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Characteristics of the Social-ecological System Components of Three major Artisanal Fisheries in the North East of Nigeria

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ABSTRACT
This paper presents information needed for the analysis of some of the artisanal fisheries of North East, Nigeria using the social-ecological systems (SES) framework. The information was collected in a study conducted from1993 to 1996 covering the upper section of the River Benue in Adamawa State, the Nguru-Gashua wetlands in Yobe State and the western shore of Lake Chad in Borno State. The results confirm the complexity and social-ecological nature of these fisheries. It revealed a widespread lack of centralized government participation in fisheries management even though its institutions have the statutory responsibility for management. The *de facto* institutions for management of local fisheries resources were found to be community-based and traditional. They operate a wide range of traditional management systems that have so far maintained the resources on which the communities depend for a livelihood. These traditional institutions were found to be under increasing threats of disappearing as a result of both biophysical and social changes. The study recommends the establishment of monitoring systems to collect trend information and the use of the social-ecological framework for rigorous analysis. It concludes that it is only through this process that adequate understanding needed to implement interventions to prevent the collapse of the systems can be achieved.

Key words: Artisanal fisheries, Social-ecological systems, traditional fisheries management, livelihoods

INTRODUCTION

The fisheries of North East, Nigeria are crucial to the economy of the region. They are not only important as a source of livelihood for a large number of people (Neiland *et al*., 1997) but also an essential component of the ecological system of the region. The fisheries are, therefore, part of a complex social-ecological system (SES) that requires a multi-faceted planning that gives equal regard to economic, social and ecological considerations.

Glaser *et al.* (2008) provide a working definition of an SES as "consisting of a bio-Geo-physical unit and its associated social actors and institutions". One of the earliest frameworks for describing and analysing SESs is the hierarchical framework Ostrom (2007). The most recent version of that framework described in McGinnis and Ostrom (2014) identifies four major categories of SES components, namely: Resource Systems, Resource Units, Governance Systems and Actors. Interactions between these variables and the outcomes arising thereof define what Ostrom (2009) describes in her Nobel Prize acceptance speech as "Action Situations". Users and other actors interact in Action Situations as a result of which they generate 'Interactions' and 'Outcomes' that affect and are affected by the resource system (and its units), the governance system and the users themselves.

In addition to the hierarchical framework, a substantial theoretical base to guide empirical investigations into social-ecological systems (SESs) has developed in the last two decades. Prominent frameworks include the panarchy concept (Gunderson and Holling, 2002), conceptual SES (Anderies *et al.*, 2004),

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network approach (Janssen *et al.*, 2006) and coupled human-natural systems (Liu *et al.*, 2007). Others include: vulnerability e.g. Gallopin (2006), robust control (Andries *et al.* (2007), human settlements (United Nations – Habitat, 2007; Alessa *et al.*, 2009), sociometabolic transitions (e.g. Krausmann *et al.*, 2008) ecosystem-based management (McLeod and Leslie, 2009) and disturbance (Schoon and Cox, 2012). Many of these frameworks are actually variations of the Ostrom (2007) framework.

All the frameworks, mentioned above, require detailed understanding and input of information on the various components of the system as identified above and on how these interact. A primary step in any analysis of an SES, therefore, is to comprehensively describe the resource system, its units, the social actors and institutions operating as part of the system and the rules and regulations governing the use of the resource.

This paper presents the results of investigations into the social-ecological characteristics of common-pool artisanal fisheries in three locations in North East Nigeria. Specifically, we present findings on the nature of resource system, the social actors and institutions, and how these interact in various systems of fisheries management at the community or village level. The primary of objective of the paper is to provide contextual and baseline information for future analysis using the SES framework towards corporation into meta-analysis, databases such as the Social-ecological systems (SESMAD) described in Cox (2014). The study is also expected to serve as an important documentation of the traditional systems of management of fisheries in the study areas, as these systems are in danger of disappearing as a result increasing modernization. Finally, it is hoped that adopting an SES perspective will lead to a better understanding of the artisanal fisheries of North East Nigeria and similar environments and to the sustainable management of the resource and the livelihoods of its users.

