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The relevance of mangrove forests to African fisheries, wildlife and water resources

FAO Regional Office for Africa

Nature & Faune is a peer-reviewed open access international bilingual (English and French) publication dedicated to the exchange of information and practical experience in the field of wildlife and protected areas management and conservation of natural resources on the African continent. *Nature & Faune* has been in wide circulation since 1985.

Nature & Faune is dependent upon your free and voluntary contribution in the form of articles and announcements in the field of wildlife, forestry and nature conservation in the Region.

Front Cover Photos, From Left:
Mangrove – home of wildlife, Kenya, James Gitundu Kairo; Mangrove crab fishermen in Kenya, James Gitundu Kairo; Natural mangrove stand (*Rhizophora mucronata)* along the shore of a river, Kenya, James Gitundu Kairo; A boy and his Fish, Togo, anonymous.

Bottom background: Mangrove trees lining a body of water, Senegal, Lyes Ferouki.

Back Cover Photos, From Left:
Degraded mangrove area in Kenya, James Gitundu Kairo; Mangroves in Red sea area of Sudan, Michel Laverdière; Mangrove wood products, Kenya, James Gitundu Kairo; Stand of red mangroves (*Rhizophora racemosa*) showing typical arch-formed stilt roots and aerial roots descending from branches, Sierra Leone, Mette Loyche Wilkie

Bottom background: Mangrove trees lining a body of water, Senegal, Lyes Ferouki

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FAO REGIONAL OFFICE FOR AFRICA

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Message to Readers

Maria Helena Semedo[1]

The world celebrates International Day for the Mangrove on the 26th of July every year! In line with the commemoration of this Day, the subject of this edition of *Nature & Faune* is a simple question: *What is the relevance of mangrove forests to African fisheries, wildlife and water resources?* It is under this banner that we tease-out elements of the mangrove ecosystem in Africa and glue them into a seamless tapestry to reveal the importance of proper management, conservation and use of mangroves.

The present edition offers a collection of 14 diverse articles highlighting different aspects of mangroves - from the lush natural stands, wildlings, nursery practices, enrichment planting, to the various uses of the mangrove ecosystems as paddy rice fields, along with fisheries and wildlife sanctuaries and salt exploitation areas. The *Special Feature* highlights an original work from Cameroon, which provides good insight into mangrove forest management from community to national level. It also provides perspectives at policy level and relevant structures through which the integrity of mangroves can be enhanced and degradation reduced. Another interesting feature of this volume is the '*Country Focus'* which explains how Madagascar's wildlife, water resources and fisheries entwine with its mangrove ecosystems.

This edition of *Nature & Faune* is the most voluminous Issue published so far, occupying over a hundred knowledge-filled pages as it strives to capture the wide scope of issues relating to mangrove management in Africa. The contributions include writings on the value of mangroves from those who are working in this field. This Issue looks at innovative ideas and best practices that have been used around the region to address pressing challenges in conservation of mangroves.

Acknowledging that mangrove ecosystems play key roles in the interface between forests, water and fishery resources and agriculture; and indeed in the whole economy of coastal areas, *Nature & Faune* received articles from experts in diverse relevant disciplines. It is therefore not surprising that specialists in water resource utilization, watershed management, aquaculture, capture fisheries, agriculture, wildlife and forest management all contributed to this edition.

The variety of uses and interactions that are discussed in the articles is fascinating. These articles accompanied by regular features, review the multiple interconnections; asking who should care about these mangrove forests and how all the different users may achieve sustainable management.

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Let's get started in discovering what unique and individual aspects of mangroves are unfolding in this edition of *Nature & Faune*.

Finally, subscribers and readers have paid tribute to two members of the Board of Reviewers who passed away during their active tenure on the Board. Adieu comrades Jean Djigui Keita and Alan W. Rodgers!

FAO REGIONAL OFFICE FOR AFRICA

Editorial

African mangroves: their importance for people and biodiversity

Ricardo Carrere[1]

Africa is richly endowed with mangroves, which cover over 3.2 million hectares, extending from Mauritania to Angola on the Atlantic coast and from Somalia to South Africa along the Indian Ocean. Mangrove covered countries in West and Central Africa include Mauritania, Senegal, Gambia, Guinea Bissau, Guinea Conakry, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea, Sao Tome & Principe, Gabon, Congo, Democratic Republic of Congo and Angola. Eastern African mangroves are found in Somalia, Kenya, Seychelles, Tanzania, Madagascar, Mozambique and South Africa (Ajonina et al 2008).

International discussions on forest conservation have dedicated insufficient attention to mangrove forests. Some of the reasons for concentrating on other types of forest ecosystems –particularly tall inland tropical rainforests- could be that these appear to have more economic value and to host higher levels of biodiversity than mangroves. Both assumptions could be challenged.

Mangroves and people's livelihoods

Mangrove forests have a huge value for coastal communities that derive their livelihoods from them. Although commonly defined as "poor" in official statistics, communities living in healthy mangrove areas have what many urban people lack: diverse and abundant food. Additionally, mangroves provide many of their needs, usually complemented with other productive activities such as farming, poultry, bee-farming and so on. Mangrove wood is a multi-purpose resource for fish stakes, fish traps, boat building, boat paddles, yam stakes, fencing, carvings, building timber, fuel and many other uses (World Rainforest Movement [2]. 2002).

The Rufiji River Delta mangroves provide a good example on the above. Located in southern Tanzania, it is the largest delta in Eastern Africa and contains the largest estuarine mangrove forest on the eastern seaboard of the African continent. The Delta region is home to over thirty thousand people who live, farm and fish in its fertile agricultural lands and rich fishing grounds. The latter produce over 80 per cent of Tanzania's prawn exports with the entire catch being wild prawns (Lawyers' Environmental Action Team).

The importance of mangroves for local communities becomes even clearer when they are degraded or disappear. In the case of Senegal, oysters, shrimp, tilapia, barracuda and

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[2] *The World Rainforest Movement is an international network of citizens' groups of South and North involved in efforts to defend the world's rainforests. It works to secure the lands and livelihoods of forest peoples and supports their efforts to defend their forests from commercial logging, dams, mining, oil exploitation, plantations, shrimp farms, colonization and settlement and other projects that threaten them.*

catfish are among the many fish species that live in Casamance's mangrove forests, but now, as a result of mangrove degradation "you can only find big fish, as well as shrimps and oysters, but you can no longer find catfish or other varieties, while there used to be plenty." (See Box1).

Box 1
The importance of mangroves for local communities: the case of Senegal

The depletion of fish stocks has particularly affected women who sell fish in bulk: "*Women are closely involved in the fishing economy in this region. We sell fish, shrimp and oysters in the market and can earn up to US$20 a day from this, which greatly benefits our families. Now it is difficult for fish-sellers in Ziguinchor markets to earn even US$4 a day because there is so little fish left to sell.*" The disappearance of mangroves harms other crops as well. Fewer mangroves means increased salt content of the water, which impedes the growth of paddy rice. "*When we plant the rice now, it doesn't grow because there is so much salt in the water.*"
Source: (IRIN- Senegal 2008)

The importance of mangroves in biodiversity conservation
Regarding biodiversity, mangrove forests have few tree species to show (6 to 10), which may lead people to think that they are biodiversity-poor. In fact, they are exactly the opposite: mangroves are an irreplaceable and unique ecosystem, hosting incredible biodiversity and ranking among the most productive ecosystems in the world. They house a wide variety of life: migratory birds, marine creatures and reptiles in addition to associated species of flora.

The aerial roots of their trees form a complex web, hosting a multitude of animal species (fish, molluscs, crustaceans) and they operate as zones for mating, refuges and nursery areas for a large number of other species. The enormous quantities of fish and invertebrates that live in these coastal waters, provide an abundance of food for monkeys, turtles, and aquatic birds and they serve as an important migratory point for many birds. (National Geographic. - Central African mangroves http://www.nationalgeographic.com/wildworld/profiles/terrestrial/at/at1401.html) (World Rainforest Movement 2002).

The Baly Bay, located to the West coast of Madagascar serves to illustrate the important biodiversity value of mangroves. Many species of animals use the bay's 7200 hectares of mangroves as nesting, roosting and feeding areas. Among the nine threatened and endemic Madagascar waterbird species, five are recorded inside the mangrove (*Ardea humbloti*, *Anas bernieri*, *Threskiornis bernieri*, *Haliaeetus vociferoides* and *Charadrius thoracicus*). For mammals, two species are recorded inside the bay, namely, the Madagascar bat *Pteropus rufus*, roosting on mangrove trees and *Delphinus sp*. In addition, mangroves constitute an important habitat for invertebrates. The most economically important is the crab *Scylla serrata* and two shrimp species: *Penaeus indicus* and *P. monodon*. (World Rainforest Movement 2002).

The economic and environmental importance of this ecosystem extends to very distant areas, as shown by the Nigerian area of mangrove swamps that stretches through the coastal states, with 504,800 hectares in the Niger Delta and 95,000 hectares in Cross River State. The mangrove forests of Nigeria rank as the largest in Africa and as the third largest in the world. By some estimates, over 60% of fishes caught between the Gulf of Guinea and Angola breed in the mangrove belt of the Niger Delta (World Rainforest Movement 2002). Mangroves have been sustainably managed by the many generations of communities living there. Sustainable use has been possible because of their profound knowledge about this ecosystem, passed on from generation to generation.

Causes of mangrove loss and degradation

However, a number of changes have taken place over the last few decades that have resulted in mangrove destruction or degradation in many countries. The direct and underlying causes that have led to the current situation have yet to be adequately assessed in each country. What follows is only a broad overview of what we consider to be the main direct causes of mangrove loss and degradation. It is important to stress that two different processes (frequently related) affecting mangroves can be observed: total destruction or degradation.

