JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
Volume 10, Number 1 (October 2022):3921-3932, doi:10.15243/jdmlm.2022.101.3921
ISSN: 2339-076X (p); 2502-2458 (e), www.jdmlm.ub.ac.id

Research Article

Ecosystem-based management of riparian forest resources: a five-year participatory forest management plan for Volta River in Nandom Municipality, Ghana

Kenneth Peprah*, Raymond Aabeyir, Paul Kwame Nkegbe

Department of Environment and Resource Studies, P.O. Box WA64 Wa, Upper West Region, Ghana, W/Africa

*corresponding author: kpeprah@ubids.edu.gh

Article history:
Received 4 June 2022
Accepted 13 August 2022
Published 1 October 2022

Keywords:
ecosystem-based management
halieutic resources
Nandom Municipality
riparian forest
Volta River

Abstract

The combination of water and land ecosystems as found in riparian areas offers valuable ecosystem resources, in dryland areas. The aim of this paper was to draw a management plan for the utilisation, and protection of the riparian forests or woodlands along the Black Volta River in Nandom Municipality. An exploratory research design was used together with quantitative and qualitative approaches. A survey of 75 respondents from 10 communities, 10 key informant interviews, and five focus group discussions in five communities were used to collect primary data. Satellite images for 2001 and 2014 were sourced from USGS site. The results revealed that riparian forest loss was 6.4% over 13 years. There was an increase in bare area by 10.6% over the same period. The study identified 49 plant resources, 14 wildlife resources, and 25 halieutic resources. A five-year management plan was developed with community participation; the implementation of which would engender sustainability of the riparian ecosystem.

To cite this article: Peprah, K., Aabeyir, R. and Nkegbe, P.K. 2022. Ecosystem-based management of riparian forest resources: towards a participatory development of a five-year forest management plan for Volta River in Nandom Municipality, Ghana. Journal of Degraded and Mining Lands Management 10(1):3921-3932, doi:10.15243/jdmlm.2022.101.3921.

Introduction

Riparian ecosystems, particularly rivers located in arid lands are resource-rich natural environments which suffer resource exploitation due to the surrounding resource-poor environments (Broadmeadow and Nisbet, 2004; Zaimes et al., 2010; Stella et al., 2013). Hence, to curtail the degradation of such riparian ecosystems, there is a need to guide their use with a management plan. In many instances, Ecosystem-Based Management (EBM) planning regime is advocated and adopted due to its compliance with sustainability goals (Doll and Bohling, 2016). Ecosystem-based management *involves consideration of all the physical, chemical, and biological variables within an ecosystem. This also means that making decisions based on the best available scientific knowledge of the functions of the ecosystem, including the interdependence of species and the interaction between species (food chains) and the abiotic environment, as well as knowledge of the temporal development of the ecosystem* (Svelle et al., 1997; Pope and Symes, 2000:7).

The EBM aims at maintaining and improving the integrity of ecosystems; and, by so doing, it ensures the sustainability of ecosystem goods and services. This is achieved through risk management systems in which governance adopts ecosystem adaptive management for directing environmental principles and strategies to achieve developmental goals and objectives with the support of scientific information and community participation (Sarda et al., 2014). In addition, EBM is directed at human activities that degrade the ecosystem and so require effective support from the legal system (Platjouw, 2019).

In the EMB approach, the ecosystem is not being managed directly, rather the human use of the ecosystem benefits (Wasson et al., 2015). The

planning focus is no longer on limited species or narrow political boundaries rather ecosystem at landscape level (Wasson et al., 2015; Platjouw, 2019).

From the International Union for Conservation of Nature (IUCN) context, the emphasis is placed on human use of the ecosystem and the impacts thereof: 'ecosystem-based management attempts to regulate our use of ecosystems so that we can benefit from them while at the same time modifying our impacts on them so that basic ecosystem functions are preserved' (Pirot et al., 2000:1). In this regard, ecosystem-based management is recommended for both large scale projects and small scale conservation and development projects (Pirot et al., 2000).

Although there is a clear understanding that natural resources and their governance are complex issues managing, designing, and implementing effective governance arrangements for riparian resources still present serious challenges among practitioners and researchers (Mwangi and Wardell, 2012; Poteete, 2012). In the present context, the small-scale conservation and development project approach was adopted. The ecosystem-based management covers the Nandom Municipality of the Upper West Region of Ghana along the Volta River (in north-western Ghana, Black Volta River). The first objective of the study was to take inventory of the riparian resources and their linkages which addressed the potentials and constraints of these resources. The second objective centred on the organisation of a five-year EBM plan.

Theory

This study used the ecosystem-based management theory, which is defined by the United Nations Convention on Biological Diversity as:

> *Ecosystem and natural habitats management seeks to meet human requirements to use natural resources, whilst maintaining the biological richness and ecological processes necessary to sustain the composition, structure and function of the habitats or ecosystems concerned. Important within this process is the setting of explicit goals and practices, regularly updated in the light of the results of monitoring and research activities* (Pirot et al., 2000:2).

This theory is geared towards the maintenance and improvement of ecosystem composition, structure, productivity, and integrity (Burton, 2005; Sarda et al., 2014). It addresses human behaviour towards the ecosystem and the unit of analysis is the landscape not a village or a farm level (Wasson et al., 2015). It uses adaptive management which is founded on the principle of systematically learning from management outcomes (Levin et al., 2018). In addition, co-management which implies managing ecosystems jointly by government and users, is embedded in the EBM (Pope and Symes, 2000). Also, there is holistic management which entails value equality of all the components of the ecosystems and, therefore the management of a complex whole (Burton, 2005). Another tenet of the EBM is sustainability which also recognises broad management objectives (Doll and Bohling, 2016). The EMB assumes humans as an integral part of the ecosystem, whether as human-with-nature or human-in-nature (Burton, 2005; Ostrom, 2007)