MATERIALS AND METHODS

Study areas

The study was conducted from 1993 to 1996 in three distinct fisheries in the North East Nigeria namely: Lake Chad (LC) on the Nigerian side, Upper River Benue (URB) covering the stretch of the river from the border with Cameroon to the Village of Borrong, near Numan, and Nguru-Gashua Wetlands (NGW) covering part of the Hadejia-Nguru Wetlands starting from Nguru town and ending in Gashua town.

The three study locations differ in many ways but share several characteristics that are typical of tropical floodplain environments. These include a strong seasonality of annual inundation of floodplain environments and fishing patterns associated with this water movement. For this reason, the three areas were investigated and analysed using a common methodology.

Study approach

The study was based on a community/village-focused approach. Randomly selected fishing communities or villages were visited and information on fisheries management was collected directly from the communities themselves. This approach was chosen since it is more likely to identify the various forms of community-based management regimes existing in the region and to provide a baseline for the assessment of the effectiveness and sustainability in relation to performance of specific local fisheries resources.

Sampling strategy

The results reported here were obtained as part of a wider research project called Traditional Management of Artisanal Fisheries in the North East Nigeria (TMAF) which was conducted from 1993 to 1996. To establish a sampling frame for TMAF, an exploratory survey was conducted from April to August 1993. Details of the survey are published in Neiland *et al.* (1997). The sampling frame for this study is based on that survey. The frame covered all three study areas and consisted of 194 villages. A stratified random sample consisting of 53 villages (9 in Lake Chad, 19 in Upper River Benue, 25 in Nguru-Gashua Wetlands) was then drawn from the frame and used for data collection. The difference in number of villages sampled per study area is because the pre-study exploratory survey showed differences between the study areas in the average number of households per village.

Information collection

The survey was operated by two teams of 23 enumerators. Each enumerator that participated in information collection was required to attend and pass a two-week training course before participating. Information was collected using semi-structured interviews and open-ended approach. This technique was pre-tested and modified through trials in a sub-sample of villages.

In addition to the exploratory survey conducted at the beginning of the project, three major surveys were conducted. The first survey focused on households and conducted interviews with household heads. The second survey, which was an investigation of fisheries management systems and institutions, focused on communities. In the second survey, enumerators worked in pairs and conducted group interviews which lasted between 1 – 2 hours per group session. Information obtained was triangulated by conducting the same interviews with various groups within the community. Participatory Rural Appraisal techniques were used to aid information collection. The third survey was a series of quarterly data collection exercises for monitoring the fisheries. In the third survey fisheries data was collected at fish landing sites from randomly selected fishermen through interviews and personal observations of the enumerators. The third survey yielded time-series information on several aspects of the resource system including fish catch composition and gear usage.

Statistical analysis

Multiple Correspondence Analysis (MCA) was used as an exploratory statistical tool to develop a typology of fishing households based on their responses. MCA is a multivariate statistical technique which allows the analysis of a sample of individuals described by qualitative (categorical) variable. It graphically displays each category or response option for the variables used as a point in a scatterplot or "map". The relative positions of the category points on the map indicate the levels of similarity or association between the categories. Logistic regression was used to determine whether the associations revealed by MCA were statistically significant.

Catch diversity index was calculated using the Simpson index (Simpson, 1949) which is the ecological version of the Herfindahl method (Herfindahl, 1955).

RESULTS

The social-ecological characteristics of the three fisheries are presented here under the following categories: fisheries resources, socio-economic characteristics, key actors and institutions, and management systems.

Fisheries resources

In all the three study areas the biophysical resource system consisted of a variety of fishing habitats and a multispecies fish stock. Logistic regression analysis revealed that all inter-site variations given in table 1 were statistically significantly different ($P<0.05$) with Wald values ranging from 5.7027 to 77.1149. For the URB, most fishing villages were located on or close to the floodplain and experienced extensive flooding of the environment for 4 – 5 months each year (September to January). Receding flood waters were often retained in floodplain depressions and low-lying areas to form ephemeral pools, water meadows referred to locally as *fadama*. These habitats lasted for 3 – 4 months into the dry season before drying up. They formed a very significant fishing habitat.

