change was responsible for the changes in forest resource use across all the ecological zones, Figure 4. Other drivers of changes in forest resource use result from increased population, development, over-exploitation, shifting cultivation and increased use of

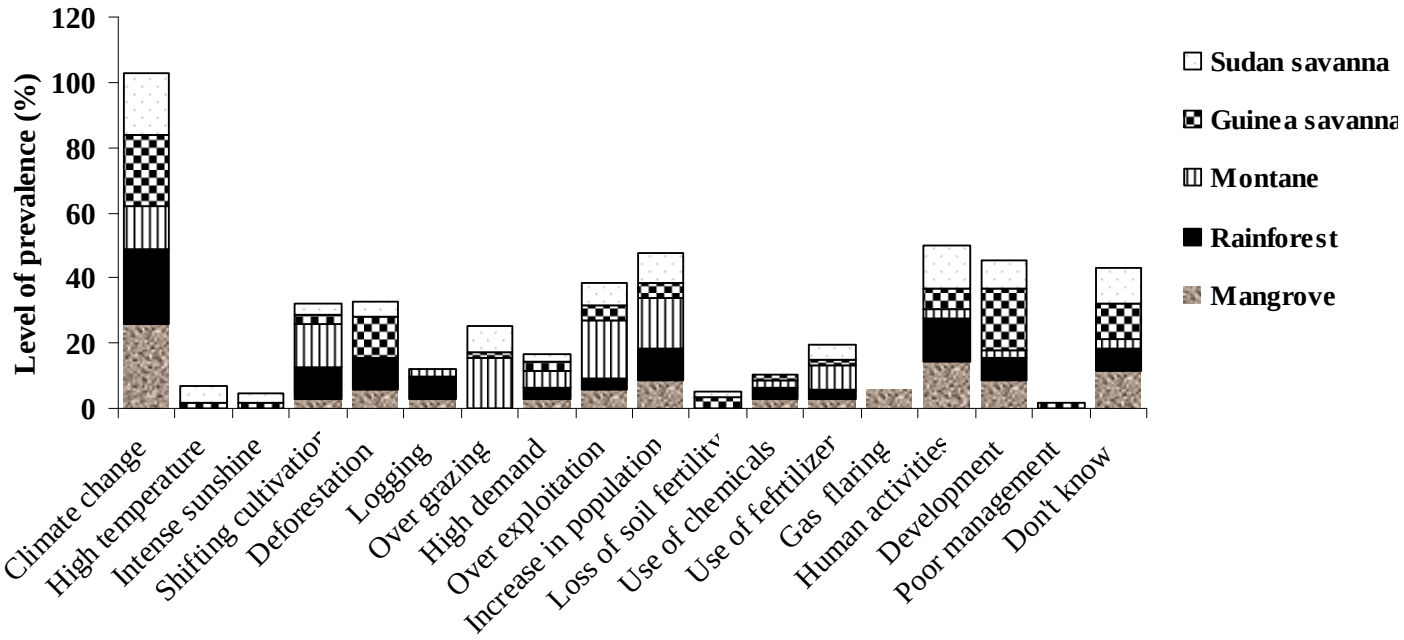

Figure 4. Causes of changes in forest resource use.

fertilizer. Gas flaring was identified as a major driver of change in the mangrove region. Overgrazing was a prominent impact in the montane and savanna areas, in the latter area loss of soil fertility was identified as influencing changes in forest resource availability and use. Logging was a predominant concern in the mangrove, rainforest and montane forest areas.

Adaptation options used by the households to mitigate climate change impacts

Households were asked about any adaptation options over and above their usual agronomic practices, being used specifically to mitigate climate change impacts. The most common response across all the ecological zones is agroforestry, being practiced by 20, 33, 36 and 27% of households in the mangrove, rainforest, montane and Guinea savanna zones respectively, Figure 5. Other options include increased weeding, mulching, plant replacement, and building of shades for plants (especially for young trees). Irrigation is the predominant response in the Sudan savanna. Water shade management is prevalent in the mangrove, rainforest and montane forests. Changing the timing of farming activities, such as increasing the fallow period and avoiding burning, is widely practiced except in the mangrove ecosystem. The use of energy saving cooking stoves and use of local drip irrigation are increasingly used in both the rainforest and the montane forest areas. Increased spraying and selective tree cutting are used in the Rainforest, Montane and the Guinea savanna, while an increasing use of wetland areas is predominant in the Mangrove ecosystem.