In some cases their total destruction may be due to urbanization, large-scale tourism undertakings, rice production or their eradication to give way to commercial shrimp farming. In other cases, partial deforestation is further aggravated by mangrove degradation – where most trees may remain standing – due to activities such as oil exploitation or mining. That is to say, the installation of pipelines, seismic exploration and open cast mines cause deforestation; while oil-spills, gas flaring and waste dumping pollute the water and the air and seriously degrade the ecosystem as a whole. Another important cause of "invisible" degradation is the use of agro-toxics in nearby agricultural production, where toxic chemicals end up in this ecosystem, thus resulting in severe impacts on mangrove biodiversity and peoples' livelihoods.

In terms of degradation, major oil spills have occurred that have devastated rivers, killed mangroves and coastal life and affected the health and livelihoods of millions of inhabitants. Although this has happened in several countries in both Eastern and Western Africa, the case of the Niger Delta is probably the worst. As denounced by Amnesty International, the local communities living there rely on "the land and natural waterways for their livelihood and sustenance. Now, they have to drink, cook with and wash in polluted water and eat fish contaminated with toxins. They have lost farming land and their incomes from oil spills and breathe air that reeks of oil, gas and other pollutants." (Amnesty International Australia 2009)

A further form of mangrove degradation results from overexploitation of its resources – both the trees themselves or the fish and other aquatic live forms that live there. In Africa, excessive mangrove wood extraction has been linked to fish smoking, building materials, fuelwood and charcoal production.

The shrinking African mangroves

During the last decades, African mangroves have been increasingly affected by deforestation. In West Africa, mangrove areas have diminished from 20,500 km2 in 1980 to their current 15,800 km2, while in Central Africa they have been reduced from 6,500 km2 in 1980 to 4,300 km2 at present (Ajonina et al 2008). Estimates of existing mangrove areas in Eastern Africa range from 2,555 km^2 to 7,211 km^2 (The Encyclopedia of Earth. 2007) and no data appears to be available as respects to the rate of mangrove loss –which has in fact occurred- during the past decades. According to the FAO, Africa has lost about 500,000 hectares of mangroves over the last 25 years. (FAO. 2007)

However, those figures cannot show the extent of mangrove ecosystem degradation, which is probably much more important than mangrove loss and is impacting heavily on both local communities' livelihoods and mangrove biodiversity. Within that context, efforts should be made to ensure sustainable use of existing mangroves, to restore degraded areas and to replant mangrove forests whenever possible and viable.

Addressing existing causes and preventing new ones

For the above to be possible, the necessary starting point is to identify and address all the direct and underlying causes of mangrove loss and degradation. In this respect, it is important to note that while most of the former have already been identified, the underlying causes are still a matter of debate that needs to be studied much further. Such analysis is fundamental in order to avoid the easy solution of putting the blame on "poverty" or "population growth", while obscuring the role of governments, international institutions and corporations in mangrove loss and degradation.

While existing problems are addressed, it would be wise to prevent the development of new ones. In this respect, policies should be adopted and implemented to stop the expansion of unsustainable industrial shrimp farming, which is now looking at Africa's mangrove areas as a new business opportunity to be exploited with little regard to the ecosystem. The negative social and environmental impacts of this activity are already well documented in all the countries where it has established itself, particularly in Latin America and Asia. The result, in country after country, is that industrial shrimp farming destroys mangroves, biodiversity and local peoples' livelihoods. The impacts of the few existing cases of industrial shrimp farming in Africa should also serve as a basis for convincing governments on this issue.

African mangroves should be allowed to continue to play the role they have traditionally played: to ensure local peoples' livelihoods through the conservation and wise use of their rich biodiversity.

References

Ajonina, Gordon, Diamé, Abdoulaye and James Kairo.- Current status and conservation of mangroves in Africa: An overview. WRM Bulletin 133, August 2008 http://wrmbulletin.wordpress.com/2008/08/25/current-status-and-conservation-of-mangroves-in-africa-an-overview/

Amnesty International Australia.- Shell in Niger Delta: The human rights cost of oil**,** 29 June 2009 http://www.amnesty.org.au/action/action/21246/
FAO- The world's mangroves 1980-2005, Rome 2007
http://www.fao.org/docrep/010/a1427e/a1427e00.htm

IRIN.- Senegal: Protecting livelihoods through mangroves, October 2008
http://www.alertnet.org/thenews/newsdesk/IRIN/d2e5bbe9dfa22c9a29675400ea01f7a9.htm

Lawyers' Environmental Action Team.- Case Study 1: Lessons from Rufiji Delta
http://www.leat.or.tz/publications/foreign.investment/2.rufiji.case.study.php

National Geographic.- Central African mangroves
http://www.nationalgeographic.com/wildworld/profiles/terrestrial/at/at1401.html

The Encyclopedia of Earth.- East African mangroves, September 2007
http://www.eoearth.org/article/East_African_mangroves

World Rainforest Movement.- Mangroves. Local livelihoods vs. corporate profits, 2002
http://www.wrm.org.uy/deforestation/mangroves/book.pdf

ANNOUNCEMENTS

THE GREAT MANDINGO WARRIOR IS GONE
(Tribute to Jean Djigui Kéita: 1936-2009)

Jean Djigui Kéita: 1936-2009

At first sight, he was viewed as an Old Wise African,
However, never has anyone had a younger spirit;
His mixed blood made people think he was a Westerner,
But he was an African from within;
And most of all, he possessed an absolutely fantastic African and Mandingo culture.

This is not a riddle, but rather an attempt to sum up the personality of a man I met in the Spring of 1979, as he had just been recruited as Senior forestry officer of the FAO Regional Office for Africa and was supervising the study tour of a group of young

African forestry officers in China. During this trip, we all came to learn to love and appreciate the numerous qualities of Jean Djigui Kéita.

He wanted to be called Djigui, but forestry officers in Mali respectfully and affectionately called him 'le Colonel'. He possessed the natural charisma needed to be a leader. His mere presence was enough to ensure the success of our regional seminars and workshops as he knew how to put everybody at ease and arouse attention and admiration through his vast knowledge of African cultures. They all wanted to be around him and searched for his company.

The name Djigui has been associated with the 'Nature et Faune' magazine that he created and of which he wrote several of the editorials. This magazine facilitated the emergence of numerous African authors in the field of wildlife and protected areas. To this day, 'Nature et Faune' continues to thrive and represents a tangible result of the wonderful work done through the African Task Force on Wildlife and national parks that Djigui masterfully and with dedication animated for almost 20 years. Until his fateful demise, Djigui was an active member of the writing committee of 'Nature & Faune'.

Beyond his role as FAO Regional Officer, Djigui also invested himself, together with other colleagues, in creating the Sahelian Forestry Officers Association of which the statutes have been formally registered in Dakar, Senegal.

I will remember with fondness a young retired officer who honored me during one of my missions in Bamako by giving me a tour of his beautiful house on the hilltop and who was so proud to walk me through the small teak and eucalyptus forest he planted years ago. He had a hard time bringing himself to cutting down trees in his forest even though they were ripe for exploitation. We spent that morning discussing silvicultural treatments and exploitation conditions of artificial woodlots in the Sahelian zone.

My last memory of Djigui goes back to early 2006 during the FAO Regional Conference for Africa held in Bamako. This vibrant FAO retiree never wanted to miss one session, taking notes as if he was still part of the Secretariat, chatting in the corridors as if he was part of the official delegations. I will never forget the dried meat he offered us on the day we departed, knowing very well how much we enjoyed it as he was the one who introduced us to it during the 10 o'clock coffee breaks he used to organize with so much friendliness in his office in Accra.

Djigui, I personally owe you this discreet and sincere friendship, this brotherly affection I had the opportunity to appreciate several times and this fruitful collaboration from the time I joined this organization, and beyond your retirement.

Rest in peace, Mandingo warrior, and may the land you revered so much welcome you.
By Pape Djiby Koné

TRIBUTE TO ALAN W. RODGERS

(*Ecologist, Botanist, Zoologist and Conservationist*)

Alan W. Rodgers: 1944 - 2009

The purpose of this tribute is to provide readers of Nature & Faune with a concise overview of the amazing life and works of Alan Rodgers, a member of its Board of Reviewers.

He was an extraordinary man who left an indelible mark on the world.

He was born in Liverpool in 1944. As a child he moved with his family to Nairobi where his father took up a lectureship he had been offered. Alan's high school education and undergraduate studies in botany and zoology were in Nairobi. At graduate level, he completed a Master's degree in conservation in Aberdeen and a doctorate in ecology at the University of Nairobi.

In the course of his working life Alan Rodgers contributed to conservation and science in diverse ways.

In 1965 he was appointed as an ecologist for the Game Department in the vast and remote Selous Game Reserve in Tanzania, which must have been a marvellous experience for a young man of his abilities and interests. He worked in the Selous for 11 years. He took part in anti-poaching patrols and conducted wildlife census counts in the aircraft that he piloted. He set up the Miombo Research Centre and produced a many scientific papers on the ecology of Africa's largest wilderness reserve, on topics ranging from lions, elephants and the ivory trade to the effects of fire on vegetation.

By 1976 Rodgers was recognised as a world expert on Miombo woodland ecology and was given a position as a lecturer at the Zoology Department of the University of Dar es Salaam. Here he eagerly shared his knowledge and inspired a generation of students, many of whom were later to join his informal army of conservationists in the common cause of protecting East Africa's natural heritage.