Local fishers therefore exploited a wide variety of fishing habitats including permanent river channels, inundated areas and recession pools and lakes. Juvenile fish from *fadama* areas formed an important part of the annual catch. For this study area, results of the household survey revealed that large rivers (43% responses) and other areas including seasonal pools, rivers and *fadama* areas (43%) were the most important fishing habitats.

In LC, the study area covered the western shore of the lake. The villages in this study area tended to be much further from permanent water (the main body of the lake) than those in the other study areas. Nevertheless, the annual inundation of the floodplain or dry lake bed resulted in villages being surrounded by water for up to 3 – 4 months (November to February) each year. As was the case in URB, the receding flood left a series of ephemeral pools and *fadama* areas near villages. These *fadama* areas

and the drainage channels through which fish retreated to the main lake formed very important fishing habitats.

Table 1: Fishing resource characteristics of three major artisanal fisheries of North East Nigeria: Upper River Benue (URB), Nguru-Gashua Wetlands (NGW) and the western shore of Lake Chad (LC). Data is based on a survey of fishing households in sample villages. % responses = % of fishing households responding that way

Characteristic	URB	NGW	LC
Major fishing environments			
Large lakes (% responses)	3	8	92
Large rivers	43	6	2
Others (residual ponds, small streams etc.)	54	86	6
Catch composition			
No. of fish genera	24	25	16
Catch diversity index (Herfindahl/Simpson)	0.126	0.158	0.254
Major fish group (% responses)	Tilapiine cichlids (24)	*Clarias* spp	*Clarias* spp
Gears/Crafts			
Major gears (% responses)			
Boat (canoe) (mean no./household)	Static nets (39) Active nets (27)	Static nets (30) Hooks (29)	Traps (32) Static nets (31)
Outboard engine (mean no./household)	1.00 0.01	0.15 0.01	0.96 0.10
Owned all gear (% households)	84	91	86
Major fishing period			
Dry season (% responses)	48	8	4
Rising flood	20	40	60
Receding flood	32	52	36

The permanent open water and the fringing swampland of the lake also represented important year-round fishing areas with almost all the fishing households (92%) considering them as primary fishing grounds.

In the NGW most villages were located near a permanent river. The NGW are formed by a confluence of a number of major rivers including the Hadejia and the Katagum, which unite to form the Komadugu -Yobe. Most of the area was subjected to extensive flooding during June-September with many villages surrounded with water and swamps for 2-3 months. As was the case in URB inundated areas, fadama areas and receding flood pools formed very significant fishing habitats. This was confirmed by the household survey which revealed that the seasonal water features were the major fishing areas (86%). Like in URB, juvenile fish formed a significant part of the catch in NGW.

The URB households fished the greatest variety of fishing areas, and this probably reflects the diversity of environments found in this major floodplain area. The mean distance travelled to fish was not great, ranging from 36 kilometres in the NGW, to 20 kilometres in the URB and LC.

The fish catch composition varied between the three study areas. The URB showed the greatest diversity of catch with 24 genera and a diversity index of 0.126. Most of the catch comprised of tilapiine cichlids i.e. *Tilapia* and *Oreochromis* spp (24%), *Clarias* spp (18%) and *Synodontis* spp (12%). At LC, 16 genera were recorded (diversity index = 0.254) with the catch dominated by *Clarias* spp (35%), tilapiine cichlids (28%) and *Heterotis* spp (20%). In the NGW, the diversity index of 0.158 was higher than in LC but similar to that in URB. The dominant groups were *Clarias* spp (25%), *Alestes* spp (20%) and *Synodontis* spp (12%).

A total of 14 – 17 different types of fishing gear classified into 6 different categories (active nets, static nets, traps, fish fences, hooks and others) were found to be in use by fishing households. In

general, modern gears such as gillnets were used more than traditional types such as basket traps. A majority of fishing households tended to use only three or four main gear types. In the URB static nets (39%) and active nets (27%) were the main gears whereas in LC traps (32%) and static nets (31%) were used mostly. In the NGW, static nets (30%) and hooks (29%) were the dominant gears. The survey found that gear ownership was high with 84 – 94% of households owning their fishing gear. Fishing households owned a range of other fishing equipment. These included paddles, canoes and smoking kilns. Boat mechanization was not common; with a figure of less than 0.1 outboard engines per household.

