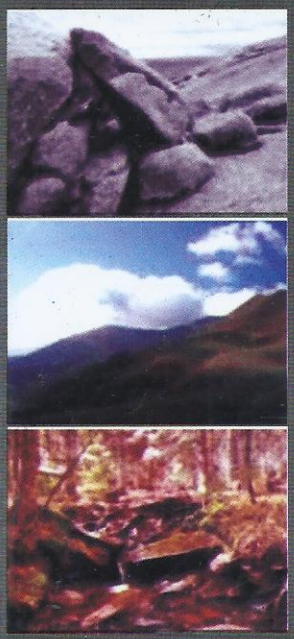

DEPARTMENT
OF GEOGRAPHY
UNIVERSITY OF IBADAN

FRONTIERS IN ENVIRONMENTAL RESEARCH AND SUSTAINABLE ENVIRONMENT IN THE 21ST CENTURY

Edited by:
Adeniyi S. Gbadegesin
Eze Bassey Eze
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Adeniyi, S. Gbadegesin & Oluwagbenga, O.I. Orimoogunje

PREFACE

The primary object of this book is to present current issues and problems relating to environmental sustainability and to discuss them as elements of the earth's surface. This book is timely because of the widespread interest in geographical approaches to solving environmental problems. This interest is present in research, management and academic areas. However, the celebration of the two Giants of Geography – Emeritus Professor Adetoye Faniran and Professor Olusegun Areola from the Department of Geography, University of Ibadan, Nigeria affords scholars to share their interest especially because of the opportunity to celebrate the erudite Giants by holding a National Colloquium on *Frontiers in Environmental Research and Sustainable Environment in the 21st Century.* The collection of articles in this book results from the scholars' concerns to evaluate environmental geography applicability to environmental management in several natural resource fields. The study of such complexes requires more than one individual. This has led to the concept of interdisciplinary research which involves diversity of skills and specialties. Environmental geography has for some time been prominent in research and management studies, but only a few components have been measured or considered in most instances.

The book is in seven divisions. General Introduction focuses on keynote address and guest lectures. Under this subdivision, Mabogunje explores globalization, existing Nigeria governance paradigm and environmental changes. He submits that all frontiers research into environmental sustainability is fraught with considerable uncertainties but with very challenging prospects of rewarding efforts. He therefore concludes that the research frontier will need to be populated by scholars from other disciplines, hopefully in a multi-disciplinary or inter-disciplinary alliance, offering their special insight into the underlying causes impairing environmental sustainability in particular areas or regions of the country whose activities are bound to impact significantly on the environment. Thomas explores some of the routes, priorities and achievements in the study of geodiversity in the humid tropical environment to date, and highlights distinctive features of these environments that deserve emphasis in future research for sustainable resource use while Goudie reveals that dry lands have a large range of environmental hazards to which more and more people are being exposed and that human activities exacerbate some of these hazards which may later be modified by global warming.

Section 1 focuses on **geomorphology and environmental management**. Faniran examines deep weathering and its significant implications for natural resources location in the humid tropical environments and how it facilitates ingress of water into the overburden. Nabegu, using aerial photographs, time series imageries and layout plans, assesses the impact of urbanization on the Jakara channel morphology and highlights the potential implications of this for sustainable urban channel management while Eze and Uquentan use the x-ray diffraction analysis to examines the clay mineralogical composition of lowland soils used for rice cultivation in Central Cross River State and conclude that rice yields were strongly influenced by clay mineralogical properties. Mshelia and Ode employ statistical technique, remote sensing and Geographic Information Systems (GIS) for the morphometric and land use/land cover analysis of three basins in Ibadan region and conclude that human activities impact negatively on stream network in the basins. Oparaku et al. report some field observations made on the impacts, characteristics, and causes of gully erosion on three geological formations of the Idah-Ankpa Plateau of the Anambra Basin, Nigeria and call for more detailed work to determine the extent of gully erosion – induced land degradation in the study area with a view to proffering ameliorative measures. Fashae examines the planform geometry of River Ogun for an improved understanding and predictive capability of the behaviour of large river channel. Dada examines geomorphological mapping from the point of view of cartography, and makes a systematic analysis of the relationship between geomorphological information and its cartographic representation in map form by combining slope data with other geomorphological features experimentally.

Section 2 is on **biogeography and environmental management**. Based on high spatial resolution geospatial technologies Areola highlights the need to return to the core values of geography as a field science that gives prominence to detailed knowledge of the local environment within the context of the wider earth environment as well as emphasizes the need for developing countries to embark on a renewed programme of detailed soil description and measurement to accumulate sorely needed technical data on their soil resources. Adewole examines various remediation techniques on metals and organic polluted soils being used in different parts of the world and offered suggestions on the need to guard against impacting damage on the soil for enhanced, healthy and sustainable ecosystem. Tomori et al. describes the distribution, mobility and impact of arsenic substances on ecosystem health and discovers that its abundance in the soils of the study area may pose serious threat to the quality of soil,

surface and underground water. Orimoogunje use soil and vegetation samples from different tree crop ecosystems over different soil associations to determine the degree and pattern of deterioration of edaphic and biotic elements under selected tree ecosystems and reveals that the substitution of tropical forest with tree crop results in ecological degradation. Ukpong examines the ecological status of the mangroves in relationship to Nypa palms an invasive species and its effect on mangrove structural development and established the importance of this for carbon sink. Based on data obtained from field study, Olanusi and Funmilayo advocate proactive strategies that would halt the rate of deforestation and initiate restoration of the vanishing species integrity. Omosuyi reviews various method of forest management practices and their relative effectiveness in Nigeria and recommends holistic management approach.