Material and Methods

Study area

The EBM presupposes that management of the ecosystem happens with a geographic boundary; hence, the use of Nandom Municipality of the Upper West Region, Ghana. It is located on the intercept of longitudes 2°25' W and 2°45' W and latitudes 10°20' N and 11°00' N. Relatively, Nandom town is about 100 km away from Wa and 276 km from Ouagadougou, the national capital of Burkina Faso, by road. The Volta River (Black Volta River, the name used in north-western Ghana) is the boundary between Ghana and Burkina Faso to the west of Nandom, hence, the riparian forest of the Volta River and its tributaries. The north of Nandom Municipality is occupied by Burkina Faso, the east by Lambussie District, and the south by Lawra Municipality (Figure 1). The Municipality has land coverage of about 404.6 km^2 and contains about 84 communities (GSS, 2014). The local climate of the Municipality falls within the interior savannah climate/tropical continental climate; that is, the tropical savannah winter dry season denoted as *Aw* of the Koppen climatic classification. Average annual rainfall ranges between 1000 mm and 1500 mm with a rainy season temperature of 27 ^oC in August and a dry season temperature of 36 ^oC but could rise above 40 ^oC. The vegetation is the Guinea savannah type (woody savannah) with trees and grasses (Peprah, 2018).

Methods of study

This study combined exploratory and descriptive research designs with a mixed method approach using a case study strategy. The qualitative data were collected using a questionnaire, a key informant interview guide, and a focus group discussion guide. The quantitative data were extracted from satellite images for 2001 and 2014 downloaded from USGS site. In a previous study, a sample size of 192.8 (approximately 200) was arrived at for the whole Municipality using a sample size determination formula (Nkegbe and Doke, 2016). Also, the gallery forests were found in 21 communities in the Municipality, that is, 25% of the 84 communities in Nandom Municipality. Therefore, 25% of the sample size of 200 was 50. The sample size was increased from 50 to 75 to include non-farm workers. Therefore, the questionnaires were administered to 75 respondents from 10 communities within the

Municipality: Napaal, Sonne, Kanbaa, Tantuo, and Guri, where seven respondents were interviewed per community and Taayaga, Kogle, Kuselle, Ketuo, and Dabawteng where eight respondents, were interviewed per community. In addition, 10 key informant interviews were conducted and five (5) focus group discussions in five communities. The 10 communities were selected from the 21 gallery forest communities using random numbers in Microsoft Excel. Direct quotations from the key informant interviews were used to complement data from the questionnaire analysis. The focus group discussions were analysed to bring out the major stories of riparian resource utilisation.

The two Landsat images for 2001 and 2014 were analysed using Maximum Likelihood and post-classification change detection in Erdas 10.1 and further analysed and composed in ArcMap 10.1 software. Since the emphasis of the study was on riparian resource management, three broad land cover types were identified: riparian forest/woodland, shrubland, and bare area.

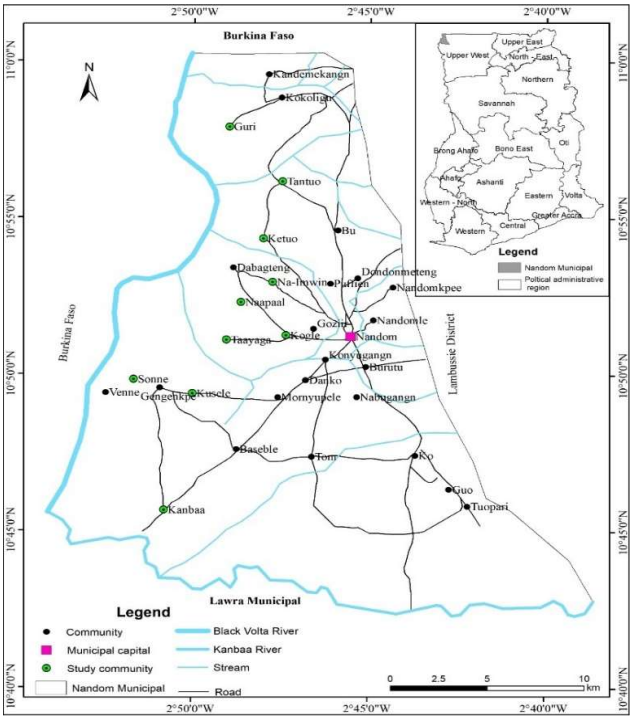


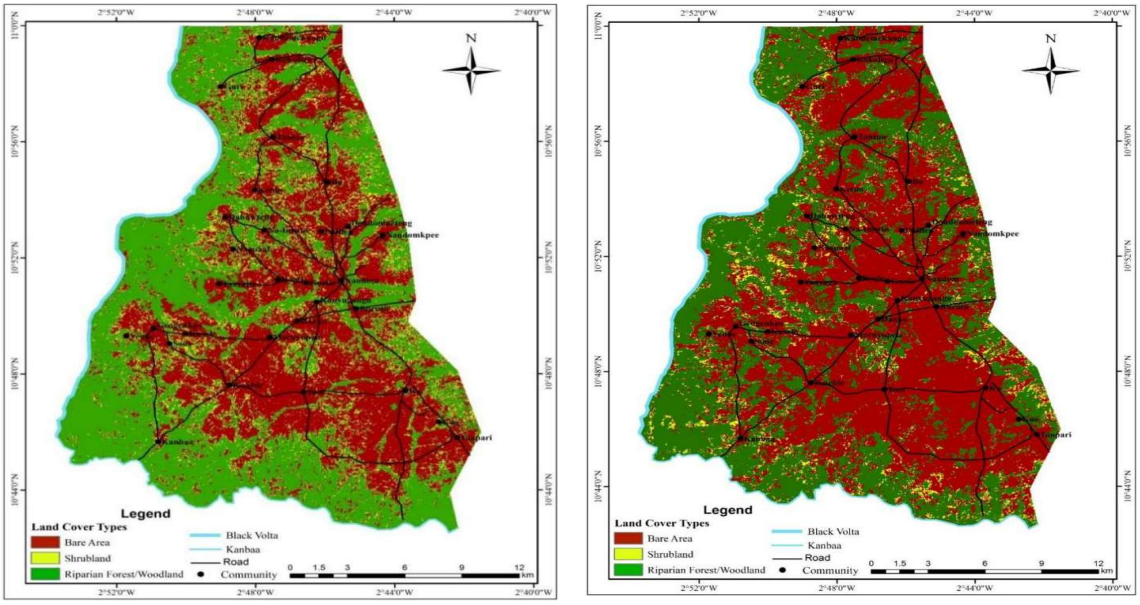
Figure 1. Map of Nandom Municipal bordered by the Black Volta River.