Socio-economic characteristics

The socio-economic parameters for the three study areas are summarized in table 2. Fishing was found to be a major occupation and source of income in all three study areas. The proportion of households who participated in fishing was highest in the URB (70%), followed by the NGW (61%) and LC (40%). This represented a fishing population of nearly 10,000 households and 8,112 adults (men and women) in LC and approximately 5 – 6,000 fishing households (11 – 13,000 adults) in URB and NGW on scaling up from the sample. The density of fishing adults was highest along the floodplain of URB (7.5/Km^2), followed by NGW (5.9/Km^2) with a much lower figure for LC (1.9Km^2).

Table 2: Socio-economic characteristics of three major artisanal fisheries of North East Nigeria: Upper River Benue (URB), Nguru-Gashua Wetlands (NGW) and the western shore of Lake Chad (LC). Data is based on a survey of fishing households in sample villages. % responses = % of fishing households responding that way.

Characteristic	URB	NGW	LC
Fishing employment			
Number of fishing households (scaled-up)	5,660	6,026	9,850
Proportion of total households (%)	70	61	40
Income sources for fishing households			
Fishing (% of households)	37	37	54
Farming	50	56	39
Labouring	4	1	1
Others	9	6	6
Disposal of catches			
Catch sold (% of total)	67	77	81
Autoconsumption (% of total)	33	23	19
Fishing income clusters (from Multiple Correspondence Analysis)			
16% income from fishing	27	22	7
34%	42	54	34
60%	22	23	42
93%	9	1	18

Fishing also accounted for a high proportion of household income in all the three study areas. The highest proportion was in LC (54%). The figures for the other areas were URB (37%) and NGW (37%). Only 5% of households reported fishing as the only source of income. Most of the households (95%) combined fishing with farming as sources of income. On average households, in the study areas, earned approximately 55% to 65% of their income from farming. Households engaged in both fishing and farming earned 40% to 55% of their income from fishing. Further analysis of clusters using MCA revealed that in LC the largest cluster (comprising of 42% of households) earned up to 60% of their income from fishing. In contrast, the largest clusters in URB and NGW earned only 34% of their income from fishing. The result confirmed that the fishing households in LC relied more heavily on fishing income than those in the other study areas.

Key actors and institutions

The study revealed key institutions and social actors involved in fisheries management at each village. The institutions and social actors with jurisdiction over the fisheries and the methods of management used varied widely between villages. Nevertheless, the two main categories of institutions involved were found. The first was government. Government was represented by State Government and Local Government. The second category found was the community-based traditional authorities. State government was represented by the Department of Fisheries (SDF) for the State in question. For example, some fishing locations in Adamawa State were found to be in total control of Adamawa State Department of Fisheries (ASDF), which was a department in the Ministry of Agriculture of that State. SDFs are the government institutions with the statutory mandate to regulate fisheries in states. Local government was also present in some instances and was represented by the unit within a department in the local government that was responsible for natural resources. Traditional authorities were part of Emirate or Chiefdom systems of government existing before modern government was instituted during the colonial era. In the Lake Chad and Nguru-Gashua Wetlands the community-based leaders in the traditional administrative system were the village head (*bulama*) and the district head (*lawan*). In the Upper River Benue (URB), the village head (*kpane*) was the traditional administrative head. Traditional management of local fisheries was overseen by these community leaders usually through a master fisherman known as a *sarkin ruwa*. In URB villages the structure was more elaborate. The village head (or *kpane*) was mostly responsible for general administration of the village. In addition, there was a *kpano habiye* which literally translates to 'elder for waterbodies'. There were also other actors some of which related to traditional religious practices preceding both Christianity and Islam. Others related specifically to management of the fisheries.