Section 3 is on **climate change, vulnerability, assessment, adaptation strategies and mitigation options for Nigeria**. Using Makkink, Turc and Hargreaves empirical models coupled with Geostationary Operational Environmental Satellite (GOES) data, he estimate potential evapotranspiration (PET) from solar radiation and atmospheric temperature, Onafeso and Olusola present a corollary ecogeomorpological classification that improves sustainable agriculture, flood/drought management and land administration practices in Nigeria. Based on temperature and rainfall data for 1931-2012, Umar establishes that annual rainfall pattern had changed from positive in 1931 to 1960 to negative in 1961 to 1990 and back to a positive in the 1991 to 2012. He also proffers that if this trend persists severe drought may occur from 2021 to 2050. Daramola examines urban populations and establishes the aspects that require strengthening in order to withstand the impacts of climate change; she also proposes development of indicators for assessing the vulnerability of urban areas in Nigeria. Using a review method Agbalajobi examines the Kyoto Protocols to answer the questions that border on gender and climate change and stresses the need to involve women actively in environmental decision making at all levels. Using focal group discussions, key informants interviews and household survey in 11 communities across 10 local Fasona et al., investigate perceptions on natural resource use, climate change and adaptation among rural communities in the wooded savanna. Finally, Oderinde and Gbadegesin examine the land use change and carbon emissions between 1984 and 2013 in Ibadan area and reveal that CO_2 emissions can be attributed to change in land use pattern

Section 4 is on **space application and Nigeria's changing landscape**. Ayeni et al., applies satellite imageries to assess land use/land cover dynamics using Markov environment modelers to predict future

land use/land cover change while Ayanlade uses GIS interpolation and down scaling methods to assess how gap in climatic parameter could be filled. Makinde reviews the capability of geospatial techniques in monitoring, assessing and analyzing the dynamics of Nigeria forests. Oderinde and Eludoyin using time series imageries, examines the land use/land cover of Oluyole Local Government Area, Ibadan, and its implication on the direction of change. Adesina and Maduekwe use geospatial techniques to assess the relationships between socio-economic factors and the spatial dynamics of vegetation cover in Idemili River Basin of South Eastern Nigeria. Adegbite and Ebeiyambba use satelite imageries to examine distributional pattern of the daycare centres in Ile-Ife' Osun State and demonstrated the value of GIS and GPS in locational analysis.

Section 5 deals with **urbanization and its environmental challenges.** Olokesusi and Olorunfemi examines the nature of vulnerability of the city of Oyo to disasters while Onwuemele and Olorunfemi assess the impacts of urbanization and flood risks as well as institutional responses and coping strategies among residents in Lagos metropolis while Adetunji et al. assesses the waste management system in a rapidly developing city of Lokoja with a view to ascertain the best method for waste disposal while Attah examine the challenges associated with solid waste generation and management and their impact on the environment in Obubra metropolis in Cross River State. This was with a view to investigating the link between content of waste stream, amount generated and management strategy of waste in the study area. Olayungbo assesses the methods of household solid waste disposal and its implication on ecosystem services in some selected wards in Ife Central Local Government Area of Osun State, Nigeria while Ezenwaji identifies human activities and land uses that tend produce wastes and the extent of pollution of the river by these contaminants using physico-chemical and microbiological parameters. Ige et al. examine the effect of industrial activities in residential environmental health in Oluyole Estate of Oyo State while Muili et al., evaluates the socio-economic effects of urban development in Osogbo with a view to formulating appropriate strategies for sustainable urban development. Asiyanbola et al. examines the challenges of urban fringe while Umaru identifies the factors influencing the use of pedestrian bridges, and the propensity to violate related traffic code by users and policy tools to discourage such violation.

Section 6 considers **religion, environmental sustainability and high school geography**. Ekanade considers the relationship between religion and a clean environment and advocates environmental education to the people through many programmes of various religions while Faniran

reviewed the recent developments the sustainability debate with a view to broadening the scope of environmental sustainability research with special reference to indigenous and religious aspects, so as to accurately reflect the all-encompassing nature of the earth's environment while. The last paper deals with high school geography in which Aderogba examines the adequacy or otherwise of Geography Laboratories and Gardens for effective teaching and learning in Nigeria. She concludes that well-equipped Laboratories, Meteorological and Geographical Gardens should be integrated parts of the school facilities for sustaining interest in geography teaching and learning.

Professor Adeniyi S. Gbadegesin

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ASPECTS OF NATURAL RESOURCE USE AND ADAPTATION TO CLIMATE CHANGE IN THE NIGERIAN SAVANNA

Mayowa Fasona, Grace Oloukoi, Felix Olorunfemi, Peter Elias, and Vide Adedayo

Abstract
This study investigates perceptions on natural resource use, climate change and adaptation among rural communities in the wooded savanna. It combines focal group discussions, key informants, interviews and household survey in 11 communities across 10 local councils coupled with vegetal surveys and remote sensing analysis of the land-use/land-cover in the study areas. The results suggest that dependence on ecosystems resources is very high. Twenty-four tree species significantly support the local economy. Wood harvesting for charcoal and fuelwood, bush clearing and burning for farmlands and animal grazing are the most unsustainable livelihood activities that generate resource use conflicts and pose significant threat to the health of the ecosystem. Community-managed forest is scarce and there is no evidence of any indigenous tree species being cultivated on woodlot. Conflict in uses is pushing some local economic tree species into the danger of extinction. Crop switch is the most common form of adaptation to climate change being practised, but a significant percentage does not have any adaptation option. Communities are well aware of the threat of extinction to some local economic tree species and are willing to partner with other stakeholders for improved ecosystems management.

Keywords: Participatory rural appraisal, vegetal surveys, natural resource use, rural livelihood, indigenous tree species, climate, savanna, Nigeria.

Introduction

The interconnection among climate, natural resource use, food security and rural livelihoods remains a key global concern as demand for ecosystems services rises. Ecosystems play an essential service in climate regulation and support for rural livelihoods and food security (Munang et al. 2011; Global Office of Science 2011; Sonwa et al. 2011; FAO 2011; Ahrends et al. 2010; Bellassena and Gitz 2008). Degraded ecosystems increase the risk of hunger and food insecurity in poor economies that rely on climate-sensitive primary sectors including agriculture, fisheries and forestry (Tambo and Abdoulaye 2012; FAO 2012a). For many poor agrarian societies, climate change is an additional stressor superimposed on existing vulnerabilities. Many of these societies are already being threatened by poverty, poor agricultural practices, low farm outputs, poor ecosystems management practices and lack of innovation to make their

economic systems sustainable. A significant aspect of rural livelihoods and food production around the world continue to degrade the environment and compromise the capacity to produce food in the future, as well as contributing to climate change and the destruction of biodiversity (GOS 2011; FAO 2012a).