DISCUSSION

The discussion will be focused around three key issues: the dependence of communities on forest resources to support livelihoods, how climate change impacts on this and what forest resource management strategies are being implemented to adapt to climate change. How insight from these two areas can be used to develop more effective forest management strategies for Nigerian communities, and the wider West African region, is discussed.

Level of forest dependence in West Africa

Indeed, the results clearly show a high level of dependence on forest resources by rural households, particularly in the mangrove and rainforest ecosystems, gradually declining towards the Sudan savanna. These results corroborate the study by Inonio (2009) that found income from forest resources account for 67% of the total income of the lower income group and some 41% of the highest income group in rural households in Delta State, Nigeria. The average annual value of harvested wild plant products from the Nigerian forests per household was 1,614,133 Naira (US$11,956); the annual net income generated from the harvest of wild plant products per

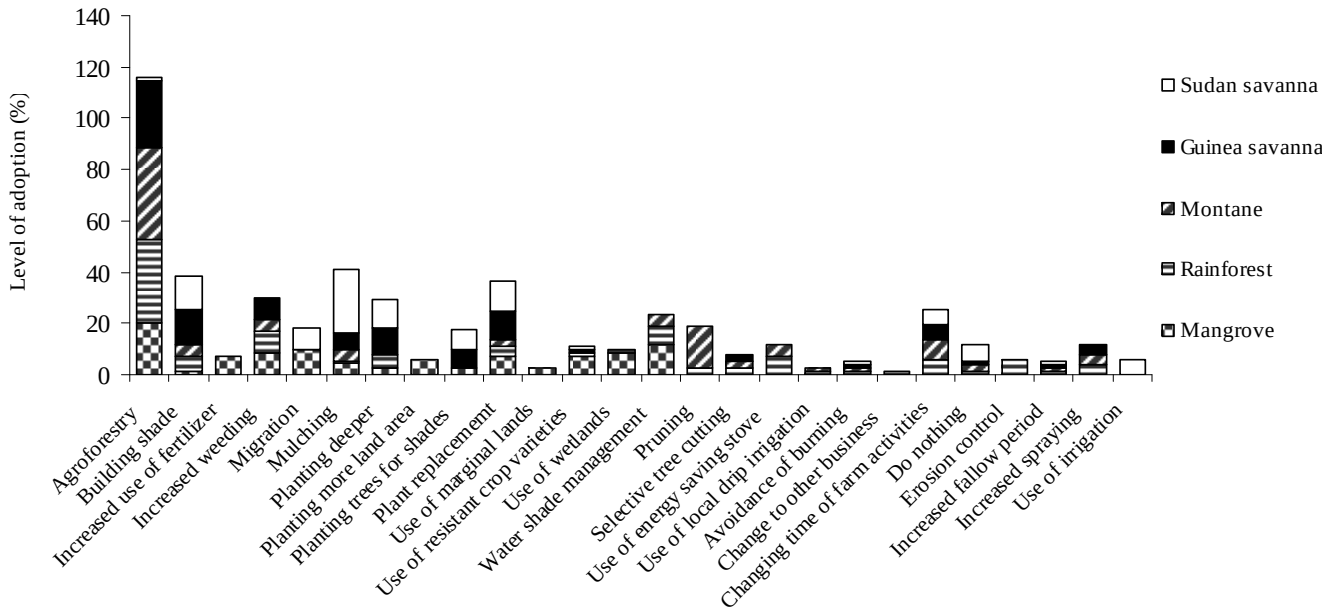

Figure 5. Adaptive forest resource management practices in response to climate change.

household was 910,252 Naira (US$6,742) (Osemeobo, 2005).