During this time Rodgers's many initiatives included a permanent research station on the edge of the Ngorongoro Crater to discourage corrupt officials from getting involved in rhinoceros poaching. He further co-founded the Tanzania Forest Conservation Group in 1982 and led students on field trips to spearhead research into the remaining fragments of Coastal Forest, another overlooked ecosystem with large numbers of rare animals and plants. Rodgers oversaw the activities of the Tanzania Forest Conservation Group for the rest of his life, and it is today Tanzania's foremost forest conservation organisation, with 45 staff supporting the management of more than 100,000 hectares of forest.

From 1984 until 1991 Rodgers worked at the Wildlife Institute of India. He produced many more scientific papers on subjects ranging from snow leopards to sacred groves, together with his monumental work *A Biogeographical Classification of India*, which is now one of the most cited and used documents in the field of wildlife conservation in India. Rodgers was the key architect in developing "wildlife science" in India, and through his contribution the institute has subsequently produced a vast array of competent biologists who are now contributing to the cause of conservation across the globe. With HS Panwar, he also put together the voluminous *Action Plan for Protected Areas Networks* in a country with a far greater human population pressure than in East Africa. This experience was to emphasise to Rodgers the urgent need to formally protect as much habitat as possible before it was too late.

Rodgers returned to East Africa in 1992, on the eve of the Earth Summit in Rio and the UN Convention on Biodiversity, to set up a project financed by the Global Environment Facility to support the management of East African Biodiversity. As chief technical adviser for this initiative, Rodgers skillfully used his prominent position to increase the protection afforded to the most important remaining patches of forest. His two great causes, the Eastern Arc Forests and the Eastern African Coastal Forests, which were hardly known at the start of the 1980s, were included in the internationally recognised list of the world's 34 biodiversity hotspots by the end of the millennium. After years of dormancy, many new forest reserves and nature reserves were gazetted through his efforts, as well as the Jozani National Park on Zanzibar Island.

Rodgers later served as the regional technical adviser to the UN Development Programme and Global Environment Facility initiatives in East Africa, where he sought to ensure that biodiversity conservation was advanced as part and parcel of the larger development agenda. He led an initiative to put together a manifesto for the environment to the Government of Tanzania in 1994, overcoming resistance from a number of government officials. His infectious enthusiasm held strong, despite his inevitable engagement with bureaucracy. He sought every opportunity to get people out into the field and do practical conservation. He was a mentor to many, who sought him out for his wisdom and encouragement, and who risked his ruthless editing of any documents that crossed his desk — wielding his red pen with pleasure to eliminate redundant prose and unsubstantiated claims. This quality found much expression in his functional role as a member of board of reviewers for Nature & Faune journal.

As a person, Rodgers had more interest promoting and encouraging the right people to achieve action and results than personal recognition. It is therefore largely to his credit that a coherent and effective conservation movement exists in East Africa today, and that so much of the Eastern Arc and Coastal Forests are now protected. They still face enormous challenges and pressures from a growing population hungry for natural resources, but their situation would be far bleaker were it not for him.

Rodgers's energy was not limited to conservation; he was also a fine rugby player, an enthusiastic actor, a keen fisherman and a generous and jolly host, who with a scratch of his grizzled beard would captivate his audiences with many a mischievous anecdote about his wild youthful years. He is survived by his first wife Bobbi Jacob and their daughter; his second wife Nicky Tortike and their two sons; and his partner Mercy Njoroge. His three children are now following his passion for East Africa and conservation.

Although he will be sorely missed his influence will continue to be felt through the many different people with whom he interacted in his diverse roles as a scientist, a teacher, a manager, a mentor, a critic, an advisor, a colleague, a friend.

By the Editor, Nature & Faune

CLIM-FO-L: Newsletter on Forests and Climate Change

CLIM-FO-L is an electronic newsletter compiled by FAO monthly as a source of information on forests and climate change. The newsletter provides information on developments in UNFCCC negotiations, publications, websites, events and job opportunities and project information. For more information, to request a subscription or to request FAO to include news in CLIM-FO, please visit:
http://www.fao.org/forestry/54538/en *or* *contact CLIM-FO-Owner@fao.org.*

News

Commemorating 2009 International Day for the Mangroves

Every July 26th has become an annual global commemorative day for the mangroves. The International Day of Mangroves was observed on Sunday 26 July 2009 and this year's theme calls for global action against the shrimp farming industry and demands the conservation of precious mangrove areas. This worldwide move may mark the beginning of a stronger international network of small-scale fishermen. Fishermen activists advocating for the rights of marine communities around the globe have been concerned about the loss of mangroves that serve as home for a diverse range of plant and animal life. Mangroves are also a source of income for local communities, and prevent soil erosion and protect the coast from storms.

By Jan Khaskheli, Pakistan Fisherfolk Forum (PFF) Karachi

For the whole article, visit - http://www.pff.org.pk/node/200

UNESCO requests reinstatement of moratorium on mangrove cutting in Belize

The UNESCO World Heritage Committee has placed the largest barrier reef in the northern hemisphere on UNESCO's List of World Heritage in Danger to help raise international support for their preservation. Belize Barrier Reef Reserve System was placed on the Danger List mainly because of the problem of mangrove cutting and excessive development in the site. This reef system was inscribed on the World Heritage List in 1996 as the largest barrier reef in the northern hemisphere, with offshore atolls, several hundred sand cays, mangrove forests, coastal lagoons and estuaries. This series of coral reefs straddles the coast of Belize, roughly 300 meters (0.2 mile) offshore in the north and 40 kilometers (25 miles) in the south. It extends for about 300 km (185 miles), making it the second largest coral reef system in the world after the Great Barrier Reef in Australia. Mangroves are being cleared for vacation and retirement homes, hotels, roads, ports, casinos, golf courses, rice fields and shrimp farms. Their destruction erodes fragile coastal lands, eliminates fish and shellfish nurseries, and natural wind and storm-surge breaks. While requesting stricter control of development on the Belize Barrier Reef Reserve System, the World Heritage Committee also requested the reinstatement of the moratorium on mangrove cutting on the site which expired in 2008.

News item culled from: UNESCO Expands List of World Heritage in Danger

Website: http://www.ens-newswire.com/ens/jul2009/2009-07-04-02.asp

Source: Environment News Service http://www.ens-newswire.com/ens/jul2009/2009-07-04-02.asp

South Africa and Mozambique Create Africa's Largest Marine Protected Area

South Africa and its neighbour to the north, Mozambique, have joined forces to create Africa's largest marine protected area. Mozambique has declared its first Marine Protected Area at Ponta do Ouro that now links with the South Africa's iSimangaliso Wetland Park to create the continent's first transfrontier marine conservation area along 300 kilometers (200 miles) of pristine beaches.

News item culled from: South Africa, Mozambique Create Africa's Largest Marine Protected Area.

Source: Environment News Service http://www.ens-newswire.com/ens/oct2009/2009-10-29-01.asp

The world's three major tropical forest regions agree on collaboration

The intergovernmental regional organizations representing the world's three largest tropical forest regions (the Association of South-East Asian Nations – ASEAN, the Amazon Cooperation Treaty Organization – ACTO, and the Central Africa Forests Commission – COMIFAC) agreed to work more closely to enhance south-south cooperation in conserving and sustainably managing their tropical forests and biodiversity. The three regions - primarily Amazon, Congo and Borneo - collectively contain more than 80 per cent of the world's tropical forests, and an estimated two thirds of all terrestrial species. More: http://www.cbd.int/doc/press/2009/pr-2009-07-16-forest-en.pdf and http://www.cbd.int/doc/meetings/ssc/bmssc-02/official/bmssc-02-02-en.doc

News item culled from: Tim Christophersen. Programme Officer for forest biodiversity, Secretariat of the Convention on Biological Diversity, United Nations Environment Programme, 413 St-Jacques O., Suite 800 Montreal, QC., H2Y 1N9, Canada Tel. main: +1-514-288-2220. Fax: +1-514-288-6588. Email: Tim.Christophersen@cbd.int

Alternative source: the ASEAN July 2009 Bulletin "World's Three Largest Tropical Forest Regions to Forge Alliance": http://www.asean.org/Bulletin-Jul-09.htm

The world's seabirds are on the decline

The world's seabirds are disappearing more quickly than any other group of bird species, and they are harder to conserve than birds based on land, where habitat can more easily be set aside for their protection. To conserve seabirds despite these issues, BirdLife International and some of its partner organizations have developed guidelines for identifying Marine Important Bird Areas for seabirds that can be applied anywhere around the world.

News item culled from: Conservation Guidelines Define Important Bird Areas at Sea

Source: Environment News Service, ENS, 2009.

Lion population in Kenya on the decline

Kenya could lose all its lions in the next 20 years if the current rate of decline continues unless urgent and decisive measures are taken, the Kenya Wildlife Service warned today. World famous for its wildlife, Kenya now has 2,000 lions in seven national parks and conservation areas, but the lion population has been declining by an average of 100 animals per year for the past seven years.

News item culled from: Kenya's Lions Could Disappear in 20 Years

Source: http://www.ens-newswire.com/ens/aug2009/2009-08-17-02.asp

Spices such as thyme proving effective as pesticides for fruits and vegetables

Common kitchen spices such as rosemary, thyme, clove, and mint, nick-named "killer spices," are proving effective as pesticides in organic agriculture's battle against insects as the industry tries to meet the growing demand for fruits and vegetables that are free of toxic chemicals. In a study presented Sunday at the opening day of the American Chemical Society's national meeting in Washington, scientists from the University of British Columbia presented new research into what they are calling "essential oil pesticides."