Most of the villages studied (70 – 80%) reported that they had exclusive rights over some fishing areas. In addition, 80 - 90% of all villages had a *sarkin ruwa* or water overseer (referred to as *kpanu habiye* in URB). The water overseer had some authority in the regulation of fishing and other activities in community-controlled waterbodies. The study confirmed the existence of both traditional (community and indigenous knowledge-based) and modern (central government instituted) approaches to fisheries regulation in the three study sites.

Management systems: typology and case studies

Overall, the types of management observed could be classified into one of three categories namely: modern, mixed and traditional (table 3). Modern systems were those in which traditional administration had no influence on the exploitation the fisheries. Fishers required licenses from government for some aspects of fishing. Enforcement was by government and based on statutory laws. Mixed systems are those in which we found a combination of traditional and modern systems of administration occurring together. In a mixed system payment may be made to private individuals, traditional leaders and/or government agencies. Enforcement may be effected through cooperation between the different parties. Traditional systems, as defined by Berkes and Farvar (1989), are those which are based on practices which have historical continuity among a group of people. In this study, these systems of management are those in which fishing restrictions were predominantly operated by the community-based traditional institutions. Traditional leaders decided whether or not fishing was allowed and when it was allowed. They sometimes received payment for allowing fishing rights and enforcement was undertaken within the community.

Traditional systems of fisheries management were the most common in the three study areas. Traditional systems operated in URB and NGW appeared to be more closely aligned to the definition of Berkes and Farvar (1989). The systems in LC are regarded as traditional only to the extent that they were controlled by traditional authorities responsible for community-based administration in general, including decisions about fisheries. This was not the case particularly in the URB (and to some extent in NGW) where specific traditional administrative structures existed for fisheries management. Modern and mixed systems were also found in a few of the villages. The variations in village level fisheries management are illustrated here by four villages: Wurro Bokki in URB (modern system), Kwatan Dawashi in LC (mixed system), Kurkushe in NGW (traditional system I) and Rugange in URB (traditional system II).

Table 3: Types of Fisheries Management regimes operating in three major artisanal fisheries of North East Nigeria: Upper River Benue (URB), Nguru-Gashua Wetlands (NGW) and the western shore of Lake Chad (LC).

Type of system	Description	Number of villages operating type of system (%)			
		URB	NGW	LC	Total
Traditional	Fisheries regulated by traditional actors and institutions based on historical practices that address conflict, resource protection, revenue collection and sharing etc.	14 (74%)	14 (56%)	3 (37%)	31 (58%)
Modern	Management by a statutory government institution. Using scientific principles of fisheries management e.g. mesh size control to protect juveniles, environment, prevention of overexploitation etc.	1 (5%)	3 (12%)	1 (12%)	5 (10%)
Mixed	Statutory government institutions working side by side (with or without conflicting interests), with community-based traditional institutions.	4 (21%)	8 (12%)	5 (62%)	5 (10%)
Total		19	25	9	53

Wuro Bokki *(modern system)*

In Wuro Bokki fishing in the nearby River Benue was monitored by officers from Adamawa State Department of Fisheries (ASDF) who had a post in the village. Management objectives stated by the department were to conserve fisheries resources and sustain the livelihoods of families dependent on the resource. The methods used included mesh-size limitations, which was promoted as part of a 'good fishing' campaign. Fishers found not complying had their catch and gear confiscated by fisheries officers from ASDF. Traditional systems had broken down as the village enlarged and inhabited immigrants that were mostly non-fishing. A large illicit petrol smuggling with outboard engines to nearby Cameroon Republic was a key source of income for many of the immigrants.

Kwatan Dawashi, LC *(mixed system)*

In LC, apart from the *sarkin ruwa*, there were no specific offices for fisheries management within the traditional administration. Instead, community heads such village heads (*bulama*) and district heads (*lawan*) that were responsible for the local administration within the Borno Emirate system of administration were also responsible for the control of access to some fisheries resources. In the villages studied in LC, the *sarkin ruwa* was usually of Hausa ethnicity and the office itself was not part of the traditional administrative system.