Furthermore, the findings also resonate with those of other scholars who identified non-timber forest products (NTFPs) to account for an enormous share of household income (Liedholm and Mead, 1993). Also in southeastern Nigeria alone, 36% of the rural population collected NTFPs daily, accounting for 94% of total income in 1996 (Nweze and Igbokwe, 2000). Wild plant products support a number of occupations in Nigeria; the most profitable being vegetable oil, chewing stick, soap, wine, fuel wood and charcoal production (Osemeobo, 2005). Apart from the provision of food and income, NTFPs are also used for traditional medicines, divination, religious ceremonies and the production of musical instruments (Osemeobo, 1993). There has been a recent and noticeable shift in many African countries and indeed worldwide, from orthodox 'western' medicine to greater use of traditional (herbal) medicines (Akunyili, 2003). Over 90% of Nigerians in rural areas, and 40% in urban areas, depend partly or wholly on traditional medicine (Osemeobo and Ujor, 1999; Bisong and Ajake, 2001). It is therefore not understandable that in spite of their real and potential value, most NTFPs remain grouped as minor forest products; these products rarely feature in statistics of forest use (Aiyeloja and Ajewole, 2006).

Aside from the direct contribution to food and economic wellbeing, there are so much intangible benefits that are closely tied to the social livelihood of the rural people. Rural communities, and to a great extent forest dwellers, have a cultural and religious bond to the forest. Knudston and Suzuki (1992) have explored the protective function of culture within a comparative perspective. Indigenous belief systems have a major protective role in a culture's relationship with the natural world, and in nature's relationship with a culture. Traditional community activities include ceremonies and festivals which utilize NTFP like skins of antelopes, crocodiles, monitor lizards and photon for drums and other musical instruments, kola (*Cola accuminata, C. nitida* and *Garcinia cola)* for sacrifice and prayers, palm wine for traditional ceremonies, festivals and entertainment.

Although our questions focused on the specifics of forest use, the broader ecosystem services and functions provided by forests cover a wide range of ecological, economic, social and cultural considerations and processes (Lindberg et al., 1997). Forests also provide scenic and landscape services and values, this more general set of services highlights ideas of aesthetics as components of forests. Trees play a fundamental role in biogeochemical cycles, improve soil fertility, control erosions, provide shelter belts, fix dune, rehabilitate eroded terrain and provided a 'land bank' that can underpin sustainable livelihoods (Oriola, 2009; Pataki et al., 2011).

Climate change impact on livelihoods

Against the backdrop of forest product dependence, people are highly vulnerable to the impacts of climate change. This is because it acts on the very essence of their sources of livelihoods, upon which they depend on daily basis for their sustenance. In this regard, there was a consensus across all regions that changes in forest resource availability and use was in part, resulting from

climate change, Figure 4. Directly, the impact is influencing the biophysical environment, especially water availability and temperature regimes that are interacting to reduce agricultural production and forest resource availability. The impact can be quite extreme and as it was the case in the adaptation practices in the mangrove and Sudan savanna areas ultimately lead to the migration of people from areas of impact, such as associated with desertification and sea level rise, to areas of more marginal forest cover, leading to excessive exploitation and potential conflict. Such an impact is exacerbated by the interaction of other social factors such as development, population growth, agriculture deforestation and urbanization, which can act in concert with climate change to impact on forest resources. Although the nature and intensity of climate change impact vary from place to place, there is no doubt that its effect on peoples' lives and welfare is enormous, and will only increase under current predictions of climate change, especially in Sub-Saharan Africa (Tedesse, 2010).

The impacts of climate change, shown in Table 1, Figure 3 and Appendix 2, vary spatially; in montane areas the impact is relatively low compared to other areas. This result may be attributable to the resilience of the montane ecosystem as a cooler habitat; this has also been identified by NASPA-CCN (2011) in Jos, Plateau State, Nigeria. The relative resilience of the tropical montane forests to climate change and drought has also been documented by Nadkarni and Solano (2002) and Ching et al. (2011). The general impact trend is one of higher rainfall in the south to less rainfall and greater aridity towards the northern region of Nigeria, Figure 4. This result is in line with physical assessments that project an increase in rainfall during the rainy season in the south of Nigeria and a decrease in rainfall amount towards the Sahel savanna though the 21st century (AIACC, 2006; IPCC, 2007; Tompkins and Feudale, 2010).