News item culled from: 'Killer Spices' Fatal to Insect Pests

Source: http://www.ens-newswire.com/ens/aug2009/2009-08-17-01.asp

Lake Nakuru National Park in Kenya recognized as an Important Bird Area

Lake Nakuru National Park in central Kenya, internationally known for its concentration of bright pink flamingos, has been designated as an international bird sanctuary. It becomes the first national park in Africa to be recognized as an Important Bird Area

(IBA) under the international IBA program established by the UK-based global organization BirdLife International and its worldwide network of partners.
News item culled from: Kenya's Lake Nakuru National Park Named Important Bird Area
Source: http://www.ens-newswire.com/ens/sep2009/2009-09-24-02.asp

About one-third of known species of plants and animals threatened with extinction
About one-third of all known species of plants and animals are threatened with extinction, finds the International Union for the Conservation of Nature in the most recent update of its authoritative Red List of Threatened Species™ issued today. "The scientific evidence of a serious extinction crisis is mounting," warns Jane Smart, director of IUCN's Biodiversity Conservation Group.
News item culled from: Rapid Pace of Species Extinctions Mounts to a 'Crisis'
Source: http://www.ens-newswire.com/ens/nov2009/2009-11-03-01.asp

Kew Gardens celebrate collection & banking of 10% of world's wild plant species
The Royal Botanic Gardens, Kew celebrated a milestone in plant conservation, the collection and banking of 10 percent of the world's wild plant species. On 15 October 2009, Kew banked its 24,200th plant species, a pink wild forest banana from China which is an important staple for wild Asian elephants. Between 60,000 and 100,000 species of plants are threatened with extinction, roughly one quarter of all plant species.
News item culled from: Kew's Millennium Seed Bank Saves 10% of World's Wild Plants
Source: http://www.ens-newswire.com/ens/oct2009/2009-10-15-02.asp

Special Feature

The challenges and prospects of developing a community based generalizable method to assess mangrove ecosystems vulnerability and adaptation to climate change impacts: Experience from Cameroon

Gordon Ajonina[1], Bertin Tchikangwa,[2] George Chuyong[3]and Martin Tchamba[4]

Summary

Mangroves provide a wide range of resources and ecosystem services for human livelihood, including fisheries production, timber production, coastal protection, pollution abatement and carbon sequestration. However, human-induced stresses ranging from: diversion of freshwater, poor land-use in and around mangrove forests, over-harvesting of resources, and pollution disrupt the natural equilibrium of mangroves. Mangroves are also predicted to suffer from the impact of climate change as the frequency and significance of environmental observations related to Climate Change (CC) increase across the entire planet's ecosystems especially in the low-lying coastal areas, especially regions such as tropical Africa, Southeast Asia and the South Pacific. However, even in the light of such warnings, there have been no clear approaches identified through which the direct environmental effects of CC can be ameliorated in the short term especially development of comparable methods that assess the vulnerability of coastal ecosystems and services. In WWF-US, Global Environment Facility Project Development Facility – Climate Change (GEF PDF B) supported initiative to develop a generalizable method to assess the vulnerability and adaptation of mangroves and associated ecosystems to climate change impacts in three project countries including Fiji, Tanzania and Cameroon. The approach intended to build and strengthen local and national capacity of targeted countries as well as on-the-ground projects demonstrating practical approaches to vulnerability assessment and adaptation by involving multiple stakeholder groups throughout the planning and execution stages of project to promote effective vulnerability assessment and climate change adaptation projects and policies. In this paper the authors assess the status of achievements of such initiatives in Cameroon. The paper also examines challenges and future perspectives for such an expanded programme in the rest of mangrove-covered countries in Africa.

Introduction

Mangroves are among the most productive terrestrial ecosystems and are a natural, renewable resource. Mangroves provide a wide range of resources and ecosystem services for human livelihood, including fisheries production, timber production, coastal

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protection, pollution abatement and carbon sequestration. However, human-induced stresses ranging from: diversion of freshwater, poor land-use in and around mangrove forests, over-harvesting of resources, and pollution disrupts the natural equilibrium of mangroves. Being composed of three important ecosystems, the terrestrial, fresh water and marine ecosystems, the degradation of the mangrove forests not only depletes the resources within their boundaries, but also affects the productivity of the adjacent coastal and marine ecosystems and is a cause of serious environmental and economic concern to many developing countries. This stems from the fact that at the interface between the sea and the land, mangroves play a pivotal role in moderating monsoonal tidal floods and in coastal protection. At the same time their primary production supports numerous forms of wildlife and avifauna as well as estuarine and near-shore fisheries. Consequently, the continuing degradation and depletion of this vital resource will reduce not only terrestrial and aquatic production and wildlife habitats, but more importantly, the environmental stability of coastal forests that afford protection to inland agricultural crops and villages will become seriously impaired (Duke *et al,* 2007).

Mangroves are also predicted to suffer from the impact of climate change as the frequency and significance of environmental observations related to Climate Change (CC) increase across the entire planet's ecosystems especially in the low-lying coastal areas, especially regions such as tropical Africa, Southeast Asia and the South Pacific. There have been no clear approaches identified through which the direct environmental effects (altered temperature regimes, precipitation patterns, extreme weather events, etc.) of CC can be ameliorated in the short term. Scientific findings are showing that marked changes are already taking place and are impacting these coastal ecosystems, and will have increasingly adverse effects even after atmospheric CO_2 emissions may be stabilized or decreased. Recent synthesis has even cautioned that society may already be faced with irreversible biophysical changes based on recent measurements and observation (Adger *et al*, 2005). Consequently, conserving and sustaining ecosystems and biological resources for the future may require a larger focus on developing adaptive resource management strategies, or coastal communities will be faced with hardships associated with the loss of many natural systems and services as a result of climate change. However, even in the light of such warnings, there has been little development of comparable methods that assess the vulnerability of coastal ecosystems and services. Most vulnerability assessments appear to have focused more on particular sectors or individual ecosystem types isolated from others. But standard methods are important in measuring, making meaningful comparisons and in planning for adaptation across ecosystem type and between sites with common habitats. For such methods to be useful to resource managers, they need to be reasonable to execute and economically feasible.

In 2003, the World Wide Fund for Nature WWF and its partners benefited from a GEF-PDF-A (A = Biodiversity) to develop a project proposal for building coastal resilience to climate change through the development of a generalizable method for assessing vulnerability and adaptation of mangroves and associated ecosystems for Africa (Cameroon and Tanzania) and the South Pacific (Fiji). By examining similar systems in three multiple locations, this project intended to develop a method that can be generalized and replicable between mangrove, sea-grass, and coral reef ecosystems by leveraging focussed activities within target countries. The approach also intends to build and strengthen the local and national capacity of targeted countries as well as on-the-ground projects demonstrating practical approaches to vulnerability assessment and adaptation by involving multiple stakeholder groups throughout the planning and execution stages of project to promote effective vulnerability assessment and climate change adaptation projects and policies. This was intended to support development of regional scale planning, as well as potentially promoting management concepts such as networks of protected areas and the links between threatened ecosystems (including upland areas). As a result, this project tries to demonstrate how policies and plans can help countries adapt to climate change. The effectiveness of this approach and adaptation strategies for the ecosystems and communities involved is being tested through pilot initiatives in each of these countries.

This paper assesses the status of achievements of such initiatives in Cameroon, challenges and future perspectives for such an expanded programme in the rest of African mangrove covered countries.

Development of vulnerability assessment methodology

In Cameroon, the project development phase kicked off with a workshop in the coastal zone of Limbe in March 2004. The workshop provided an opportunity for regional stakeholders engaged in the management of mangroves in Cameroon to devise strategies to reduce the negative impacts of climate change on these ecosystems and strengthen the livelihood security of human communities within mangrove areas. It served as a scoping exercise to further the development of proposed project goals, objectives, and activities.

Stakeholders agreed on working definitions of vulnerability as exposure, sensitivity and/or adaptive capacity of an ecosystem to change impact also often used interchangeably with resilience to mean the ability of the ecosystem to maintain system function, services and processes in the face of change (bounce back to its original pre-disturbed state after a disturbance which may be a climate change impact or anthropogenic impact); resistance as its ability to absorb change (withstand) ; and adaptation as actions or measures put in place to increase resistance of the ecosystems to anthropogenic or climate change impacts. Three pillars of adaptation planning identified were: Impacts-based: Identify impacts, then assess vulnerability to those impacts, then identify adaptations. Risk-based: Develop scenarios of risks, identify possible vulnerabilities to those risks and then identify possible adaptations. Vulnerability-based: Assess the causes of social vulnerability then develop adaptations that will reduce overall vulnerability to any change.

Three mangrove key sites were selected during the workshop for the testing of the methodology with the involvement of many institutions in the execution of the project including community based organisations within the Cameroon Mangrove Network, consultants from research institutes, universities and university students with CWCS playing the lead role in collaboration with WWF Central African Regional Programme Office (WWF-CARPO). These sites included Ndongoré (Rio Del Rey Estuary), Douala-Edea (Cameroon Estuary) and Ntem Estuary (Ndongoré) representing the mangrove covered areas in Cameroon with the present country surface area of about 200 000 ha (Ajonina *et al*, 2008; UNEP, 2007). Ongoing activities within these sites have been capacity building of local NGOs to appropriate the project through workshops and on-field training activities on the monitoring of four key aspects of vulnerability assessments:

climate (temperature and rainfall regimes); ecological (baseline assessment of mangrove species zones, condition, productivity, biomass, phenology, stand dynamics, sedimentation rates under mangroves, tidal and sea level amplitudes, elevations relative to sea level); socioeconomic (human population census and resource use interactions and perceptions); and policy aspects which include policy actions at local, national and international levels.