Results

Riparian resources

Land cover types and their spatial and temporal variation

The qualitative pattern of the land cover of the Nandom Municipality is shown in Figures 2a and b for 2001 and 2014, respectively. The spatial pattern revealed that riparian forest/woodland (green colour) dominated the landscape, especially along the Black Volta to the west and the Kanbaa River south of the municipality, respectively. Small patches of shrubland (yellow colour) were observed at the periphery of a bare area. The land cover of the Municipality as of 2014 showed a similar spatial pattern as in 2001, although the bare area was spatially more visible than in 2001 while riparian forest/woodland became less visible than in 2001. Figure 3 compares the three classes of land cover types after 13 years of anthropic pressures (2001 and 2014). The quantitative distribution of the three land cover types identified in the study revealed that riparian forest/woodland covered 48.74% of the landscape followed by bare area, which covered 41.56% in the year 2001. The shrubland covered the least of the total area of the district as of 2001 (9.70%). In the year 2014, the extent of the riparian forest/woodland and shrubland reduced to 42.32% and 5.56%, respectively, while the extent of the bare area increased to 52.11%. The qualitative impression of the changes in the land cover from 2001 to 2014 is presented in Figure 4. Persistence in the bare area and riparian forest/woodland dominate the landscape with patches of gain and loss in riparian forest/woodland. The distribution of the extent of losses in each of the three land cover categories as of 2014 is shown in Figure 5. The results revealed that the riparian forest/woodland lost 14.19% of its extent in 2001 to bare area, and 3.93% to shrubland while 30.62% of it persisted. This means that more of the riparian forest/woodland was converted to a bare area.



(a) (b)

Figure 2. The qualitative pattern of the land cover in the space of the Nandom Municipality for 2001 (a), and 2014 (b).

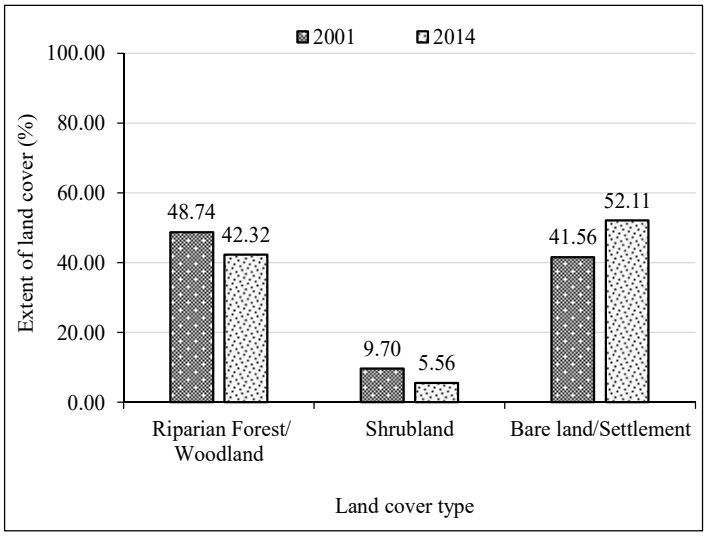


Figure 3. Extent of land cover types for 2001 and 2014.

For the same period, shrubland lost 5.42% to the bare area and 3.67% to riparian forest/woodland, while 0.61% remained unchanged. This implies that the bare area is increasing at the expense of shrubland. Also, the bare area lost 1.02% and 8.03% to shrubland, and riparian forest/woodland, respectively and 32.5% persisted. The analysis revealed that shrubland is the most vulnerable to change while the bare area is the most resistant to change. A comparison between the gain and the loss in each of the cover categories is shown in Figure 5(b). The results indicate a net loss of 6.42% in the riparian forest from 2001 to 2014. This suggests the riparian forest generally suffered degradation or deforestation of 6.42%. The bare area experienced a net gain of 10.55% for the period, whereas shrubland experienced a net decrease in extent of 4.14%.

Plant, wildlife, and animals identified in the riparian area

Tables 1, 2, and 3 show an inventory of plants, wildlife, and animals, respectively, found in the riparian area of the Volta River in the Nandom Municipal. The plants are mostly used as food through the consumption of their fruits or edible leaves, timber, and medicinal purposes (Table 1). The wildlife

resources are used mainly as meat, thereby providing direct food and income through the sale of the meat (Table 2). Table 3 indicates various kinds of aquatic animals, including crocodiles, hippopotamus, and some fish types found in the Black Volta River in the Nandom Municipal.

Potentials and constraints

Table 4 shows the summarised potentials and constraints of the various resources such as forests, fauna, halieutic, and human in the Nandom Municipal.