However, there remains high uncertainty about regional predictions in rainfall in West Africa (Willey, 2008; Buontempo, 2010). Existing rainfall forecast and general circulation models have some fundamental weaknesses when applied to West Africa and have difficulty simulating the annual cycle of rainfall (Redelsperger et al., 2006). A comparison of the Sahelian climate observed (1961-1990) with climates simulated by six general circulation models show a marked rainy season almost throughout the year along with a considerable bias (140-215 mmyear^{-1}) in annual aggregate rainfall estimates as compared to the observed data (ECOWAS-SWAC/OECD, 2008). In some of the models, the start of the rainy season appears one to two months prior to the observed trends (Kamga and Buscarlet, 2006). Such discrepancy in different models on the impact of changing climate regimes further highlights the importance of capturing information on climate and ecosystem variability from other sources such as historical and earth observation data (Pfeifer et al., 2012) or capturing societal perspectives and community memory as presented here. Although it may not be perfect, peoples memory and perception are vital in understanding climatic anomalies, especially where their perceptions are in agreement with measured trends consistent across space, which was the case in this study. More importantly, the information comes from rural based stakeholders who are closely connected to these resources and climate trends which impact on their livelihood on daily basis. Their views can therefore act as an arbiter where such disagreements exist between observed and simulated trends, since they are the ones with actual experiences.

Adaptive forest resource management strategies in the face of climate change

Among the adaptation options identified in this study, agroforestry stood out as the adaptation option of choice for most of the farmers. In addition to providing shade, trees produce fruits and generate additional income. Agwu et al. (2011) also found out that 23% of the rural dwellers in Nigeria use agroforestry as an adaptation option to climate change. Kowero (2011) assert that local communities are using autonomous traditional knowledge and practices in their attempts to cope with current climate viability and change, as they have done throughout time. According to Larwanou et al. (2011), a number of studies have shown that African communities, particularly at the local level, have intimate understanding of surrounding forests and have historically developed coping strategies to adverse climatic conditions, such as using agroforestry systems, and are currently making efforts to adjust to environmental changes being experienced.

In addition, Roberts (2009) suggests that the revival, further development and application of such indigenous knowledge and associated social institutions and governance structures represent an important element in the adaptation responses of forest-dependent people to climate change. Capturing and maximizing the potential of the traditional approaches and knowledge, combined with insights from forest science, will be critical for the development of effective strategies for coping with anticipated changes in forest productivity, in essence, achieving a situation where the use and management of forests are both adapted to anticipated climatic conditions and valued by local communities (Sampson et al., 2000; Parrotta, 2002; Kowero, 2011). The use of agroforestry as an adaptation option to climate change will no doubt continue to expand in all the zones, not just for the fact that it meets the livelihood needs of the farmers, but it is also a source of security to the farmers in times of crop failure, as it serves as an alternative source of income, firewood, stakes and possibly fruits. Enete et al. (2011) identified agroforestry as ranking second (after multiple/intercropping) in profitability of adaptation options and promotes shading and shelter, reduces further

depletion of forests, increase food production and at the same time responds to process of rebuilding soil fertility (Okali, 2011). Beyond the local gains of using agroforestry, this practice is recognized by many as a trailblazer in the quest for climate change mitigation for its 'win-win' advantage, combining local use (timber, fruit, shade, medicine, etc) with global issues of carbon sequestration (FAO, 2005; Kleine et al., 2010; Kowero, 2011; Opere et al., 2011; Larwanou, 2011; Larwanou, et al., 2011; Spence, 2005, Ranasinghe, 2004; UNFCCC 2008; Agobia, 1999). Agroforestry has a particular role to play in mitigation of atmospheric accumulation of greenhouse gases, due to potential for carbon sequestration, improve soil nutrient, nutrient uptake, water percolation, aeration, water recharge and general soil water balance, thus should be encouraged (Louise et al., 2007; Prabhakar and Shaw, 2007; IPCC, 2000).

A special form of agroforestry identified in this study is watershed management, used to moderate water flow and protect streams from drying up. Farmers avoid cutting the forest and leave strips of about ten meters between their farms and the streams. A number of communities also practice similar watershed management practices in other countries (Kerr et al., 2002; Farrington and Lobo, 1997; Turton and Bottrall, 1997; White and Runge, 1995; Ravnborg and Guerrero, 1999). Findings also show that drought-induced impacts in India have reduced the average crop income (as a percentage of total household income) in non-watershed managed farms from 44 to 12%, this share remained unchanged at about 36% in the adjoining watershed managed farms (Shiferaw et al., 2005). Another form of watershed management is selective tree cutting which provides alternative shade for arable crops in Nigeria. In addition Nyong et al. (2007) reports that local farmers' increase the fallow period of cultivation, which encourages the development of forests and diminish moisture and nutrient deficiencies (Mertz, 2009; Skinner, 2002; Swearingen and Bencherifa, 2000) as a measure to address climate change-related impacts.