In particular, many livelihood activities by the rural population in many parts of Africa continue to be in conflicts with the objectives of ecosystems preservation driven by the government. Addressing local poverty and hunger is essential for successful protection of biodiversity which will in turn contribute to improving rural livelihoods and food security. Rural livelihoods in the Nigerian Savanna are significantly tied to spatio-temporally variable climate-sensitive natural resource systems (Fasona et al. 2013; Abiodun et al. 2012 Fasona et al. 2011). Increasing the adaptive capacity of vulnerable and potentially vulnerable poor rural communities in the savanna is an urgent challenge. Sustainable land ecosystems management is an important component of climate adaptation. Significant reductions in negative climatic impacts are feasible when adaptation is well conceptualized and fully implemented (Kurukulasuriya and Rosenthal 2003). Adaptation strategies that are more likely to succeed in poor rural communities require integration of coordinated efforts aimed at poverty alleviation and food and water security with measures to combat ecosystems degradation (UNFCCC 2007). In addition, existing traditional knowledge bases and technology must be countenanced to sustain and improve on present livelihood options and improve resilience and coping strategies (GOS 2011). Some of these are well documented in Nigeria's policy documents related to natural resources, but their implementation has been very poor. Traditional knowledge provides the basis for ecosystems-based livelihoods in most rural communities. It also contributes to cultural and economic practices, natural resource use, local trade, forest management practices and the development of commercial products.

Rural communities have significant role to play in maintaining the integrity of ecosystems to ensure that it continues to support food and water production and other livelihood activities (Zoa 2009). Recognition of the role of communities as stewards of ecosystem services and strengthening their capacity and empowering them to manage the ecosystems sustainably is essential for adaptation (Folke et al. 2002; Fabricus and Koch 2004). This paper argues that adopting a social-ecological system perspective that integrates the people-focused rural livelihood approach with conservation-focused natural resource

management approach is needed to improve the adaptive capacity of rural communities and ensure ecosystems sustainability. A good starting point is to assess the rural perceptions on resource use and ecosystems management. This paper discussed the real-life experiences of communities with regards to access to and use of ecosystem resources, as well as adjustments to changing climate.

Materials and Methods

Study Area

The area is roughly defined by Longitudes 3°50' to 5°50' East and Latitudes 8° to 9°15' North. It covers about 40,000km^2 in parts of Oyo, Kwara and Niger States in West-Central Nigeria (fig. 1).

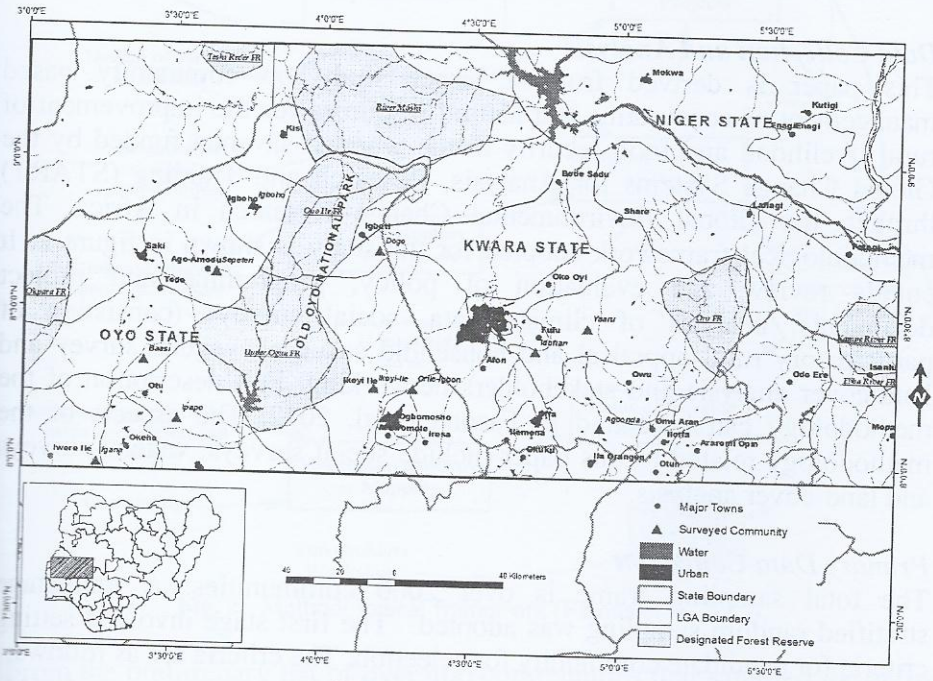

Fig. 1: The study area.

The area falls within the wooded savanna (also called derived savanna) that is dominated by mixture of forest and woodland interspersed with tall grasses and fire-resistant trees. The tree cover is as much as 30%. This zone continues to expand to the south as more forest land is degraded (Bucini and Lambin 2002; Hoffmann and Jackson 2000). The protected

forest of the Old Oyo National Park (OONP) is the most significant forest block in the study area. A number of other forest reserves that exist have been significantly degraded by uncontrolled human activities. The area is also a very important headwater for several important rivers including the Teshi, Moshi, Asa, Oro and Kampe rivers that flow into the Niger River and Ogun, Ofiki, Oba and Oyan Rivers which flow southwards towards the Atlantic Ocean (Fasona et al. 2013). The wooded savanna is characterized by a sub-humid Koppen's *Aw* climate [*an* equatorial savanna where minimum precipitation is less than 60mm in dry season (Kottek et al. 2006)]. Population density is relatively high and survival for large rural communities depends on small-holder rainfed agriculture (Afiesimama et al. 2006; Odekunle et al. 2005).