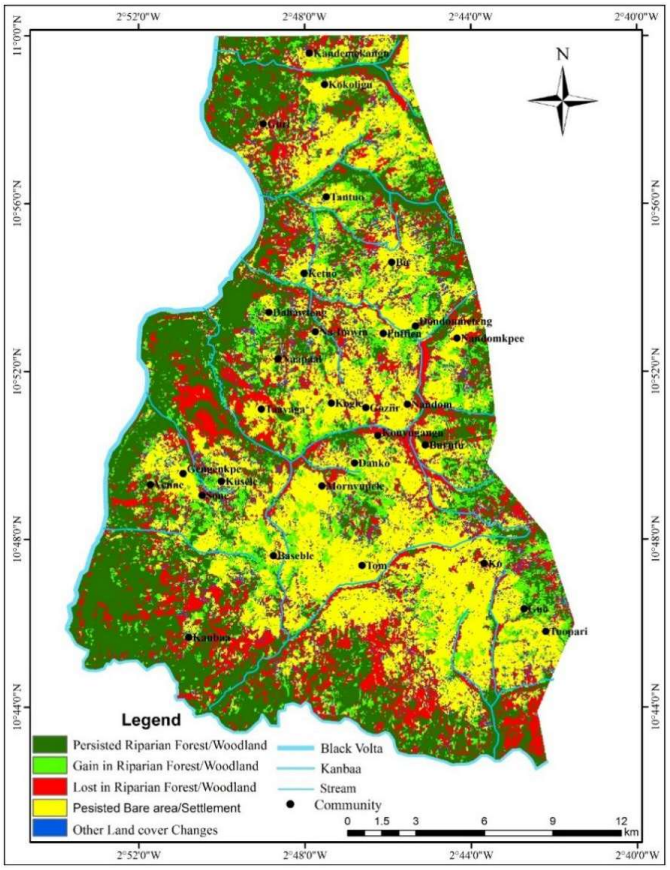
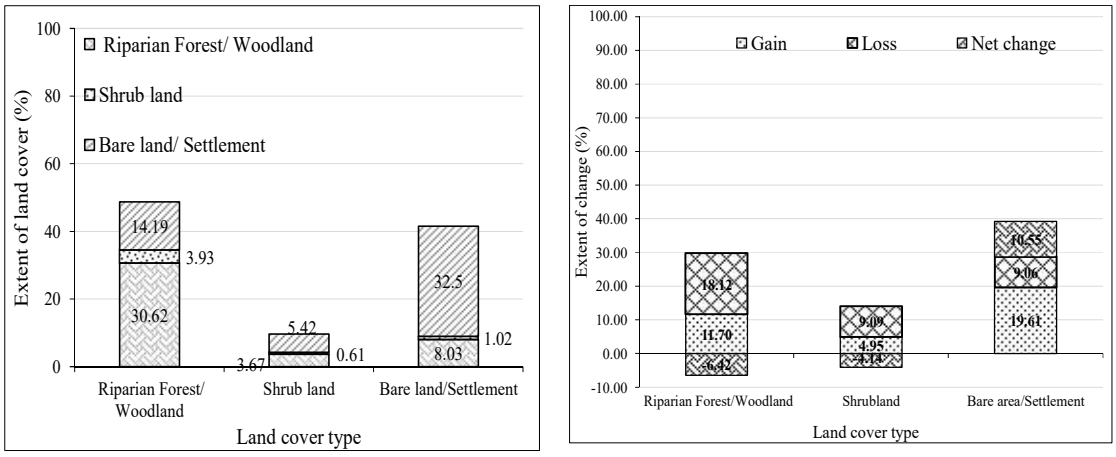


Figure 4. Spatial distribution of changes in land cover for the period 2001-2014.



(a) (b)

Figure 5. (a) Distribution of changes in land cover; (b) Summary of the changes within each land cover type for the period 2001-2014.

Table 1. Typology, uses of plant resources, and user impressions about their availability in the Nandom Municipal.

Plants			Status	Potential
Local (Dagaare) Name	**Common Name**	**Botanical Name**		
Kog	Mahogany	*Khaya senegalensis*	Scarce	Timber, Rafters, Medicinal
Gaar/Gaa	Ebony	*Diospyros mespilifomis*	Plenty	Timber, Rafters, Food-fruits, Medicinal
	Blackberry	*Rubus fruticosus*	Scarce	Firewood, Food-fruits/leaves, Medicinal
	Yellow berry	*Physalis peruviana*	Scarce	Firewood, Food-fruits/leaves, Medicinal-yellow fever
Tomgbo		*Cordia myxa*	Plenty	Firewood, Fibre for rope, Animal feed – pigs, Local grue – fruit
Sigtir	African birch	*Anogeissus leiocarpus*	Scarce	Firewood, Rafters, Medicinal – skin rashes/bodily pains
Kogtir		*Terminalia macroptera*	Plenty	Firewood, Rafters, Medicinal – roots for blood tonic, bark & roots are used as a dye
Bangna	Monkey bread/Wild bauhinia	*Piliostigma thonningii*	Plenty	Food – leaves, Medicinal – leaves for wound treatment
Yilla (Yilli)		*Mitragyna inermis*	Plenty	Food – fruits, Firewood, Rafters, Medicinal – skin rashes/chicken pox
Kankyelle	African copaiba balsam tree	*Daniellia oliveri*	Scarce	Timber, Rafters, Firewood,
Nakyiine Obgangur	African peach	*Sarcocephalus latifolius*	Plenty	Firewood, Medicinal – stomach
Gurpelle	Acacia	*Acacia sp.*	Plenty	Medicinal – jaundice
Zunsule		*Lanea sp.*	Plenty	Medicinal – waist pains
Kakala	Afzelia/African mahogany	*Afzelia Africana*	Scarce	Wood – making xylophone, medicinal, leaves used as fodder
Tantie	Shea	*Vitellaria paradoxa*	Plenty	Oil, Rafters
	Dawadawa	*Parkia biglobosa*	Plenty	Food – fruits, rafters
Pongpong/ pumpong		*Sterculia setigera*	Plenty	-
Kankan	African fig	*Ficus gnaphlocarpa*	Plenty	Food, Firewood
Liema		*Ximenia americana*	Plenty	Food
Nonuoma			Plenty	Firewood, Medicinal
Gong	Kapok/Silk-cotton tree	*Ceiba pentandra*	Plenty	Medicinal – for local poultry
Ore/ora		*Saba senegalensis*	Plenty	Food, Weaving, Medicinal
Dol	Dry zone cedar	*Pseudocedrela kotschyi*	Plenty	Medicinal – chest/abdominal pains
Liga	African rosewood/ African teak	*Pterocarpus erinaceus*	Plenty	Wood – making xylophone/mortar, firewood, fodder, nitrogen fixation
Pure	Tamarind	*Tamarindus indica*	Plenty	Food – fruits & leaves– for preparing T.Z., non-alcoholic drink
Kalenzuge		*Gardenia erubescens*	Plenty	Food – fruit/leaves for soup, medicinal
Bagnegbe/ Agna/haraa		*Vitex doniana*	Plenty	Food
Sege/ Siansule		*Lannea acida*	Plenty	Food – fruit
Kpagra	Sweet detar/ Tallow tree	*Detarium microcarpum*	Plenty	Food – fruit, Firewood

Management plan

Organisation of EBM's five-year riparian management plan

With reference to organisational structure for management of the riparian forest, Figure 6 shows an organogram. Table 5 further highlights the linkages between the community implementation committee, and the eight other stakeholders. Priorities, needs, and responsibilities of all the major actors are clearly spelt out. Following this, a logical framework was also developed in which the overall goal of the project is to ensure both land and water-based ecosystems' health and sustainability.