Mulching was also identified to be on the increase in all the zones. Mulching protects sown seeds by moderating soil temperatures, suppressing diseases and harmful pests, and conserving soil moisture (Nyong et al., 2007; Salinger, 2005; Ishaya and Abaje, 2008). Agwu et al. (2011) also found out that 74% of Nigerian farmers use mulching as an adaptation to climate change. Schafer (1989) and Osunade (1994) also report the use of mulching in the Sahel to conserve carbon in soils and this is becoming increasingly common with the rise of organic farming and potential for reducing Greenhouse Gas Emissions (Nyong et al., 2007).

Furthermore, increased time spent on weeding across the ecological zones, due to increased rainfall during the rainy season is common, particularly in the rainforest. Farms are weeded two or more times than usual; this resonates with the findings of Apata et al. (2009), Agwu et al. (2011); Enete et al. (2011) and Ozor et al. (2012) who found out that 64% of Nigerian farmers experience increased weeding as an impact of climate change. Due to uncertainties in farming season, particularly increasingly erratic rainfall patterns, households change their time of farming activities to start planting whenever they are sure that the rains have stabilized. Agwu et al. (2011) found out that 38% of farmers in West Africa change their planting dates in response to changes in rainfall pattern due to climate change. Swearingen and Bencherifa (2000), Smit and Skinner (2002), Salinger (2005), Howden et al. (2007), Ishaya and Abaje (2008), Deressa et al. (2009), Apata et al. (2009) and Enete et al. (2011) also identified the change in the timing of farm operations in different parts of Africa.

Associated with changing of planting dates, is the use of irrigation in order to cope with water shortages and, or plant in normal seasons when there is no rainfall. Irrigation practices improve farm productivity and enable diversification of production in light of climate-related changes (Brklacich et al., 1997; Klassen and Gilpen, 1998). Implementing irrigation practices involves the introduction or the enhancement of specific water management innovations including centre pivot irrigation, dormant season irrigation, drip irrigation, gravity irrigation, pipe irrigation and sprinkler irrigation (Smit, 1993). In the rainforest and montane regions, locally fabricated drip irrigation is practiced to supply water to newly transplanted seedlings to help establishment. It is a unique form of irrigation predominantly used among cocoa farmers in Cross River State Nigeria. After repeated years of crop failure due to drought, some farmers trialed a drip irrigation system using empty cans with small perforation at the base, wide enough for water to drip (approximately one drop in every 5 -10 s) with the other end open, (in some cases, fine sand is poured into the base to regulate water flow), the cans are filled with water and with a stick each is tied just above the base of each plant, until the cocoa plants are well established. In this way most farmers have recorded up to 100% success in plant establishment, though it is predominant among farms close to the streams as this might not be cost effective elsewhere. Findings have also shown that a wide variety of local technologies have been developed in semi-arid and arid regions, to harvest and conserve water in traditional silvo-pastoral and agroforestry systems (Smit and Skinner, 2002; Laureano, 2005; Osman-Elasha et al., 2006; Larwanou, 2011).

The increased use of wetland is prevalent in the mangrove ecosystem where farmers take advantage of areas periodically flooded by fresh water from streams to cultivate vegetables and flood tolerant crops. The resilience and increased use of such groundwater wetlands in the face of climate change has also been reported by Morton (2007); Deressa et al. (2009), Fernández (2010), Daniel and Kauffman (2011) and Murdiyarso et al. (2012). In general, irrigation increases

Figure 6. Energy saving cook stove before the kitchen wall is covered.

soil moisture in the light of moisture deficiencies associated with climate change and reduce the risk of income loss due to decreasing precipitation, increasing evaporation and recurring drought (Smit and Skinner, 2002).