Field Testing

Community based vulnerability assessment monitoring efforts

- Monitoring stations and infrastructure that will regularly provide scientific data for field testing of *Vulnerability Assessments* (VA) have been completed in three mangrove sites of Ntem, Douala-Edea and Rio Del Rey estuaries with the involvement and project appropriation of a network of over 12 local NGOs and CBOs in field monitoring efforts spread over the Cameroon coastal area (Figure 1). These community group members regularly feed project management with vital data.
- Continued awareness raising and capacity development of local population on mangroves and climate change impacts
- Training carried out on the climatic, ecological and socio-economic aspects of the methodology for over ten local organization members of Cameroon Mangrove Network (CMN) through several on-field training workshops by CWCS and group of consultants from University of Buea. Members of six local organizations voluntarily collect basic ecological data by regularly monitoring the established ecological structures set in the three sites consisting of four (04) 0.1 ha Permanent Sample Plots (PSP) in Ntem and Rio Del Rey sites to complement eleven (11) PSP already set in Douala-Edea which can contribute to the evaluation of mangrove forest dynamics and ten (10) stations for monitoring of tidal dynamics, mangrove including micro-topographical influence on mangrove distribution and river sedimentation for monitoring catchment dynamic processes, and periodic assessments of water quality and biodiversity assessments, climatic data collection, socioeconomic surveys on resource use patterns and interactions, etc. In Douala-Edea emphasis was on the strengthening of existing VA monitoring structures, especially the monthly waterfowl counts and river sedimentary monitoring in the lower Sanaga reduced to biannual monitoring for waterfowl to coincide with migratory patterns from experience from ten years monthly monitoring efforts with local organisations.

Figure 1: Monitoring tidal/sedimentation station by representatives of local community based organisations in the Rey Del Rey Project site in Cameroon. Note the prominent aerial roots of the mangrove trees. (Photo Ajonina)

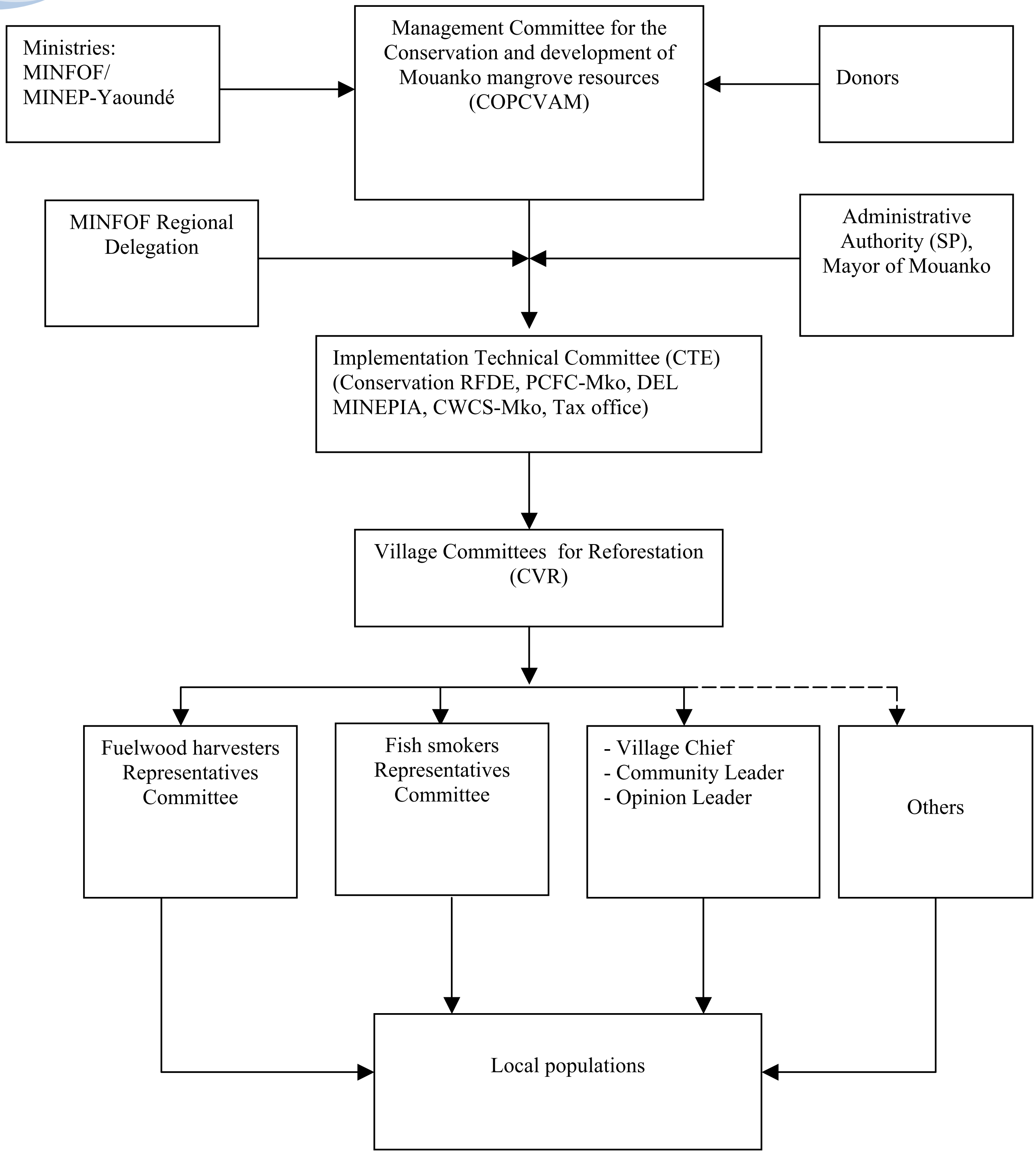
Activities to rehabilitate mangrove forests

Though the original intention of the project was for interventions (*adaptation*) to flow from the analysis (*VA*), however adaptation initiatives have taken place concurrently with the VA, largely due to time constraints. As a result some interventions have been focused on building resilience in mangrove systems rather than direct adaptation to demonstrated impacts or vulnerabilities.

- Policy change.

  Like in other African countries, specific policies to protect mangroves do not yet exist in Cameroon. A National Mangrove Plan is awaiting endorsement from the government, but also needs to be mainstreamed into broader policy including the new Poverty Reduction Strategy Papers (PRSP). Mangroves would be currently considered by the government as a separate forest ecosystem with specific needs in the ongoing review of the 1994 national forestry law. This project is further highlighting their importance including the ongoing lobbying for the official endorsement of the national policy and strategies for the sustainable management of mangroves and wetlands. Gazettement of the project sites as Ramsar Sites of international importance for protection of wetlands is underway with the completion of information sheet for some.

  At the local level, policy development through institutionalisation of mangrove management in a participatory manner through local mangrove steering committees and consultative platforms with key stakeholders involving local administration was undertaken (see the governance structure Figure 2).



Other Abbreviations:

MINFOF :	Ministry of Forestry and Wildlife
MINEP :	Ministry of Environment and Protection of Nature
MINEPIA :	Ministry of Livestock and Animal Industry
RFDE :	Douala-Edea Wildlife Reserve
PFCF :	Hunting and Wildlife Checkpoint
SP :	Sub-Prefect

Fig. 2: Governance structure of local mangrove management committee Douala-Edea region, Cameroon

- Mangrove restoration

a) Nurseries for community mangrove green-shield establishment
Mangrove nurseries have been established in Ntem estuary by the population of Campo Beach with over 4000 mangrove seedlings raised and established as green shield to protect Campo Beach from coastal erosion and wind. This is a community initiated project based on negative experience from collapsing engineering construction of concrete walls along the beach (an example of social vulnerability assessment). Several of such village green-shields exist in Douala-Edea area. Selected members of local organisation in the Campo village monitor nursery seedling development and record in conceived data sheets.

b) *Restoration of degraded mangrove forests*
Similar activities have been realised in the Douala site with up to 15 ha of mangrove forests being replanted from established nurseries and wildings obtained from mother trees during the community mangrove wood demarcation activities implemented by the COPCVAM. This was also through the initial support of the French NGO Planète Urgence volunteers, Oxfam NOVIB and GEF Small Grants Programme funding.

- Efficient mangrove management through demarcation and control of community mangrove wood gathering zones enforced by the local mangrove management committee (COPCVAM) to curb further mangrove deforestation from illicit and uncontrolled wood harvest. COPCVAM initiated field programmes coordinated by CWCS and Conservation service of the Douala-Edea Reserve to demarcate and control future wood gathering zones. Criteria for demarcation of zones included mangrove stands further away from permanent plots, exclusion of seaward mangrove zones and creek margins.

- Mangrove wood energy efficiency management
This involves the implantation of energy efficient fish smoke houses designed and being tested by CWCS within fishing camps in the Douala-Edea (Figure 3B). They formed the bases of the In the Hands of Fishers (IHOF) Workshop of community based approaches to mangrove and fisheries management organised by CWCS supported by the Mangrove Action Project (Los Angeles) in collaboration with the then Cameroon Ministry of Environment and Forestry in May 2003 at Edea. Twenty fishing camps have so far either benefited on the implantation of smoke houses with assistance of SNV (Netherlands Development Organisation) and Oxfam NOVIB or had sites in their various zones surveyed for such implantations. A new energy efficient smoke house (Figure 3) project has been selected among the two country projects to benefit from avoided deforestation initiatives under the CDM process with technical project development assistance from the French based Carbon Initiative (CASCADe).