Table 2. Typology and uses of wildlife resources in the Nandom Municipal.

Wildlife Resources			Status	Potential
Local Name	**Common Name**	**Scientific Name**		
Taasir	Cane Eaters/ Grasscutters	*Thryonomys swinderianus*	Plenty	Meat – Food, Income from sale
Song	Rabbits	*Oryctolagus cuniculus*	Plenty	Meat – Food, Income from sale
Walla	Antelope	*Bovidae sp.*	Plenty	Meat – Food, Income from sale
Kur	Tortoise	*Testudinidae*	Scarce	Meat – Food
Mwaam	Monkey	*simiiformes catarrhini / simiiformes platyrrhini.*	Plenty	Meat – Food, Income from sale, Pet
	Deer	*Cervidae*	Scarce	Meat – Food, Income from sale
	Squirrel	*Sciuridae*	Plenty	Meat – Food, Income from sale
Zun	Python snake	*Pythonidae*	Plenty	Meat – Food, Income from sale
Ong	Rat	*Rattus*	Plenty	Meat – Food, Income from sale
Woduo/Weduo	Bush pig	*Potamochoerus larvatus*	Scarce	Meat – Food, Income from sale
	Partridge	*Perdix perdix*	Plenty	Meat – Food, Income from sale
	Bush dog	*Speothos venaticus*	Scarce	Meat – Food, Income from sale
Zanzang	Bat	*Chiroptera*	Plenty	-

Table 3. Inventory of types of animal resources in the Volta River in Nandom Municipal.

Living Animal Resources in Water			Status	Potential
Local Name	English Name	**Scientific Name**		
Ib-ba	Crocodile	*Crocodylinae*	Scarce	Food, Medicinal
Zinsaala	Black Fish	*Centrolophus niger*	Plenty	Food, Medicinal
Diallo	Mudfish	*Neochanna burrowsius*	Plenty	Food, Income from sale
Magnu	Electric Fish	*Electrophorus electricus*	Reduced Catch	Food, Income from sale
Zunsir	Red Tail	*Buteo jamaicensis*	Plenty	Food, Income from sale
Piitir	Tilapia	*Oreochromis niloticus*	Plenty	Food, Income from sale
	Hippopotamus	*Hippopotamus amphibius*	About Ten (10)	Tourism
Kur	Turtle	*Testudines*	Plenty	Food
	Catfish,	*Siluriformes*	Plenty	Meat – Food, Income from sale
	Oysters,	*Ostreidae*	Plenty	Meat – Food, Income from sale
	Lipids		Plenty	Meat – Food

Table 4. Potentials and constraints of resources in Nandom Municipal.

(A) Forest Resources	
Potentials	**Constraints**
• Availability of medicinal trees can sustain traditional medicines/herbs	✓ Annual bush burning affects the natural regeneration process of these trees in the Municipality ✓ Increasing demand for charcoal and firewood ✓ Low interest in establishing plantations for wood fuel and the local construction industry ✓ Over-dependence on natural trees for charcoal production and firewood
• Timber trees for the construction and sustenance of traditional houses	✓ Annual bush burning affects the natural regeneration process of these trees ✓ Low interest in establishing plantations for wood fuel and the local construction industry put pressure on the remaining natural timber and economic trees in the municipality
• Availability of raw materials for the local rafters to sustain their business	✓ Low interest in establishing plantations for wood fuel and the local construction industry put pressure on the remaining natural timber and economic trees in the municipality
• The presence of economic trees such as shea and dawadawa trees can sustain the shea butter and	✓ Low interest in establishing plantations for wood fuel and the local construction industry put pressure on the

dawadawa processing industries in the municipality • The trees in the forests and woodlands are sources of CO_2 sink and have the potential to mitigate climate change	remaining natural timber and economic trees in the municipality ✓ The use of economic trees for charcoal production is a threat to the local shea butter and dawadawa processing industries in the municipality ✓ Annual bush burning affects the natural regeneration process of these trees ✓ Low interest in establishing plantations for wood fuel and the local construction industry put anthropic pressures on the remaining natural timber and economic trees in the municipality ✓ Unsustainable charcoal production and uncontrolled bush burning can reduce the ability of the trees to sequester CO_2

(B) Fauna Resources

Potentials	Constraints
• The fauna resource provides opportunities to supplement the meat requirement in the municipality • The presence of fauna presents opportunities in hunting as a source of livelihood • Association of family lineages in the municipality to wild animals as totems could be a source of protection for such animals	✓ Continuous destruction of vegetation can affect the habitat and availability of the wildlife in the municipality. ✓ Hunting as a source of livelihood is a threat to wildlife in the municipality.

C) Halieutic Resources

Potentials	Constraints
• The presence of the hippopotamus in the municipality creates opportunities for tourism development • The availability of varieties of fish creates income generation opportunities for the local people in the municipality. • The halieutic resource provides opportunities to supplement the meat requirement in the municipality	✓ Increasing drought in the municipality could destroy the habitat of halieutic resources ✓ Continuous destruction of riparian vegetation can impact negatively on the availability of these resources

(D) Socio-economic Resources

Potentials	Constraints
• Presence of a radio station provides opportunity for easy and wider public education on common environmental, social, and health issues • Many health facilities (hospital, polyclinic, health centres, CHPS compounds) • Many educational institutions which create opportunities for human resource development • Good road network provides opportunities for the communities in the municipality to be connected and accessible • Presence of telecommunication companies (MTN, Vodafone) provides opportunities for social interaction and business development • The presence of the "Kakube" Festival of the people of the Nandom Traditional area provides opportunities for social interaction, advertising the culture of the people, and development opportunities	✓ Inadequate skilled personnel for industrial activities. ✓ High unemployment rate could affect the financial ability of the people to use these health facilities ✓ High unemployment rate could affect the financial ability of the people to use these health facilities ✓ Bad nature of roads (no paved road in the municipality) ✓ Interference from similar telecommunication facilities from neighbouring Burkina Faso can thwart the efforts of these communication companies and prevent others from operating in the municipality ✓ Migration of the people to the middle and southern parts of the country in search of sustainable economic activities can affect the quality of the cultural activities during the festival ✓ Inadequate sponsorship packages for the festival affect its patronage ✓ Bad nature of roads within the municipality and linking the neighbouring districts (unpaved roads) also affect the patronage of the festival