In Kwatan Dawashi, fishing on the floodplain of Lake Chad, around the village, was under the jurisdiction of the village head (*bulama*). Fishing in this environment took place mainly during recessional period when isolated pools and drainage channels were the main fishing grounds. The stated management objectives were: to generate revenue and to avoid conflict. The main fishing method used was a type of fish fence known as *dumba*. The fish fences were made from rows of basket traps which caught retreating fish. There were limited sites in which dumba fishing could be carried out. To be allocated a site, the fisher must negotiate a fee with the bulama. Part of the fee collected by the *bulama* is given to the Local Government Authority (LGA). The district head (*lawan*) also receives part of the proceeds. Fishing rights to isolated pools are sold before they begin to dry completely.

Kurkushe NGW *(traditional system; type I)*

Kurkushe lies on the banks of River Katagum in the Nguru-Gashua wetlands. Management regimes in Kurkushe could be divided into two main categories. Management of main river, the River Katagum, which passes by the village, was different from that of residual pools on the floodplain. Fishing on the stretch of the River Katagum by the village of Kurkushe was only open during the peak flood period.

Once the flood recedes, the river becomes a series of sectors each representing the deepest stretches of the river. The same sectors reoccur annually and the villagers had a name for each of them. The key people responsible for the management of the river sectors were the *bulama* (village head) and his 'water management council'. The council comprised of the *jarma*, the *charaku*, all *mai anguwa*s (village heads) and the *sarkin samarai* (male youth leader). The *jarma* was responsible for collecting a portion of the catch from fishers using hook lines and calabashes; the *charaku* supervised fishers using nets and the *mai anguwas* and the *sarkin samarai* were responsible for planning the fishing seasons and resolving conflicts between fishers. The river sectors were fished one at a time. Each sector was fished until it was exhausted. Selection of which sector to be fished was done randomly giving villagers the advantage of knowing the sector being currently fished and easier to detect outsiders. A four part sequence of gear use was permitted in each sector during receding flood. Large traps known as *sankiya* were allowed first. These were followed by hooks in a type of fishing known as *zabi zuba* (trial fishing). The trial fishing period was followed by fishing with clap nets known as *homa* and then finally with seine netting to complete fishing on a sector.

Management of floodplain fishing pools was different from that of the river sectors. In this case, pools were owned by individuals and families. The *bulama* and the *jarma* families were among the families that owned floodplain residual pool fishing grounds. A common practice by owners of these pools was to build fences around them during the receding flood thereby trapping fish in them. Owners, in consultation with the *bulama*, decide when to open the grounds for fishing. Once the ground was open, any member of the family (a family can consist of several households) may fish there. Non-members of the family may fish in such locations but must make some payment to the head of the family. A proportion of income earned by family from such fishing grounds was required to be given to the *bulama* as tax.

Rugange *(traditional system; type II)*

In URB most of the fishing villages were inhabited by the Bwatiye an ethnic group that lives along the River Benue with few settlements in Cameroon but most in Nigeria. All these villages had some form of traditional system of management of fisheries resources. Although there were slight variations between villages the major actors were the same in all villages.

A typical example of the Bwatiye fisheries management institutional arrangement is that found in the village of Rugange. In this village, the *kpano habiye* (water elder) had oversight of fisheries resources. His duties were similar to those of the *sarkin ruwa* in NGW and LC. All the waterbodies for which ownership was claimed by the village were under the custody of the *kpano habiye* who was different to the *kpane* (the village head). He is assisted by the *Ndomache* who acts in his absence. His chief security officer is the *kpakake* who is responsible for enforcement. The *kpano habiye* had no control on fishing on the main channel of the River Benue. However, fishers on this channel were expected to inform him when fishing on the stretch of the river by his village. According to the villagers this was necessary to enable them to mount a rescue in case of any distress on the river. All streams and channels in the proximity of the village were, however, controlled by him and he was the only one allowed to declare them open or closed for fishing. Although the *kpano habiye* had the power to declare fishing open or closed, he was not regarded as the owner of these resources but the custodian and a 'wise man' that knows best when fishing should open or close. His position is earned by virtue of his extensive knowledge of the fisheries. He is trusted to decide when a water body is ready to be fished.