A

B

Fig.3 :(Top: A) Traditional fish smoke house and (Below: B) Improved smoke house in the Douala-Edea Project site (Photos by Bertin Tchikangwa)

Preliminary results

Earliest results of actions implemented so far include completing of field monitoring stations and infrastructure in the three mangrove sites (Ntem, Douala-Edea and Rio Del Rey estuaries). Through regular monitoring by the community groups, these should provide scientific data for field testing of the generalisable methodology. Initial result is thus limited to the high level of community participation and appropriation of the methology, which translated in their massive participation and involvement in the monitoring exercise. It is envisaged that they would continue to regularly feed project management with data that will be analysed to test the methodology. As part of the project, a symposium to bring together stakeholders from within and without Cameroon (i.e. seven other mangrove countries in Africa) is scheduled to hold in April 2010. By this date, it is hoped that the project would have generated enough data to present concrete results of the field testing.

Challenges and future perspectives

The major challenge lies in the ability to establish strong and informed links or relationship between vulnerability assessments and climate change adaptation efforts and the expansion of the endeavours in other African mangrove covered countries.

Challenges

Specific challenges are:

- Ability to sustain voluntary local community data collection work
- Ability to analyse data to inform climate sensitive decision making processes
- Collecting vital meteorological data given the poor state of meteorological infrastructure in Cameroon and analyse climate change data
- Up-scaling from pilot activities
- Private sector involvement especially extractive industries that have a greater impact on the mangrove ecosystems
- Sustainable financing mechanisms to sustain the endeavour.

Future perspectives

Vulnerability assessments based perspectives include:

- Production of a consolidated VA manual based on consolidation and analysis of existing VA data to show important patterns and trends (mangroves species zones and condition, stresses, past sea level history and projection and their impacts.
- Exploration of mechanisms to sustain local community data collection/monitoring processes especially covering basic subsistence and transport costs for members of the local organizations involved in the data collection process. The possibilities of integration into ongoing conservation and development projects, collaboration with private sector actors especially extractive industries are also being explored
- Continued local capacity building by training of local organisation in basic data processing techniques (general training workshops, etc.) in order to appropriate the methodology and make informed decisions.
- Enhance VA information sharing mechanisms to make informed decisions making processes (forestry code, coordination of mining, oil & gas and forestry sector, etc)

Perspectives to enhance mangrove ecosystem adaptation to climate change impacts would include:

- Continued mangrove restoration work in degraded mangrove zones within the project sites and support of establishment or maintenance of green shields to protect the coast from erosion.
- Energy efficiency management to enhance avoided mangrove deforestation through the establishment of modern mangrove wood energy efficiency ovens for fish processing within project sites
- Continue local institutional strengthening such as COPCVAM initiative to implement concrete adaptation activities including control of community wood gathering activities
- Continued policy mainstreaming work (mangroves and wetlands…) using the Cameroon Mangrove Network to organise integrated coastal area management forums

- Promote the gazettement process for marine national parks especially by seaward extension of existing coastal national parks especially Douala-Edea National park to protect local fisheries resources and promote sustainable fisheries.

Acknowledgements
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References

Adger, W.N., Huges, T.P., Folke, C., Carpenter, S.R. and J. Rockstrom 2005. Social-ecological resilience to coastal diasters. *Science 309: 1036 – 1039*

Ajonina G., Ndiame, D. and J. Kairo, 2008. Current status and conservation of mangroves in Africa: An overview. *World Rainforest Movement Bulletin 133*.

Ajonina, G.N. (2008). Inventory and modelling mangrove forest stand dynamics following different levels of wood exploitation pressures in the Douala-Edea Atlantic coast of Cameroon, Central Africa. *Mitteilungen der Abteilungen für Forstliche Biometrie, Albert-Ludwigs- Universität Freiburg.2008- 2. 215p*.

Duke N.C., Meynecke J.O., Dittmann S., Ellison A. M., Anger K., Berger U., Cannicci S., Diele K., Ewel K.C., Field C.D., Koedam N., Lee S.Y., Marchand C., Nordhaus I. and F. Dahdouh-Guebas. 2007. A World Without Mangroves? *Science 317: 41 – 42*

UNEP. 2007. *The mangroves of Western and Central Africa*. UNEP-Regional Seas Programme/UNEP – WCMC. 88pp.

Articles

The role and work of African Mangrove Network (AMN) in conservation and sustainable use of mangroves in Africa

Ayaa Kojo Armah[1], Abdoulaye Diame[2], Gordon Ajonina[3], and James Kairo[4]

Introduction

Mangroves cover most of the coastal areas of Africa. They are salt-tolerant inter-tidal forest communities and are restricted to tropical and sub-tropical areas in the world. The total mangrove area in Africa is estimated at 3.2 million ha (about 19% of global coverage) distributed as follows: 63% on the Atlantic coast; and 37% on the Indian Ocean and Red Sea coasts. There are 9 species of mangroves in the Indian Ocean coast, compared to 6 species on the Atlantic coast and 4-5 species in the Red Sea Coast.

Like other mangrove areas in the world, mangroves of Africa play quite significant ecological, socioeconomic and climate amelioration functions: supporting high flora and fauna diversity; providing direct wood and non-wood products and services to the people in terms of building poles, charcoal, tannins, firewood; shoreline protection and also serving as reliable carbon sink. An old-growth mangrove forest in the north coast of Kenya has been estimated to contain up to 500tC/ha, for both above and below ground components. Despite these roles and functions, mangroves have been severely impacted over the years, with West Africa reporting a 20-30% loss and Eastern Africa an 8% loss within the past 25 years. Major causes of mangrove degradation and loss in Africa have been over-exploitation of resources, conversion of mangrove area for other land uses such as, pond aquaculture, agriculture, coastal landfill, urbanization as well as indirect effects of pollution and upstream land use. National and international efforts through a variety of projects and programmes on mangrove conservation have been initiated throughout Africa with organisations such as the FAO, WWF, EU, the Guinea Current Large Marine Ecosystem (GCLME) project and UNEP. These organizations work with mainstream government departments to conserve mangroves.

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With the view to fostering regional collaboration to save African mangroves from further destruction and to collectively work to bring the mangrove agenda to the fore in national and international arenas, the African Mangrove Network (AMN) was established in Cameroon in May 2003. Current membership comprise 22 countries, including; Mauritania, Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon, Sao Tome& Principe, Congo, Democratic Republic of Congo, Angola, Kenya, Somalia and Tanzania (Figure 1).

Figure 1: Map showing current member countries of the African Mangrove Network (AMN)

Vision and mission of AMN

AMN's main vision and mission is to create and animate a framework for exchange and concerted actions of NGOs and CBOs on mangroves. The network further aims at promoting cooperation with African decision makers, development partners and counterpart networks in Asia and America towards the emergence of a "mangrove civil society**".** Specific objectives of the network include:

- strengthening operational capacities (material, technical and financial) of mangrove ecosystem conservation actors;
- promoting and strengthening the participation of local populations in the formulation and execution of programmes or projects towards the protection, safeguard and sustainable management of mangrove ecosystems ;
- undertaking active lobbying and advocacy against local, national or international policies and projects which adversely affects the functional integrity of the mangrove ecosystems;
- developing partnership with research institutions, governments and all initiatives geared towards sustainable management of mangrove ecosystems;
- participating in the implementation of different national, regional and international programmes related to the protection, safeguard and sustainable management of mangrove areas.

Organisational Structure
AMN has a clearly defined constitution which was recently modified during the second General Assembly (GA) in Ghana (27-30 April 2009). The GA is the highest decision making body and comprises all members of the Executive (Bureau) and Country Focal Points; the Executive Board (EB) is headed by the Board Chairman (BC) from the NGO Resource and Environment Development (REDO) based in Ghana; the Secretariat is based in Senegal and hosted by the NGO West African Association for Marine Environment (WAAME). It is headed by the Executive Secretary (ES) who manages the day-to-day activities of the network with assistance from an Accountant, Secretary, Communication and Webmaster. A Technical Advisory Group (TAG) gives technical advice and strategic guidance while the Country Focal Points (CFP) coordinate the implementation of decisions at country level. The AMN, through its website (www.mangrove-africa.net), regularly briefs members and the world at large on its programmes, current mangrove conservation and sustainable management issues.

Activities
AMN has been playing quite a unique pan-African coordinating role on rehabilitation, conservation and sustainable utilisation of mangrove resources by undertaking programmes ranging from capacity building, advocacy, awareness creation, promoting the use of improved smoke ovens, mangrove reforestation, promoting alternative income generation opportunities to management plan developments in different countries. The following are some of the key accomplishments of the network.

- Capacity building in mangrove management plan development in Cameroon and Benin.
- Supporting mangrove reforestation and evaluation in Congo, Guinea, Senegal, Benin, Nigeria and Ghana.
- Supporting mangrove protected area establishment in Liberia.
- Advocacy campaign on shrimp farming impacts in Nigeria.
- Enhancing mangrove nursery and plantation establishment in Kenya.