(E) Riparian Forest along Black Volta River

Potentials	Constraints
• Capable of conserving the water in the Black Volta River • Serve as a natural filter of river water	✓ Farming close to the river, felling trees close to the river for construction, charcoal and firewood ✓ lack of conscious effort to protect the riparian vegetation ✓ indiscriminate dumping of plastic waste in the municipality

• Serves as buffer zone capable of: ✓ reducing the direct flow of plastic waste into the river ✓ reduce soil erosion and siltation of the river	✓ uncontrolled bush fires in the municipality
(F) Human Resources	
Potentials	**Constraints**
• Quality human resources • Availability of labour	✓ Inadequate job opportunities can result in migration

These will be achieved through the attainment of the purpose, which is to develop five-year action plan for managing the riparian forest ecosystem. Details of the framework are obtainable from the authors upon request.

Action plan

A five-year action plan has been developed and proposed for the management of riparian forests in the Nandom Municipal (Table 6). Table 7 shows project design and implementation for the five years.

Discussion

In 2001, the riparian forest land cover type was the dominant type (48.7%). The least land cover type was shrubland (9.7%) (Figure 2a). After thirteen years, the riparian forest declined (42.3%) in area coverage (Figure 2b). From the results, there is evidence of degradation and regrowth in the riparian forest/woodland. However, the rate of degradation and that of regrowth are unmatched resulting in a net loss in the riparian forest/woodland of 6.4%. The net loss in the riparian forest/woodland is a manifestation of the adverse impact of the anthropic pressures on the riparian forest/woodland. This is a source of concern for the management and sustainability of the riparian forest/woodland. However, the evidence of regrowth suggests that the riparian areas that were converted to shrublands have the potential of regaining their original riparian state if the right measures are put in place.

The observed decline in the riparian forest/woodland (net loss) and increase (net gain) in the bare area from 2001 to 2014 is not surprising as a similar decline in closed and open savannah woodlands have been reported in the Black Volta Basin covering northern Ghana (including the Nandom Municipality) for the years 2000, 2015, and 2018 (Amproche et al., 2020). The decline in the riparian forest/woodland could be attributed to expansion of farmlands and settlements. This is consistent with the observation of Amproche et al. (2020) and Nandom District Assembly (2014) that the direct causes of degradation of the vegetation in the Municipality includes fuelwood harvesting, agriculture expansion, sand winning and development of infrastructure.

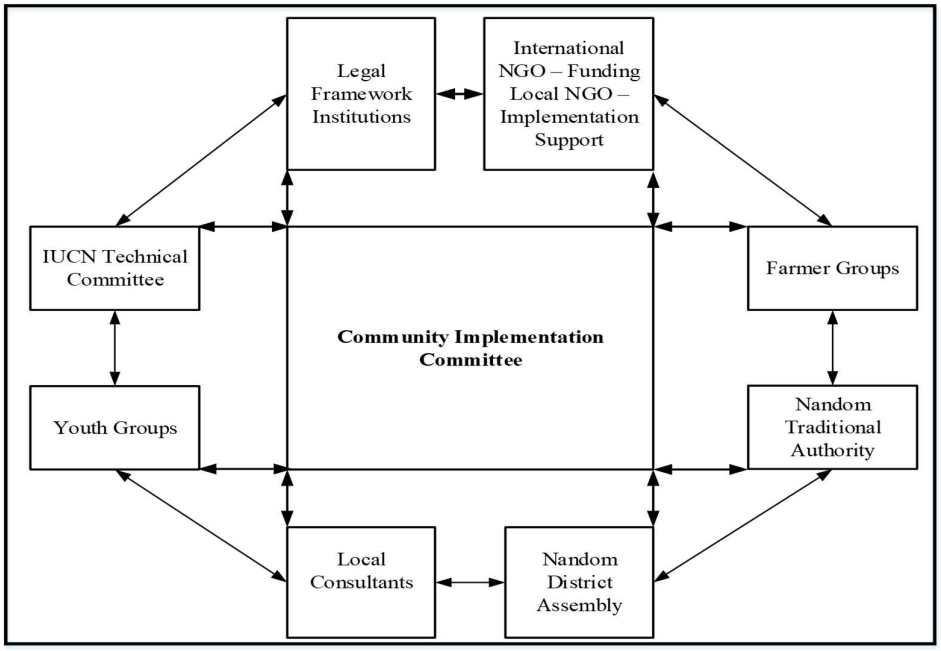


Figure 6. Organogram for implementation of five-year riparian forest management plan.

Table 5. Relationship between the Major Implementing Actors.

Key Actors for Plan Implementation	Priorities	Needs	Responsibilities
Community implementation committee	Community welfare	Flood-resistant tree seedlings, implements for putting-off bush fires [wellington boots, whistles, cutlass, motorbikes, torchlight], farm implements, Trainers for capacity building, Irrigation pumps	Mobilisation, Liaison, Formation of management committees, Prevention of bush fires and wood harvesting
International NGO	Conservation of natural environment,	Funds	Tree planting and tending; labour for fire belt creation Customs and taboos enforcement
Local NGO	Community development	Supplementary livelihoods	Tree planting and tending; labour for fire belt creation Customs and taboos enforcement
Farmer groups	Community development	Supplementary livelihoods	Enactment of byelaws
Nandom Traditional Authority	Community development	Modern political collaboration	Review, monitoring and evaluation
Nandom Municipal Assembly	Community development	Backing of the central government	Tree planting and tending; labour for fire belt creation
Local consultants	Local consultants	IUCN and community collaboration	IUCN and community collaboration
Youth groups		Employable ventures	
IUCN technical committee		Collaboration of community and local consultants	

Table 6. Five-year development and management plan for Nandom Muncipality riparian forest.