Data Collection and Analysis

This paper is derived from a larger study on community based management of ecosystems and natural resources for the improvement of rural livelihood and food security in the wooded savanna funded by the Global Change Systems for Analysis, Research and Training (START) through the Global Environmental Change Research in Africa. The methodological framework adopted for the study is shown in figure 2. It entails review and evaluation of policy, programme and project documents, analysis of climate data, social surveys (consisting of participatory rural appraisal and household surveys), vegetal survey and land-cover analysis and stakeholders networking. Full description of the methodology can be found in Fasona et al. 2012. The aspects of the methodology related to this paper include social surveys, vegetal surveys and land-cover analysis.

Primary Data Collection

The total sampling frame is over 2000 communities. A multistage stratified random sampling was adopted. The first stage involved setting criteria for candidate community for selection. The criteria are as follows:

- The community must not be more than 5km away from a forested land or woodland in order to be able to connect livelihood to forest or woodland. This is based on the assumption that the more isolated a forested or woodland landscape, the less the risk of disturbance;
- Communities around protected areas have higher chance of being selected. This was to enable us probe into how resource use

conflicts are managed between community and park managers and to also understand their concept of alternative livelihoods; and

- The community must be a rural or semi-urban. This is based on the assumption that the natural resource capital is more important to livelihood and food security in rural and semi-urban areas than urban area.

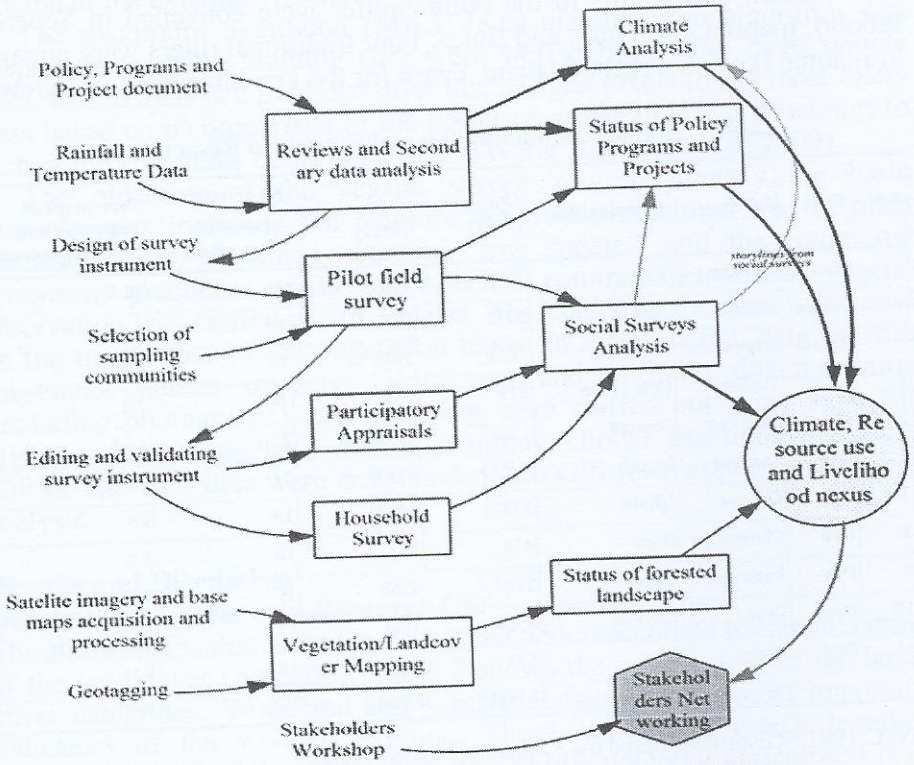

Fig. 2: Methodological framework (Fasona et al. 2012).

From the preliminary list of over 400 communities that satisfied the above criteria, another stage of stratified random sampling was used to select 42 community clusters across 21 LGAs mainly in Oyo and Kwara States. A pilot survey was carried out on the 27th and 28th December 2011. Based on the results from the pilot survey, the sample size for the final survey was further reduced to 11 communities (total estimated population of about 140,000). These communities were spread across 10 LGAs in Oyo and Kwara States. The final survey was conducted from the 5th to 9th February 2012. The final sample size was 191 households (see table 1).

Three sets of questionnaires/interview guides were designed for households, key informants/focused groups and government (Local and State Governments) offices in charge of natural resources and related agencies. The questionnaires captured several aspects of individual and community life and human-environment interaction. The final engagements include questionnaire administered to household heads, focal group discussions and key informants. Five focal group discussions with selected men women and youths in the communities were convened in Sepeteri, Igboho, Ipapo, Orile Igbon and Baasi. Four traditional rulers were engaged in Iganna, Ikoyi Ile, Agbonda and Yaaru for the key informant interview.

Table 1: Surveyed Communities and Household Respondents

S/N	State	LGAs	Communities	*Population (1991)	**Population (2012)	No of selected household respondents	Percentage of respondents to total respondents
1	Kwara	Ifelodun	Yaaru	1222	1961	22	11.5
2	Kwara	Ifelodun	Idofian	5519	8857	16	8.3
3	Kwara	Irepodun	Agbonda	1030	1653	13	6.8
4	Oyo	Surulere	Orile Igbon	219	351	14	7.3
5	Oyo	Saki East	Sepeteri	12317	19766	22	11.5
6	Oyo	Iwajowa	Igarna	17666	28350	17	8.9
7	Oyo	Orelope	Igboho	38871	62380	19	9.9
8	Oyo	Olorunsogo	Dogo	450	722	10	5.2
9	Oyo	Itesiwaju	Ipapo	5962	9568	19	9.9
10	Oyo	Orire	Ikoyi-Ile	3328	5341	23	12.0
11	Oyo	Atisbo	Baasi	541	868	16	8.3
				87125	139817	191	100

*NPC 1991 **Estimates based on 2.83 annual growth rate.

Key informat interviews were conducted with government officials at the state and local government levels as well as the officials of the Old Oyo National Park. Using appropriate softwares, both descriptive and quantitative analytical methods were used to analyze the data.