Future perspectives
AMN strategic orientations have been clearly stated in the 2009-2014 Action Plan developed during the Ghana General Assembly. It has an overall objective of promoting the conservation and ecologically sustainable development of mangroves and associated coastal habitats in Africa for the benefit of present and future generations and for the preservation of its intrinsic biodiversity, ecological, aesthetic and other values. The Action Plan has six priority areas as follows:

	Priority Areas	Priority Objectives
1.	Integrated Coastal Zone Management	Promote the conservation, restoration and sustainable utilisation of African mangroves within the context of integrated coastal area management
2	Mangroves and Climate change	Promote mitigation and adaptation of climate change
3	Information, Education and Awareness Creation	Strengthen information, education and sensitisation campaigns
4	Policy advocacy and development	Advocate and support development of national and regional mangrove forest policies
5	Fund-raising	Promote fund raising initiatives
6	Governance	Strengthen the Governance mechanism within the AMN

Despite the above efforts, the AMN has challenges in mobilising funds to accomplish its activities. The AMN is concerned about the grave consequences of mangrove loss to mankind and recognises the time to conserve, protect and restore degraded mangrove lands is now! The international community is therefore called upon to support AMN efforts in addressing the impacts of climate change on mangrove ecosystems including its vulnerability on human communities through research and advocacy. We invite you to join us save the mangroves of Africa and the world to ensure that future generations also benefit from the goods and services mangrove ecosystems provide.

Acknowledgement
AMN has received financial support from the International Union for Conservation of Nature – Netherlands (IUCN-NL), Swedish Society for Nature Conservation, Friends of the Earth (FoE) and World Wildlife Fund for Nature (WWF). Food and Agriculture Organization of the Unties Nations (FAO) remains one of the main technical partners of AMN.

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FAO REGIONAL OFFICE FOR AFRICA

The Application of the Ecosystem Approach to Mangrove management: Lessons for Ghana

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Summary

The area of mangrove in Ghana has suffered significant depletion in the last 30 years. Causes of loss are based on anthropogenic pressures which will increase with population rise and the climate variability. The impact of this loss of mangrove cover reduces ecosystem services such as fish breeding and nursery as well as erosion control. These losses have a negative effect on marginalised coastal populations, especially women and the elderly. The FAO and CBD ecosystem approach to natural resource management provides a tool for government to revisit the issue of mangrove management in Ghana using adaptive management, participatory engagement with local communities and a holistic approach involving various disciplines. The immediate assessment of frameworks such as the ITTO Action Plan for Mangroves; the World Bank Code of Conduct for Mangrove Ecosystems for their implementation in the Ghanaian context should be carried out by Government. Capacity to apply the FAO system of ecosystem management needs to be built in Ghana.

Introduction

Ghanaian coastal ecosystems provide unique services and are habitats for important coastal species such as waterfowl, crabs, shrimps, marine turtles and juvenile stages of commercial fisheries (Dankwa & Gordon, 2002; EPA/UNOPS 2004; Tweneboah, 2009). Mangroves are trees and shrubs that grow in saline coastal habitats in the tropics and subtropics – mainly between latitudes 25° N and 25° S. The term mangrove is also applied to the mangrove swamp forest ecosystems as a whole. Mangroves are closely related to the forestry and fisheries sectors, and other coastal wetland ecosystems (Clark, 1992; Lawson, 1986; Sackey *et al.*, 1993). They are severely under threat and have lost much of their area in Ghana (Coleman *et al.* 2005; Gordon, 1998; Rubin *et al.*, 1998) partly due to the fact that they are seen as "commons (Hardin, 1968). They are important links in the coastal ecological chain, providing the basis for livelihoods for many marginalized coastal communities (Diop *et al*. 2001; Porter & Young 1998). Ghana has built a strategy for management and protection of nature reserves as well as a strategy for wetland management; however there have been no specific legal rules and regulations for mangrove management (Agyepong *et al.* 1990). The great value of Ghana's mangroves, the current and potential pressures placed on them as well as their management status are the issues of growing concerns, especially to managers, planners and policy makers at

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central and particularly local levels (Gordon & Ibe, 2006). A plan for protection and development of mangrove forests in Ghana is necessary since increasing pressures on the resource and the threat of sea level rise and associated climate change phenomena will exacerbate the situation in future. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change predicts with high confidence that Climate variability and change could result in low-lying lands being inundated, with resultant impacts on coastal settlements (Boko et al. 2007). Climate variability and change, coupled with human-induced changes, would affect ecosystems such as mangroves with additional consequences for fisheries and tourism. Boko et al (2007) state that not only would the projection that sea-level rise could increase flooding, have implications for health, sea-level rise will also potentially increase the high socio-economic and physical vulnerability of coastal cities. The cost of adaptation to sea-level rise could amount to at least 5-10% of gross domestic product. It should be noted that this figure is in the same range as the planned annual growth rate of the Ghanaian economy over the next 50 years (MOFEP, 2007).

The aim of this review is to assess how Ghana has managed its mangroves to date. We also wish to explore how the use of frameworks such as the Driver-Pressure-State-Impact-Response (DPSIR); and use of the principles of the ecosystem approach as espoused by FAO (FAO 2003; De Young *et al*. 2008) as well as the Convention on Biological Diversity (CBD) can be applied in mangrove management.

The Driver-Pressure-State-Impact-Response framework

Arthurton *et al*. (2002) used the Driver-Pressure-State-Impact-Response framework to illustrate the linkage between the dual drivers/pressures of deforestation and cultivation and their impact on the coast. The latter includes the degradation of wetland habitats, which results from reduced water retention in the catchment and greater severity of flooding (Finlayson *et al.*1998; Gordon 1998, 2000). Mensah (2009) points out that DPSIR and related frameworks have been criticized for over simplifying reality, ignoring other linkages within the socio-ecological system, not incorporating the relations between the elements where responses to one pressure can become pressure on another part of the system, and not addressing the fact that some elements may be more relevant than others (Berger *et al.*, 1998; Rekolainen *et al.*, 2003). Other comments suggest that DPSIR has shortcomings in its function as a neutral tool and is biased when it was designed to establish proper communication between researchers and stakeholders/policy makers; with the need to research into effective incorporation of the social and economic concerns of *all* stakeholders (Svarstad *et al.*, 2008).

The Ecosystem Approach to management

The ecosystem approach (EA) proposed under the CBD is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way (Christensen et al., 1996; Smith & Maltby, 2003). That is *"the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity"*. It encourages community involvement in the effective management of species and habitats (UNEP, 2000). Ecosystem Management (EM) emphasises ecological interactions within an ecosystem, rather than human activities, and implies that it is possible to understand, control and manage entire ecosystems (Brodziak & Link, 2002; Kappel et al. 2006). On the other hand, Ecosystem-Based Management (EBM) is an integrated, science-based approach to the management of natural resources that aims to "sustain the health, resilience and diversity of ecosystems while allowing for sustainable use by humans of the goods and services they provide" (Kappel et al. 2006). The ecosystem approach has two main dimensions, vertical within a sector, e.g., forestry or fisheries and horizontal, i.e., cross sectoral/integrated management. EBM's goals include learning how these biophysical and socio-economic spheres interact. It also includes understanding of the linkages among activities and social and ecological system components by using institutional and scientific ways of managing multiple human activities within entire ecosystems (Kappel et al. 2006). Understanding how humans interact with ecosystems is important because decisions on natural resource use and management are made in a social context (Savory, 1988).

The FAO Technical Guidelines on the ecosystem approach to fisheries (EAF) (FAO 2003) define EAF as follows: "An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries." The FAO views the EA as being based on three pillars; societal well-being, ecosystem well-being and the "ability to achieve" which refers to the governance and policy framework needed to deliver the first two pillars.

Despite the clear definition given by both the FAO and the CBD, there is still an element of uncertainty at the level of implementation of the ecosystem approach. Much of the confusion that surrounds the ecosystem approach is that the EA is an approach to management not to science – but as a management approach it has implications for science. For mangroves, this situation is compounded by the ambiguous position that mangrove ecosystems have for managers – do they belong to administrative units that manage the land or the sea, should they be managed by government departments that deal with fisheries or forestry?

Discussion: The Ecosystem Approach as Applied to Mangrove Management in Ghana

Ecosystem Well-being

The following summary on the state of mangrove ecosystems of Ghana is based on the account given by Gordon & Ayivor (2003) and Diop *et al*. (2001). Out of the 81,342 km^2 of total forest area in Ghana, mangroves cover about 140 km^2.They are limited to a very narrow, non-continuous coastal area around lagoons on the west of the country; and to the east, on the fringes of the lower reaches and delta of the Volta River (UNEP, 2007). They are most extensive to the west in the stretch between Cape Three Points and Côte d' Ivoire, especially, areas around Half Assini, Amanzure lagoon, Axim, Princes Town and Shama, among others. To the east of the country, they are best developed at Apam, Muni lagoon, Winneba, Sakumo-1 lagoon, Bortiano, Korle lagoon, Teshie, Sakumo-2 lagoon, Ada, Sroegbe and Keta lagoon. Six species of mangroves found in Ghana are *Acrostichum aureum*, *Avicennia germinans*, *Conocarpus erectus*, *Laguncularia racemosa*, *Rhizophora harrisonii*, and *Rhizophora racemosa* (Table 1). The open lagoons tend to be dominated by *Rhizophora racemosa*, whilst closed lagoons with an elevated salinity contain *Avicennia germinans*, *Conocarpus erectus*, *Laguncularia racemosa* and *Acrostichum aureum* (UNEP, 2007).

Table 1. Mangrove area estimates for Ghana

Year	1980	1990	1997	2000	2005	2006
Area (km^2)	181	168	214	138	124	137

Source: UNEP, 2007

Wetlands and mangrove in Ghana provide a number of vital ecosystem functions (World Bank, 1996). In addition the products they provide can be for human use at the subsistence, commercial, recreational levels (Amatekpor, 1997). The primary causes of wetlands and mangrove degradation can be linked to activities such as exploitation of fish, crabs and oysters, fuel wood gathering (See Figure 1), salt extraction, urban pollution and urban encroachment. The local populations who live in the mangrove areas have traditionally used mangrove products and the mangrove environment over the years. They have mainly exploited it for wood, fish, crabs and oysters. Nevertheless, mangrove areas in the country have received virtually no attention in terms of conservation and sustainable management.