Yrs	Activities to be carried out during the year	Months of the year											
		J	F	M	A	M	J	J	A	S	O	N	D
Year I Activities	Creation of individual pits for compost making				■	■	■						
	Transplanting of tree seedlings in the individual 'compost pits'				■	■	■						
	Mulching of the tree seedlings						■						
	Creation of fence around each tree seedling				■	■	■						
	Watering or irrigating tree seedlings during the dry season	■	■	■	■	■					■	■	■
	Creation of fire belt around the riparian forest during the dry season									■	■		
	Formation of Watch Dog Committee for fire and tree felling prevention	■	■	■									
	Sensitisation and education on riparian forest resource protection										■	■	
	Introduction of alternative and supplementary livelihood options				■	■	■						
	Monitoring and evaluation	■	■	■	■	■	■	■	■	■	■	■	■
Year II Activities	Continuation of year one's activities	■	■	■	■	■	■				■	■	■
	Creation of fire belt around the riparian forest during the dry season									■	■		
	Enhancement of alternative and supplementary livelihood options				■	■	■						
	Replacement of dead tree seedlings				■	■	■						
	Watch Dog Committee continues its work	■	■	■									
	Monitoring and evaluation	■	■	■	■	■	■	■	■	■	■	■	■
Year III Activities	Continuation of year one's activities	■	■	■	■	■	■				■	■	■
	Continuation of year two's activities	■	■	■	■	■	■				■	■	■
	Creation of fire belt around the riparian forest during the dry season									■	■		
	Diversification of alternative and supplementary livelihood options				■	■	■						
	Monitoring and evaluation	■	■	■	■	■	■	■	■	■	■	■	■
Year IV Activities	Continuation of year one's activities	■	■	■	■	■	■				■	■	■
	Continuation of year two's activities	■	■	■	■	■	■				■	■	■
	Continuation of year three's activity				■	■	■						
	Increasing access to alternative and supplementary livelihood options				■	■	■						
	Monitoring and evaluation	■	■	■	■	■	■	■	■	■	■	■	■
Year V Activitie	Continuation of year two's activities	■	■	■	■	■	■				■	■	■
	Continuation of year three's activity				■	■	■						
	Continuation of year four's activity				■	■	■						
	Review of five years activities							■	■	■	■	■	■

Table 7. Years of project design and implementation.

Activities	Year I				Year II				Year III				Year IV				Year V			
	Quarters of a year																			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.Formation of Watch Dog Committee for fire and tree felling prevention																				
2: Sensitisation and education on riparian forest resource protection																				
3: Introduction of alternative and supplementary livelihood options																				
4: Monitoring and evaluation																				
5: Delineation of the riparian forest management area																				
6: Creation of fire belt around the riparian forest																				
7: Start growing of tree																				
2.4: Enhancement of alternative and supplementary livelihood options																				
2.5: Replacement of dead tree seedlings																				
3.1: Enforcement of forest and wildlife policies																				
3.2: Individual, traditional authorities and committees monitoring																				

Furthermore, the Nandom Municipality is reported to have a high degradation index and is vulnerable to degradation because the Municipality has been granted more exploration leases than it can support (Moomen and Dewan, 2016). In a study of riparian forests in Kenya, closed forest was reduced by 52.7% from 1990 to 2010, and shrubland was reduced by 21.7% for the same period. However, with the introduction of legislation illegalising consumptive forest use, closed forests increased by 30.8% from 2010 to 2017 and shrubland increased by 35.1% for the same period (Muhati et al., 2018).

Analysis of the transition of the riparian forest/woodland to the other land cover types shows that it lost more of its state to the bare area than to shrubland from 2001 to 2014. This is also an indication of the intensity of the anthropic pressures on the riparian forest/woodland in the municipality. The transition from forest/woodland to bare area within the period raises questions about the short to medium-term sustainability of the riparian forest/woodland if more of it is converted to the bare area. This is because the bare area cannot easily transition to riparian forest/woodland through natural regeneration in the short-term considering the poor climatic and soil conditions of the area. This could be attributed to the expansion of farmlands and settlements into the riparian areas as the Nandom area developed from a sub-district status in 2001 to a district status as of 2014 (Nandom District Assembly, 2014). For the same period, shrubland coverage was 9.7% in 2001, lost 5.4% to the bare area and 3.7% to riparian forest/woodland while 0.6% remained unchanged.

The analysis of the transition of the shrubland to the other land cover types revealed that the bare area is increasing at the expense of shrubland as it lost more than half of its original extent in 2001 to the bare area. However, the bare area showed resilience to change (32.5%) for the same period as it lost marginally to shrubland (1%) and riparian forest/woodland (8%). This suggests that the bare area consists of permanent areas such as settlements and farmlands. The results revealed that shrubland is the most vulnerable to change while the bare area is the most resistant to change. The increase (net gain) and high persistence in the bare area from 2001 to 2014 is not a surprise as the Municipality is reported as one with the highest population density in the Upper West Region (Nandom District Assembly, 2014). However, the observed net gain in the bare area from 2001 to 2014 is not as large as the 21% gain in the bare area from 2000 to 2015 as reported in Amproche et al. (2020). The difference could be attributed to differences in the extent of the study area, temporal interval, and definition of the land cover categories.

About 49 plant resources were identified by the respondents, 14 wildlife resources, and 25 animals living in the Volta River (halieutic resources). These resources offer the potential for socio-economic development of the Municipality amidst various constraints to the exploitation and use which border on sustainability issues. The degradation earlier alluded to is an indication of unsustainable anthropic pressure exerted by the residents.

The organogram indicates major stakeholders as the implementing committee, farmer associations, Nandom Traditional Council, Nandom Municipal Assembly, youth groups, local consultants, international consultant (IUCN), legal system, and non-governmental organisations (local and international). Stakeholder analysis has been provided in Table 5. Tables 6 and 7 are activity schedules to aid the implementation of the plan. The monthly schedule is shown in Table 6 and the quarterly schedule for five years is provided in Table 7.