Landcover Mapping and Vegetal Surveys

A generalized land-use and vegetation map for the study area was produced from Landsat 7 ETM^+ image scenes acquired between 2005 and 2006 (p190r054 of 14 November 2006), and (p191r054 of 18 November 2005) and downloaded from Landsat Geocover datasets archive

(*www.landcover.org/data/*). The Landsat images bands 7, 4 and 2 were subjected to band compositing using Idrisi® Taiga software (*www.clarklabs.org*). A land cover classification schema derived from the USGS land-use/land-cover schema (Anderson et al. 1976) was developed through a process that includes the collation of land-cover signatures during the field reconnaissance, accumulation of spectral signatures that ensure inter-image consistency, and modification of the classification schema of the existing 1:250,000 Vegetation and Land use data.

The maximum likelihood (MAXLIKE) classification algorithm was adopted because the training sites were well defined with large sample sizes. MAXLIKE is a hard classifier that assigns pixels to the most likely class based on a comparison of the posterior probability that it belongs to each of the signatures being considered (Weng 2002; Eastman 2009).

The objective of the vegetal survey was to identify the basic characteristics including the land-use activities, individual tree or plant species present, dominant economic tree species, and the traditional ecosystem practices across the selected communities. Close vegetal observation was carried out in 15 sites. The choice of the sites was based on the uniqueness of the vegetation either in their natural state or with substantial human impacts. Geotagging and attribute documentation (including photographs) and recording were carried out using Juno SB high sensitivity handheld mobile mapping Global Positioning System (GPS). The GPS data were downloaded into GIS for mapping and further analysis.

Results and Discussion

General Land-cover and Resource Use

The study area is dominated by woodland which accounts for about a third of the land-cover categories. Table 2 shows the areal extent of the land-cover categories. Woodland and shrub/grassland are the most important indicators of the wooded savanna. These two cover type's together account for 45% of the total land-cover. While potential agricultural land (not currently cultivated) accounts for 16.8%, land under cultivation accounts for about 8.2%. The OONP (a stretch of contiguous protected forest reserves including the Upper Ogun, Oyo Ile and parts of Moshi) is the most significant primary forest. This forest block accounts for about 3,115km^2 (or 50%) of the total forest land. Unlike in Cameroon, Gambia, Ethiopia, and Tanzania where community-based forest management initiative thrives (Zoa 2009; FAO 2011), community-managed forest or woodland is scarce in Nigeria. The only community owned forest in the study area is a small (about 4.73ha or 450 acres) historic oak forest sighted at Igboho town in Orelope LGA of Oyo State.

Table 2: Statistics of the Generalized Land-cover and Vegetation, Year 2011

LUC_code	LULC Class	Area (km^2)	Percentage
1	Urban	576.9	1.5
2	Woodland	12796.2	32.1
3	Forest	6230.4	15.6
4	Shrub/grassland	5162.9	13.0
5	Wetland	1649.4	4.1
6	Cultivation/commercial agric	3252.4	8.2
7	Farmland/fallow/grazing area	6691.2	16.8
8	Floodplain agric	2245.6	5.6
9	Water	278.4	0.7
10	Bare surface	490.8	1.2
11	Alluvial	11.1	0.03
12	Burnt surface	59.2	0.4
13	Cloud/shadow	412.6	1.0
	TOTAL	39856.9	100

Source: Authors Analysis (2012)

This historical oak forest locally called '*Igbo-Oba*' (the forest of the kings) was described as the ancestral cemetery of the ancient '*Alaafins*' (Kings of the Old Oyo Kingdom). It consists of very tall *Ceiba pentandra* and *Adansonia digitata* which were described during the focus group discussion as being over a hundred years old. The historic oak forest thus exemplifies how traditional history and beliefs can interface with ecosystems management.

Twenty four different tree species are very significant to the local economy (table 3). They are used in construction (building, shed, furniture and fabrication of handles for simple farm tools), road mending, herbs and therapy, oil and balm, leaves, roots and seeds for soup, cane weaving, chewing sticks, and fuelwood and charcoal. The aggregate percentage responses suggest that Anogeissus *leiocarpus (Ayin), Prosopis Africana (Aayan), Vitalaria Paradoxa (Emi), Acasia (Kasia) and Azadirachta Indica (Dongoyaro)* are the most preferred wood species for a variety of domestic uses including construction and health issues. In particular, *Anogeissus leiocarpus*, *Prosopis Africana* and *Vitalaria Paradoxa* are the three most outstanding species of significance to rural livelihoods and local economy of the wooded savanna. Apart from the fruit trees (*Psidium guajava, Magnifera indica, Citrus sinensis* and Anacardium *occidentale*), only *Acasia* and *Gmelina Arborea* are the non-indigenous tree species that made the list of useful trees in the study area.

Table 3: Ranking of Wood Species for Local Use

SN	Local name	Scientific name	Building	Farm implements	Sheds	Home furniture	Road mending	Herbs/therapy, oil & balm	Leaves collection/harvest	Seed/roots and soup	Cane/chewing stick	Aggregate Percentage Score	Charcoal production
1	Ayin	Anogeissus leiocarpus	14.1	16.1	17.7	13	15.6	7.8	2.6	10	12.5	**109.4**	***5.2***
2	Aayan	Prosopis Africana	1	8.3	3.6	0.5	1.6	1	0.5		78	**94.5**	***0.5***
3	Emi (shea butter)	Vitalaria Paradoxa	18.2	12.5	10.9	19.8	13.5	10.4	8.9			**94.2**	***45.8***
4	Kasia	Acasia		1.6	9.4	3.1	5.7	6.8	1	10.4	5.7	**43.7**	***6.3***
5	Dongoyaro (neem)	Azadirachta indica		1.6	1.6	1	4.2	17.2	9.4	7.3		**42.3**	***2.1***
6	Iya	Daniela ogea	12	12	1.6	6.8	1.6	2.1	1			**37.1**	***1***
7	Iroko	Milicea excelsa	6.8	2.6	5.7	11.5	5.2	2.1	0.5			**34.4**	***0.5***
8	Aganho (mahogany)	Khaya Senegalensis	9.4	0.5	1.6	9.4	4.2	8.3	0.5			**33.9**	***3.1***
9	Igba	Parkia biglobosa		2.1	3.6	2.6	2.6	4.2	2.6		8.9	**26.6**	***2.1***
10	Cashew	Anacardium occidentale									23.4	**23.4**	
11	Idi	Terminalia glaucescensis		3.6	2.6	3.1	3.6	5.2	1		2.6	**21.7**	***2.1***

Table 3 contd.