Apart from the different on-farm adaptation techniques, households also practice some adaptation options which also saves them time and cost. One of such options is the use of improved wood-burning cooking stoves (ICS) which was developed in the mid-1970s. This option addresses the two main drawbacks of open fires, by including a combustion chamber and a tube to take the smoke outdoors (Troncoso et al., 2007). The use of ICS, especially in the rainforest and montane areas by rural households is regarded as another 'win-win' option; as it is not just effective in climate change abatement (saving the forest by reducing the amount of fuel wood used for cooking), but very cost effective. The ICS is made from locally available materials, Figure 6. During cooking, up to one quarter of the usual amount of firewood used in open fire stoves are used, while retaining virtually all the heat directly below the pot and the smoke is channeled outside the wall through the hollow in the bamboo stick. Nangoma and Nangoma (2007) reports that the ICS uses less firewood than an open fireplace, produces more heat energy, produces less smoke and runs on any form of available fuel. In places where this stove has been introduced in Nigeria, virtually all the households in the communities have adopted the ICS as the women have more time for profitable ventures like farming, trading, social activities which help improve their socioeconomic wellbeing. Also, impacts on forest are reduced with potential higher carbon sequestration.

Since the burden of preparing household meal lies on the women in most traditional homes in developing countries, the ICS saves them from being exposed to the physical challenges occasioned by the use of excessive wood in traditional wood burning open stove. In addition the smoke causes a lot of health impact, especially for the women and their children who they carry on their backs while cooking. The association of adoption of climate change adaptation options, especially ICS with greater opportunity for social progress has also been reported by the World Health Organization (2006) in improving health, World Bank (2009) and Bennett (2013) with regard to other social benefits. A report by the WHO estimates that 4 million people, in particular women and children, die prematurely from smoke inhalation, respiratory illnesses or incur long-term physical harm from collecting fuel.

Particularly, in Africa, Bennett (2006) has noted that the use of ICS addresses most of the Millennium Development Goals (MDGs) as follows: by reducing the required fuel consumption by two-thirds, poverty is reduced and more money is available for other purposes (MDG 1). Less time is needed for collecting fuel by women and children which allows more time for other activities such as education (MDG 2 and 3); it is

physically less demanding and reduces the exposure of women to the risk of physical attack. The health and safety of mothers and children will also improve because of substantial lower smoke levels (MDG 4 and 5).

Moreover, the ICS ensures environmental sustainability, because of lower fuel consumption and reduced deforestation (MDG 7) (Bennett, 2006). These and other concerns clearly justify the need for urgent integration of ICS into the socioeconomic lives of rural households in the developing world.

Bailis et al. (2009) reports that dozens of organizations have developed projects to promote the use of ICS since the mid-1990s; one of such was the Mexican Patsari Stove Project that was well suited to local cooking practices, burnt less wood by over 60% relative to traditional cooking stoves. Interventions for disseminating ICS since the 1970s were mainly designed for increasing fuel efficiency, often because of a link between deforestation and household energy use (Eckholm, 1975; Arnold et al*.,* 2003; Ruiz-Mercado, 2011). Thus, there are more than 160 cook stove programs running in the world, ranging in size, scope, type of stove disseminated, approach to technological design, dissemination and financial mechanisms. The two largest and longest programs are credited with introducing approximately 210 million stoves between them, 85 % in China and 15% in India, and affecting the lives of more than a billion people (Gifford, 2010; Smith, 2007).

In the case of India, reducing deforestation was often the main motivation (Bailis, 2007). The Chinese program focused primarily on increasing fuel efficiency to sustain local welfare and stem the demand for fossil fuels in rural areas (Smith et al., 1993). In the light of the foregoing, regardless of how beneficial these energy use option could be in the short run, what their long time implication can be is yet unclear. This is because of the fear among certain scholars that the shift may be unsustainable in the long run. Nevertheless, they offer good opportunities for poverty reduction, environmental protection and general socioeconomic wellbeing of the rural dwellers if they are effectively integrated into their everyday lives.

Implication of climate change adaptation for Africa

In addition to the plethora of benefits from adaptation as has been x-rayed in this paper, it is also heart-warming that a series of global modeling analyses show that the benefits from undertaking adaptation may outweigh the costs by a factor of about two in Africa (African Development Bank (AfDB) and African Development Fund (AfDF), 2011), thus giving hope for the future of climate change adaptation in the region. In addition, it is evident that Africa possesses a wealth of social networks that have enabled people to survive throughout an environment of harsh climatic conditions. These networks represent safety nets for many of its inhabitants through compensation for their low financial incomes and helping many maintain their livelihoods. These networks should be built upon and further strengthened (Osman-Elasha, 2013).