Conclusion

The Nandom Municipality along the Volta River is a very rich riparian ecosystem that has suffered degradation due to human pressures exerted on the available plant, wildlife, and halieutic resources. Bare area and settlement have become the dominant land cover type instead of the previously dominated riparian forest/woodland. However, 49 plant resources, 14 wildlife resources, and 25 halieutic resources are an indication of the great potential of resources to support the socio-economic development of the Municipality. Nonetheless, without proper planning to ensure sustainable utilisation of these resources, the downward spiral of resource degradation will heighten. Therefore, the proposal for a five-year plan including the plan's organogram, stakeholder analysis, and time schedules, will ensure adequate protection of both river water and the adjacent land ecosystems.

Acknowledgements

We are very thankful to the International Union for Conservation of Nature (IUCN) for selecting our team to carry out this research. We are equally grateful to IUCN for the research grant. We appreciate the working relationship with the IUCN-Burkina Faso staff and we thank the members of the study communities in Nandom for the data and cooperation during the research.

References

Amproche, A.A., Antwi, M. and Kabo-Bah, A.T. 2020. Geospatial assessment of land use and land cover patterns in the Black Volta Basin, Ghana. *Journal of Remote Sensing and GIS* 9:269, doi:10.35248/2469-4134.20.9.269.

Attuquayefio, D.K. and Fobil, J.N. 2005. An Overview of biodiversity conservation in Ghana: Challenges and prospects. *West African Journal of Applied Ecology* 7:1-18, doi:10.4314/wajae.v7i1.45621.

Broadmeadow, S. and Nisbet T.R. 2004. The effects of riparian forest management on the freshwater environment: a literature review of best management practice. *Hydrology and Earth System Sciences* 8:286-305, doi:10.5194/hess-8-286-2004.

Burton, J.P. 2005. Ecosystem management and conservation biology. In: Watts, B.S. and Tolland, L. (eds.), *Forestry Handbook for British Columbia*, (Vancouver: Faculty of Forestry, University of British Columbia), 308-319.

Doll, C. and Bohling, K. 2016. Ecosystem-based management and forestry on the Central Coast of British Columbia, Canada. Munich: School of Management, Technische Universitat Munchen.

GSS. 2014. 2010 Housing and Population Census, District analytical report, Nandom District (Accra: Ghana Statistical Service).

Levin, S.P., Essington, E.T., Marshall, N.K., Koehn, E.L., Anderson, G.L., Bundy, A., Carothers, C., Coleman, F., Gerber, R.L., Grabowski, H.J., Houde, E., Jensen, P.O., Möllmann, C., Rose, K., Sanchirico, J.N. and Smith, D.M.A. 2018. Building effective fishery ecosystem plans, *Marine Policy* 92:48-57.

Moomen, A.-W. and Dewan, A. 2016. Assessing the spatial relationships between mining and land degradation: evidence from Ghana. *International Journal of Mining, Reclamation and Environment* 1-14, doi:10.1080/17480930.2016.1188253

Muhati, L.G., Olago, D. and Olaka, L. 2018. Land use and land cover changes in a sub-humid Montane Forest in an arid setting: A case study of the Marsabit forest reserve in northern Kenya. *Global Ecology and Conservation* 16: 1-17, doi:10.1016/j.gecco.2018.e00512.

Mwangi, E. and Wardell, A. 2012. Multi-level governance of forest resources. *International Journal of Commons* 6(2):79-103, doi:10.18352/ijc.374.

Nandom District Assembly. 2014. Maiden Medium Term Development Plan for Nandom District (2014-2017). Government of Ghana Ministry of Local Government and Rural Development.

Nkegbe, P.K. and Doke, D. 2016. Contribution of riparian areas to food security and adaptation to climate variability and change in the Nandom District in Ghana. IUCN Burkina Faso. Mimeo.

Ostrom, E. 2007. A diagnostic approach for going beyond Panaceas, *Proceedings of the National Academy of the Sciences of the United States of America* 104(39):15181-15187, doi:10.1073/pnas.0702288104.

Peprah, K. 2018. Agroclimatology of Africa with Special Reference to Ghana. Woeli Publishing Services Accra.

Pirot, J.Y., Meynell, P.J. and Elder, D. 2000, Ecosystem Management: Lessons from around the World (Gland, Switzerland and Cambridge, UK: International Union for Conservation of Nature (IUCN).

Platjouw, M.F. 2019. Dimensions of transboundary legal coherence needed to foster ecosystem-based governance in the Arctic. *Marine Policy* 110:1-10.

Pope, J.G. and Symes, D. 2000. An Ecosystem Based Approach to the Common Fisheries Policy: Defining the Goals', (Petersborough, UK: JNCC).

Poteete, A. 2012. Levels, scales, linkages, and other 'multiples' affecting natural resources. *International Journal of Commons* 6 (2):134-150, doi:10.18352/ijc.318.

Sarda, R., O'Higgins, T., Cormler, R., Diedrich, A. and Tintore, J. 2014. A proposed ecosystem-based management system for marine waters: linking the theory of environmental policy to the practice of environmental management. *Ecology and Society* 19(4):51-65, doi:10.5751/ES-07055-190451.

Stella, J.C., Rodriguez-Gonzalez, P.M., Dufour, S. and Bendix, J. 2013. Riparian vegetation research in Mediterranean-climate regions: common patterns, ecological processes, and considerations for management. *Hydrobiologia* 719:291-315, doi:10.1007/s10750-012-1304-9.

Svelle, M., Aarefjord, H., Heir, H.T. and Øvreland, S. 1997. Assessment Report on Fisheries and Fisheries Related Species and Habitats Issues. Oslo: Ministry of the Environment.

Wasson, K., Suarez, B., Akhavan, A., McCarthy, E., Kildow, J., Johnson, S.J., Fountain, C.M., Woolfolk, A., Silberstein, M., Pendleton, L. and Feliz, D. 2015. Lessons learned from an ecosystem-based management approach to restoration of a California estuary. *Marine Policy* 58:60-70, doi:10.1016/j.marpol.2015.04.002.

Zaimes, G.N., Iakovoglou, V., Emmanouloudis, E. and Gounaridis, D. 2010. Riparian areas of Greece: their definition and characteristics. *Journal of Engineering Science and Technology Review* 3(1):176-183.