12	Melina (gmelina)	Gmelina arborea	14.1	3.6								**17.7**	
13	Abafe	Piliostigma thonningii	1	9.4	1	1.6	2.1	1.6				**16.7**	
14	Odan		1	0.5	6.3	3.1	3.1	1	1			**16**	
15	Ibepe (pawpaw)	Carica papaya								15.1		**15.1**	
16	Oparun (Bamboo)	Bambusa vulgaris	1.6		6.8	2.1	0.5	0.5	0.5			**12**	
17	Apepe		1.6	5.2	0.5	0.5	1	0.5	1.6	1		**11.9**	***1***
18	Sedun		2.6	3.1	2.6	1		1				**10.3**	***0.5***
19	Orombo (citrus)	Citrus sinensis								9.9		**9.9**	
20	Mangoro	Magnifera Indica	2.6								4.7	**7.3**	
21	Odu			0.5	2.6	0.5	0.5	1	0.5			**5.6**	
22	Ope	Elaesis guineensis			3.1	0.5	1	0.5				**5.1**	***1***
23	Guava	Psidium guajava		1.6	0.5			1.6	0.5			**4.2**	***0.5***
24	Asapa				0.5							**0.5**	
25	Any Dry wood				0.5	4.2	0.5	7.8	0.5			**13.5**	***13***

Source: Authors Analysis (2012)

These indigenous economic tree species grow in the wild and none is currently cultivated in woodlot or plantation. G*melina arborea* and *Tectona grandis* (both non-native timber species) are the dominant species found in woodlots owned by the State governments and the British America Tobacco Company ostensibly in trust for the local communities, but in reality they are restricted area for the local population. The indigenous tree species are traditionally suited to the local climate and are found as individual stands across the area. The national policy on forestry listed the provision of seedling to conserve priority indigenous trees species, promotion of cultivation of fast growing trees species for forest regeneration, and encouragement of individual and community participation and partnership in ecosystem management through cultivation of woodlots as some of its priority strategies. In reality, there is no evidence to suggest that these were discussed, tried or implemented in the communities.

Resource Depletion and Resource Use Conflicts

A number of forest and woodland resource uses in the wooded savanna conflict with sustainable ecosystems management and accelerate ecosystems degradation.

Production of Charcoal

Charcoal production typifies the conflict between the short-term ecosystems provisioning services required by people and the long-term supporting services needed to maintain the health and integrity of the ecosystems to ensure continuous flow of ecosystems goods and services. Commercial conversion of wood into charcoal is a major ecosystems destruction activity. But it also provides livelihoods for a significant number of people. Charcoal is a major energy source for a small number (about 2%) of rural homes, but for a large number of urban homes due to inadequate power supply in Nigeria. Field data analysis shows that the adolescent, youth and elderly are all engaged in the business of making charcoal for sale which is dominated by the male youth in all the communities. FDG and KII reveal that charcoal making is generally detested. Attempts have been made in the past by community leaders to ban the trade at Ikoyi Ile, Iganna and Agbonda. But this became difficult to maintain due to lack of alternative means of livelihoods. Other factors such as inadequate legislation, lack of commitment from the state governments, poor public power supply and the international trade dimension were also cited as some of the reasons why the trade thrives.

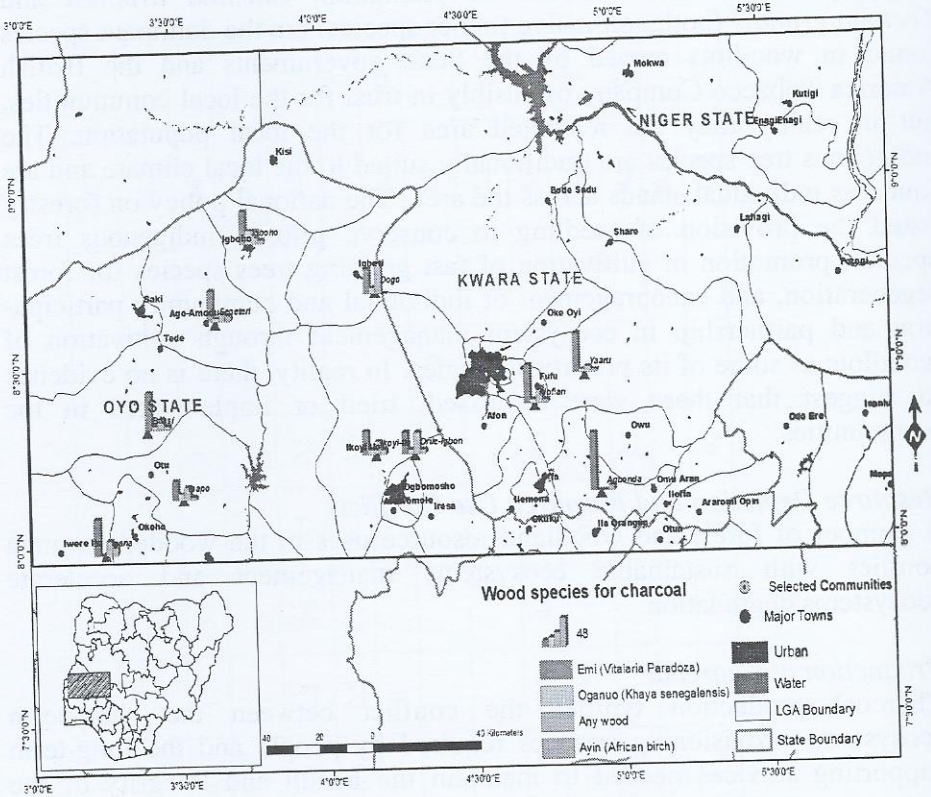

Fig. 3: Preferred wood species for charcoal making.