The *kpano habiye* had the power to fish during the closed season, therefore, it is unlikely that his decisions to open or close the fishery were based on his personal interest.

In all Bwatiye villages, the management of streams and water channels differed from that of floodplain pools in two ways. Firstly, unlike the streams which were collectively owned by the village, isolated pools on the floodplains were owned by families or clans. Secondly, in all clan or family-owned fishing grounds, specific rituals were required before they were opened for fishing. Anyone fishing on these fishing grounds before the rituals were performed was regarded as risking their lives and those of their families by angering the spirits. In a variation of this system found in Rugange village, a specific person referred to as the *njubware* was responsible for overseeing the family floodplain fishing grounds belonging to the village. The *njubware* worked with a priest known as the *kpaplei* who was responsible for performing the necessary rituals. The *kpaplei* was part of the village traditional religious institution

headed by a chief priest referred to as the *njiojumache*. In some of the villages, such as Njoboliyo, where Christianity has had a foothold, the role of traditional religion has diminished drastically. In those villages decision making and arbitration on fisheries matters was mostly carried out by the village elders led by the village head.

The commonest form of management employed in the Bwatiye system is access restriction through closed seasons and areas. There were also restrictions on gear type which was mostly imposed on fishers from outside the village. Apart from such restrictions, once a fishing ground was declared open, anyone could come to fish there but fishers were required to make some form of payment to the owners of the ground. If the resource was owned by a clan or family, payment, usually in the form of fish, was made to the head of the clan or family. For fishing grounds owned collectively by a village, payment was made to the village head. The study found that in recent years many owners had started to demand cash payment instead of a portion of the catch.

DISCUSSION

Several issues lend themselves to discussion in relation the social-ecological characteristics observed in the artisanal fisheries in this study. However, central to all issues is the question of sustainability. In this section we discuss the potential role that the SES approach may play in enhancing sustainability in the fisheries under consideration. We discuss this from both the heuristic value perspective and the potential for application of insights gained from analysis.

The sustainability of fisheries resources has several dimensions. First of all, there is the issue of sustaining the fish stocks on which the fishery depends. These are the species of fish that are of subsistence value to the fishers. Subsistence species, however, are there because the ecological status of the environment in which they live allows them to survive and thrive. The availability of these species depends on the sustainability of the ecosystems in which they exist. It is also a key determinant of the sustainability of the livelihoods of many members of the community that depend on the resource for their living. Sustainability must therefore be viewed in holistic way. This is the idea behind the SES approach.

Heuristic value of SES frameworks

Many of SES frameworks currently in existence are designed to serve primarily as heuristic tools for studying specific phenomena in SESs. One of such phenomena is disturbance. Fleischman *et al.,* (2010) define SES disturbance as "a relatively discrete event that disrupts social and ecological communities, resulting in changes to the biophysical and social environment". Disturbance creates change and is therefore directly linked to the issue of sustainability. Drastic changes in the biophysical and social environments can affect resource availability with positive or negative consequences on the livelihoods of the communities that rely on them. A primary objective in managing SESs is to enhance system resilience (or robustness). When applied to ecological systems, resilience is defined as the capacity of a system to maintain structure and function through disturbances, without necessarily returning to a particular reference state (Folke, 2006). In SESs, ecological resilience must be viewed from an overall context that includes the robustness of the human institutions that determine how resources within the ecosystems are used. Robust human institutions are those that have the capacity, to continue to meet performance objectives despite uncertainty and shocks (Anderies and Janssen, 2007). Many variations of the SES framework are designed specifically to improve understanding of the role of disturbance and associated systems characteristics such as resilience, robustness and vulnerability.

A variation that may be useful for analysis of villages in this study, is that proposed by Alessa *et al.,* (2009). In this variation of the SES framework, human settlements are treated as discrete SESs, made up of the human inhabitants of the settlements and the biophysical environment on which they depend for their livelihoods. They define a resilient SES as that which has the capacity to meet its needs and desires within the means of its local environment. They admit that this definition is idealized since as the size of the human settlement increases it becomes less feasible to expect it to totally depend on its local environment. Despite this reservation, the framework has a great potential as a heuristic tool especially in settings such as the ones encountered in this study. Using the approach proposed by it, settlements are categorized on a continuum in which each is assessed as either trending towards

increasing resilience or vulnerability. Case-studies of individual villages could then be used for lesson-learning in other areas.