Nevertheless, despite these successes stories, limited scientific capacity and other scientific resources which combine as factors to frustrate adaptation has been identified (Washington et al*.,* 2004, 2006). In addition, evidence abounds in Africa of an erosion of coping and adaptive strategies as a result of varying land-use, biophysical changes, socio-political and cultural stresses. Thus, these traditional coping strategies may not be sufficient, either currently or in the future, and may lead to unsustainable responses in the longer run. Erosion of traditional coping responses not only reduces resilience to the next climatic shock but also to the full range of shocks and stresses to which the poor are exposed (DFID, 2004). These short-term responses and isolated projects (Sachs, 2005), good as they may be are not enough, rather, long term solutions that could be considered include mainstreaming adaptation into national development processes (Huq and Reid, 2004; Dougherty and Osman, 2005). Bok et al. (2007) identified a complex range of factors, including behavioural economics (Grothmann and Patt, 2005), national aspirations and socio-political goals (Haddad, 2005), governance, civil and political rights, literacy, economic well-being and stability, demographic structure, global interconnectivity, institutional stability and well-being, and natural resource dependence (Adger and Vincent, 2005), as emerging and powerful determinants of vulnerability and the capacity to adapt to climate change.

In order to address some of these challenges, build resilience and strengthen adaptation capacity in Africa, several scholars have posited different options at the disposal of stakeholders, such as:

(1) Approaches that address multiple environmental stresses and factors hold the greatest promise for Africa, particularly given the limitations in capacity, in terms of both human capacity and financial resources. Efforts to design implementation strategies that address land degradation, loss of biological diversity and ecosystem services, as well as adaptation to climate change, such as through enhancing adaptive capacity, will be more likely to succeed than uncoordinated efforts (Osman-Elasha, 2013).

(2) Micro-financing and other social safety nets and social welfare grants, as a means to enhance adaptation to current and future shocks and stresses, may be successful in overcoming such constraints if supported by local institutional arrangements on a long-term sustainable basis (Ellis and Bahiigwa, 2003; Chigwada, 2005).

(3) Incorporating indigenous knowledge into climate change policies can lead to the development of effective adaptation strategies that are cost-effective, participatory and sustainable (Robinson and Herbert, 2001).

(4) A series of more targeted adaptation investments are required and it is crucial that African decision-makers factor climate change into all long term strategic decisions starting immediately (AfDB and AfDF, 2011).
(5) Adaptation needs to be complemented with global emission reductions. Although the policy focus in Africa is rightly on adaptation, the global need to reduce greenhouse gas emissions remains unchanged (AfDB and AfDF, 2011).
Thus, the successful implementation of some or all of these in addition to other development strategies that focus on enhancing the livelihoods of the rural people will go a long way towards enhancing the their ability to cope with climate change.

Conclusion

Rural households in Nigeria are dependent on forests for supplementing of their livelihoods; income from the forest ranges from about 14% in the Sudan savanna to 47% in the mangrove ecosystem. In addition to providing direct income to the rural dwellers, forest resources generate employment; provide medicines and other products for the urban population, international trade, social welfare and environmental benefits. Climate change impacts, particularly increase flooding and erosion; erratic rainfall; high temperature; uncertainties in the onset of farming season; high disease and pest infestation; loss of soil fertility; strong wind and excessive rainfall in the south to severe water shortage in the north of Nigeria. Over 75% of the household agree that there have been adverse impacts of climate change, except in montane forests where the majority of the households (67%) assert that there has not been a significant change in forest resources. Among the adaptation options used by the households, agroforestry is predominant; increased weeding, selective tree cutting, avoidance of burning, use of energy saving stoves, watershed management, pruning, the use of local drip irrigation, changing planting dates, mulching, use of drought resistant varieties, increased spraying and plant replacement are also used.
There is no doubt that forest resources are an indispensable asset to the survival and livelihood of the rural West African households. Thus, adverse effect on forest resources will have serious consequences on the livelihoods and health of many households across Nigeria and the wider West African region. The adverse effects of climate change are already noticeable, with adaptation choices being made at the household level with concomitant viewable social and economic progress. There is an urgent need for a concerted effort among stakeholders, to invest in adaptation options that are not just effective, but sustainable. In addition, the information on the social perspectives of climate change as presented here are very useful in the hands of policy makers and development practitioners in formulating policies and strategies that are compatible with local norms and values. This will ensure a continuous flow of forest resources for the forest dependent poor.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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