Vitalaria Paradoxa is the most preferred tree species (46% of respondents) for the production of charcoal across the communities (fig. 3). *Vitalaria paradoxa* is also the second most preferred (after *Anogeissus leiocarpus*) for local constructions and health and therapy issues. During the FGDs, some community members refer to the *Vitalaria paradoxa* as the 'cocoa of the savanna' (a reference to the economic importance of the tree which is comparable to the real cocoa). The multiple, contradictory uses of the *Vitalaria Paradoxa* put the tree as likely the most endangered in the wooded savanna of Nigeria. Yet, it is neither cultivated in woodlot/plantation nor purposely planted by the local population. Engagement with different stakeholders suggests that only fruit trees including citrus, mango and cashew are planted. Other local economic trees including *Vitalaria paradoxa* grow wild in discreet locations and people have to wade through the woodlands to locate them.

Firewood Harvesting

Uncontrolled harvesting of fuelwood for commercial purpose is another significant threat to the terrestrial ecosystems. Results from the field survey suggest that about 84% of rural households rely on firewood for cooking and heating. Fuelwood is also the most preferred energy source for 59% either because it is readily available (42%), it is considered free (14.6%), or it is cheaper than other fuel sources (13.5%). In addition, commercial fuelwood collection provides supplemental income for a significant number of rural households. About 50.5% of the household's belief any available dry wood is good enough for firewood and 3% again favored the *Vitalaria paradoxa* as the most preferred for fuelwood.

About 56% of households affirmed that trees harvested for both charcoal and fuelwood are never replanted. This is an important issue for ecosystems management. Possibility of natural regeneration is cited by 41% as the major reason for non-replanting of harvested trees. Other reasons cited include lack of seeds or seedlings (15%), lack of information about the need to replant (2.6%) and no reason at all (17.2%). About 49% know no particular method for preserving their lands and 20% are indifferent to forest preservation. About 9.9% favour the creation of more protected areas and 6.3% prefer traditional means including creation of local sacred forest/groves. About 2% suggested that some trees species should be prevented from being cut in the forest either by government law or some local code or cultural norm. The general belief across most of the communities is that ***trees are planted by God*** which is a reference to strong belief in natural regeneration of the ecosystem. Part of the action plans of the national policies on agriculture and energy were to encourage the establishment of commercial, private and community fuel woodlots, reduce contribution of fuelwood consumption in domestic energy uses and encourage the production, effective distribution and use of alternative energy to fuelwood. Evidence from the field suggests none of these has been achieved and there is little to show that they are presently being pursued.

Bush Clearing for Agriculture

Farming is the major occupation for about 65% of the rural households. Clearing of bush is seen as necessary exercise that must be done by farmers prior to cultivation. Cutting and burning is the traditional and still the predominant method of bush clearing and practised by over 80% as shown in table 4. A breakdown of the statistics shows that cutting and bush burning were the most prevalent methods of bush clearing by the

respondents (45.3%). This was followed by those that cut down the vegetation without necessarily burning them (35.4%). The reasons for any option are based on perceptions and consideration about the chosen method being better than any other (27%), it is easier or less tedious (19%), it is cheaper in terms of labor cost (15%), it is the only known method (13.5%), it is the traditional method (11.5%), or it just does not matter whichever method is used (14%). Additionally, 38% believe bush burning has no negative effect on the environment. Only 6.8% believe that bush burning is a threat and 3% think it has some potential to advancing desertification and land degradation.

Table 4: Methods of Bush Clearing

Method	Frequency	Percentage
Cutting alone	68	35.4
Burning alone	6	3.1
Use of Chemicals	11	5.7
Ploughing	3	1.6
Cutting & burning	87	45.3
Cutting, burning & Chemical	1	0.5
Indifferent	15	8.4
Total	**191**	**100**

The various methods of land preparation do have grave implications for the ecosystems. While the conversion of forest and woodlands into farmland generally leads to degradation of the terrestrial ecosystems, clearing land through bush burning destroys specific animal habitats and plant communities. In several instances, fire often extends beyond the original intended lands into other areas thereby causing severe ecosystems perturbation. Frequent fires in the wooded savanna (especially during the dry season) often retard the growth of trees and prevent forest and woodland communities from reaching their climax. About 22% of households are indifferent to any future threats to the ecosystems and biodiversity resulting from bush burning.

Animal Grazing

Free-range grazing by nomadic pastoralists remains a key factor of ecosystem degradation in the savanna. The constant free movement degrades soil and makes them unsuitable for agriculture. Responses from

KII and FGD suggest that nomadic pastoralists often allow their herds to wander into farmlands and destroy cultivated crops. In addition, they also set fire on the woodlands with the assumption that such a fire enhances early growth of forage undergrowth. Through these actions, the long-term support services (including the ability of forest and woodlands to support climate regulation and soil nutrient cycling) important to the health of the ecosystem is often traded for the short-term benefits. An immediate impact of the actions of the agro-pastoralists is the now common conflict with the small-holder crop farmers. About 90% of the LGAs surveyed agree that clashes between the nomadic herdsmen and crop farmers now occur regularly and posed a very serious threat to human security in the savanna. About 8.3% of the households also believed that conflict with the nomadic agro-pastoralists remains the most important challenge facing the rural dwellers in the savanna. The national policy on agriculture listed as one of its priorities the establishment of dedicated grazing reserves with water access for livestock to reduce resource conflicts. The responsibility of creating the grazing reserves was allocated to the state governments. As at the time of the fieldwork none has been created and the constant conflicts thus persist.

Community Perceptions on Climate Change and Adaptation

General Perception on the Climate

Although there are no existing agricultural output data to compare with perceptions on changing rainfall signals and shift in growing periods, since rainfall is the limiting factor of agriculture in the savanna, it could be reasonably inferred that shifting growing season would correspondingly have negative impact on output. The sampled communities are generally aware of climate change and its implications as suggested in their observations on rainfall and temperature.