Applications to resource management

Improving our understanding of how SESs, such as the artisanal fisheries in this study, enables managers of resources to translate insights gained into management practices that promote system sustainability. In this study, for example, baseline and contextual information has revealed that traditional systems of management have been very important in sustaining the fisheries resources within the proximity of most of the villages within our study areas. The study has also revealed that some communities were already experiencing demographic changes due to the influx of outsiders (a network disturbance) and other types of disturbances that may threaten the continued existence of traditional management systems.

Potential insights from SES analysis may help identify entry points for co-management arrangements between the statutory fisheries management institutions such as the SDFs and community-based traditional actors so that they continue to play the roles that they have played in the past preventing overexploitation, mitigating conflict and ensuring a degree of equity in access to resources. These are responsibilities that centralized statutory institutions usually lack the capacity to carry out themselves. Nevertheless, as urbanization, demographic changes and other forms of system disturbance increase, traditional systems are unlikely to continue to have the capacity to effectively manage fisheries resources without some form of modification that incorporates contemporary management principles. Co-management between central government and the local users is therefore a logical way forward. The SES framework enables better understanding of the linkages that exist between actors and institutions and the way in which these can be harnessed to forge a partnership that promotes adaptive management.

FAO (2005) provide a set of criteria regarded as essential for successful co-management. These are: an enabling policy and legislative environment, empowerment of the communities, effective linkages and institutions and adequate resources. These criteria essentially constitute the roadmap for putting in place effective co-management arrangements. In our study areas, the existence of community-based traditional institutions, with long histories and vast indigenous knowledge of fisheries resources, create a fertile ground for the establishment of co-management arrangements. However a great deal of work still needs to be done in order to be able to meet the necessary criteria for putting these arrangements in place.

Conclusion and recommendations

The study confirms the complex nature of the artisanal fisheries of North East Nigeria and underlines the need for a social-ecological approach as a means for achieving sustainability. Several variations of the SES framework are available that have the potential for use in the description, analysis and planning for the sustainable management for this purpose. The choice of which framework to use will depend on the specific characteristics of the location under consideration. Fortunately, the basic data needed for analysis is usually almost the same regardless of which variation of the framework is chosen.

Secondly, the study reveals that although central government agencies have the statutory mandate for the management of fisheries in the region, they are largely absent at the community level. Where they were present, their impact on resource sustainability has been minimal or even deficient. In most fishing communities, the *de facto* institutions for fisheries resource management were community-based and mostly traditional in nature. Traditional systems operated by these institutions have largely succeeded in sustaining local fisheries resource systems and the livelihoods of the local communities that use them. These systems are however under threat from a variety of environmental challenges both social and biophysical. The demographic nature of local communities, for example, is rapidly changing. Young people who could take over traditional systems are receiving western education and moving out of communities. New ethnic groups, with different traditions, are beginning to settle in local communities. Security challenges resulting from religious insurgency have led to a drastic decline in fishing and fisheries related activities, particularly in the Lake Chad area. It is doubtful that traditional systems will be able to cope with such drastic changes. A possible way forward may be to establish co-

management arrangements in which central government provides the enabling environment to promote the adaptive capacities of existing community-based institutions for fisheries management.

Finally, the study also reveals that wide gaps still exist in the information needed for resource management planning and innovation. In particular, a great deal of work still needs to be done to obtain trend data that is essential for assessing changing patterns. Several attempts have been made to establish fisheries information systems in the past. All these attempts, including the efforts by fisheries departments of State Governments, have failed mainly because they were too centralized and over-ambitious. For future efforts to succeed information system design must incorporate stakeholder involvement and the data collection system should be decentralized with each local community collecting its own data. The role of government should be restricted to providing technical assistance to communities.

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