Rainfall

About 94% of households believe that there have been changes in the patterns of rainfall. In terms of the present annual rainfall compared to 10 years ago, 60.4% believe rainfall has been decreasing, 21.4% believe it has been increasing and 8.3% think it has remained unchanged. Table 5 shows the peoples' perception on number of rainy days, onset and cessation of the rains, onset of the growing season and length of the growing season in recent time compared to 10 years ago. Rainfall remains the limiting factor of most livelihood and food production activities in the Nigerian savanna. Its quantity and distribution across time and space is also critical to poverty and food security. The general perception of

significant percentage of the people is that there has been a decline in all these variables. This has implications for small-holder rainfed agriculture on which rural livelihood thrives.

Table 5: Perception on Number of Rainy Days, Onset and Cessation of the Rains (based on household responses in percent)

Number of rainy days	Rainy days	Onset (delayed)	Cessation (earlier)	Onset of growing season	Length of the growing season
Increasing	13	3.6	4.2	1.6	0.5
Decreasing	37.5	37.5	33.9	34.9	39.5
Average	16.1	26.0	24.9	21.4	18.8
Below Average	0.5	3.6	2.6	2.1	1.6
Above Average	1.6	0.5	1.6	1.0	1.0
No Changes	7.8	7.3	9.9	14.1	12.0
Fluctuates	6.3	10.9	10.4	11.5	12.0
Indifferent	17.2	9.4	12.0	12.5	13.6

Temperature

Temperature affects evapotranspiration and the quantity of soil moisture available for crops. Generally, 91% of households believe there has been a change in the pattern of temperature. In terms of the general pattern of annual temperature in recent times compared to 10 years ago, 61.5% think it is getting warmer, 11.5% believe it is decreasing while 14.6% think it has been average (when compared with optimal temperature for farming activities). Figure 4 shows the perception of hot days in recent time when compared to 10 years ago across the communities. In terms of the number of hot days in recent times compared to 10 years ago, 42.7% believe hot days are increasing, 14% think it is decreasing, 14.1% think it is normal (with respect to farming), 4.2% see no change, and 7.8% think it has been fluctuating. Correspondingly, 27.1% believe cold days (in this case, the days of lowest daytime temperature normally experienced during the rainy season) are decreasing. 15.1% believe it has been increasing while 18.2% think there has been no considerable change and 8.9% think it has been fluctuating.

Community Adaptation to Climate Change

The FGD and KII affirm that changes in rainfall signals often lead to crop failure. Crop-switch is the most popular adaptation option among the

communities. The following extracts from the discussions with some of the community leaders confirm this assumption:

> *The Traditional ruler of Yaaru community: "since about **12 years that I move into my town from Lagos, well, for the past 6 years the rains have reduced. Some of the flowing rivers which used to disturb our children from going to school have been drying up especially during the dry season"***

The Community Head of Baasi: "In comparison to the last ten years, we used to have two planting seasons in a year, but now it is once in a year. Last year, the rains started very fast and it stopped very early. When things like this happen we normally change our crops.

The traditional ruler of Iganna community: "I had my primary and secondary education in this area so the pattern of rainfall then is not the same as we are having nowadays. Last year it rained in March. By the time we were preparing for planting in April we had no rainfall till the end. By the time it get to May, June, and July we start to plant preparing for the August/September planting season and by October ending the rain ceased. This occurrence led to massive crop failure. What we do is that if we want to plant melon, either water melon or the usual melon, the usual practice is to plant by April and it must be planted for 3 months with little rainfall. In case we had much rain and it is not yet ripe for harvest that will bring loss and most times crop failure. So the effect is that our planting period is changing as the weather condition changes which is not easy to adjust to".

The Chairman Community Development Association of Sepeteri: "So far, the weather condition has changed compared to the previous years. In previous years, it always rains at the expected time but nowadays things are changing seriously. Back then, we plant our maize in the third month and by the fifth month cassava will be on our farms. But now we usually see rain in the fifth month and it will not last a long period before it ceases".

The Aare-Ago (High Chief) of Igboho community: "Nowadays we expect rain at the normal period but it did not rain and that brings the problem of crop failure. For now, there is no solution.

Among the households, 22% have no adaptation strategy and 30% claimed to adapt to adverse climate condition by switching crops and rationing available food resources. A few others (especially in Iganna and

Idofian) increase their use of different types of fertilizer as adaptation option. But some communities are open to new thinking and they are evolving new adaptation options for farmers. For example, Baale Agbe (Chief farmer) of Iganna community put it this way:
"We learn new things every day. Bush burning is a common practice with the local farmers here. But this year our plan is to leave the grasses for cattle to eat so that we can have manure in return which will be very useful for our farmland and cultivation.

Conclusion

The growing and increasingly interconnected global threats of ecosystem decline and climate change will profoundly test the ability of the rural poor to maintain viable livelihood options and to escape poverty which could undermine and possibly reverse the progress towards achieving the MDG. Whilst the ecosystem-based adaptation approach is not a panacea for all problems, it can be integrated with other strategies including climate mitigation, poverty alleviation and sustainability to form the foundation for a successful integrated strategy for food, water and human security. Threats to natural and agro-ecosystems are important to rural livelihoods. Ensuring sustainability by meeting the challenges of rural livelihoods and preserving the ability of the ecosystems to perform long-term regulating and supporting services requires adjustments and trade-offs which must be actualized. Building partnership through natural resources management projects that are community-driven or have substantial community-participation is important to sustainable natural resource management in the wooded savanna.

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The primary object of this book is to present current issues and problems relating to environmental sustainability and to discuss them as elements of the earth's surface. This book is timely because of the widespread interest in geographical approaches to solving environmental problems. However, the celebration **of the** two Giants of Geography – Emeritus Professor Adetoye Faniran and Professor Olusegun Areola from the Department of Geography, University of Ibadan, Nigeria afforded scholars to share their interest especially because of the opportunity to celebrate the erudite Giants by holding a National Colloquium on *Frontiers in Environmental Research and Sustainable Environment in the 21st Century.* The collections of articles in this book result from the scholars' concerns to evaluate environmental geographical applicability to environmental management in several natural resource fields. The study of such complexes requires more than one individual. This has led to the concept of interdisciplinary research which involves diversity of skills and specialties. Environmental geography has for some time been prominent in research and management studies, but only a few components have been measured or considered in most instances.

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