Mangrove ecosystems support a wide array of biodiversity in Ghana. The ecosystems and their associated wetlands provide habitat for high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species (Marquette *et al*., 2002). Thousands of waterfowl, many of them migratory, visit Ghana during the northern winter (Ntiamoa-Baidu & Hepburn 1988; Ntiamoa-Baidu & Gordon 1991). Mangroves serve as sanctuaries and nestling grounds for several of these birds.

Figure 1. Clear cut mangrove

Gordon and Ibe (2006) note that physical alteration and destruction of habitats along the West African coast is very common, especially near river mouths and lagoons. This is evident in shoreline erosion, changing hydrological patterns, and water abstraction and impoundment by the opening of channels to the sea or by physical structures such as ports and harbours. Tweneboah (2009) gives the issues directly affecting the coastal zone of Ghana to include: population increases and poverty; loss of habitat and land through coastal erosion; wetland and mangrove degradation; fisheries degradation; poor access to safe drinking water; poor sanitation; industrial pollution of land; and water pollution.

Despite the ecological and economic (See Box 1) importance of mangroves, they continue to be over exploited on a daily basis with little or no control. In most coastal communities in Ghana, mangrove ecosystems are used in a variety of ways such as fishponds, salt pans, sugarcane fields, human settlements and other agricultural uses. The mangrove stands from the forest are felled for firewood which serves variety of purposes, including domestic fuel, fish smoking and distillation of *akpeteshie* (local gin). A large quantity of the mangrove wood is also used for constructional purposes and for fishing (Lawson, 1986; Singh, 1987; Amatekpor, 1998). Mangrove exploitation intensified, particularly in the Volta Basin, following the construction of the Volta dam in 1964 and the consequential loss of fishing and farming opportunities for downstream communities. Many of the small creeks silted up due to the loss of the annual floods, necessitating the dredging of channels to maintain water access to some communities (See Figure 2).

Between 1980 and 2005 the mangrove area fell from 181 km2 to 137 km2 representing a loss of 24% (FAO 2007).

Box 1. Economic returns from mangrove in the Lower Volta

Mangrove related economic activities such as fuel wood, fish smoking, *akpeteshi* distilling, construction of houses, harvesting of crabs, fish and black snails are significant. The net return per person to fish smoking is about US $30 per week while the contribution to roofing a house is estimated to be US $ 85. The total returns to mangrove related harvesting to the study area comes to US $ 340 per hectare per year. Mangroves benefit marine fisheries by increasing the yield. The increase in fisheries as a result of the presence of mangroves was estimated to be US $ 165 per hectare. Based on these figures from the lower Volta, The total value for just mangrove related harvesting and contribution to marine fisheries is over US $ 500 per hectare. Using an estimated 12,000 ha. as the area of mangrove in Ghana, gives the value of mangrove as well over US $ 6,000,000 per year as this does not include all the other ecosystem services that mangroves provide such as erosion control, trapping of pollutants provision of biomass for the detritivore food chain etc.

Source: Lower Volta Mangrove Project

Figure 2. Dredging in mangrove areas of Lower Volta to maintain water access to communities

Societal Well-being

The local communities are well aware of the importance of mangroves to their lives but due to lack of options they have no choice but to keep destroying them. Tweneboah (2003) notes that in most cases, it is women, children and the elderly who are impacted most by the loss of mangroves as these marginalized groups have limited alternatives.

The land tenure system and the ownership and sale of mangrove as currently practiced do not promote sustainable use. Mangrove plots are leased for ten years. The new owners of the mangrove (not the land) clear cut as soon as possible wait five years clear cut again and then just before handing the mangrove back to the owners, clear cut again.

Donors are now more aware of the need to have integrated projects when dealing with mangroves. An example of such a project is the "Regeneration, Sustainable use and Management of Mangrove in the Keta Lagoon Complex Ramsar Site". This project funded by a Ramsar Small Grant, is based in a Ramsar site which has become degraded due to mangrove over-harvesting, with subsequent negative impacts on fishing resources and the turtles' breeding grounds. There are two main components: awareness creation and capacity building among local communities to enable mangrove restoration and sustainable use, and creation of alternative income-generating activities. Mangrove plantations and woodlots will be established and workshops on goat, crab and grass-cutter rearing, as well as fish farming will be run.

Ability to Achieve

Ministries and agencies whose activities border on mangroves and biodiversity in general include: National Development Planning Commission, Ministries of Environment and Science, Lands and Forestry, Food and Agriculture, Justice, Local Government and Rural Development, Environmental Protection Agency, Fisheries Commission, Water Resources Commission and Wildlife Division of the Forestry Commission. In spite of the existence of these institutions and departments, mangrove management and conservation has been far from satisfactory. A major constraint has been the lack of coordination, collaboration and networking among the policy developing institutions on one side and policy-implementing institutions on the other. There is also the problem of lack of capacities of some institutions. This results in lack of baseline data and deficiencies in information management.

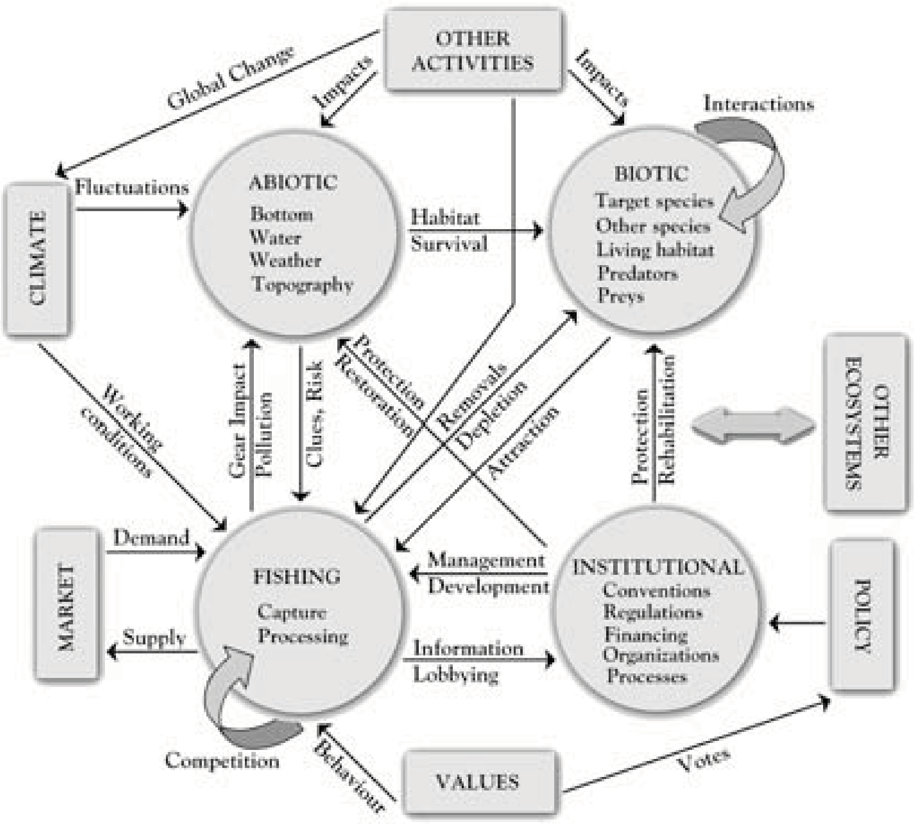
There are a number of legislation governing management, development and conservation of specific natural resources (Hens & Boon 1999). Most of the legislation tends to be sector-based; they may be conflicting, obsolete, deficient and unenforceable. More so, there is no single comprehensive legislation in the country that handles all natural resources in totality. Neither is there a specific elaborate legislation on biological diversity. However, there is legislation of relevance to biodiversity use and conservation. Despite the existence of various legislations, the conservation and management of the country's biological resources still leaves a lot to be desired. While legislation on the use of resources of the terrestrial systems abound, there are only a few national laws that deal with the protection of the marine environment. Mangrove is one of the habitats that is deemed sensitive and any development in an area with mangroves requires and Environmental Impact Study by Ghanaian law. Even though Ghana is signatory to and has ratified a number of international conventions and agreements relating to the marine and coastal environment in general and biological resources in particular, she has failed to translate many of them into national legislation for implementation purposes.

Conclusions

Clearly mangroves in Ghana and their management have been given a low priority in practical terms. The mangroves are now in a serious situation, and the "business as usual" approach will not correct the situation. There are a number of institutional and operational bottlenecks in the system which precludes progress in developing a comprehensive mangrove management plan.

The first is a severe lack of the information needed to evaluate and, where possible, enhance the different tools for assessing indirect interactions and their impacts on mangroves. Each of the arrows in Figure 3 below represents a data set or information required for the understanding of the system for its management. For the most part mangrove managers in Ghana operate in an environment of severely limited data availability. Part of this problem is linked to lack of trained personnel so there is a need to develop training tools for capacity building in EA as applied to mangroves, with an emphasis on identifying and reconciling operational objectives in the mangrove ecosystem, with particular emphasis on biological and ecological objectives and indicators.

Though many models and systems are available both the Ecosystem Approach and the DPSIR framework have been well proven in coastal environments and there is no need to "reinvent the wheel". Use of EA and DPSIR will offer opportunities for mangrove mangers in Ghana to streamline their operations. The use of a more holistic approach with the needed participation from all stakeholders, coupled with the political will to implement management prescriptions may be the key to saving Ghana's mangroves.



Source: Garcia, et al. 2003

Figure 3. Simplified diagram of an ecosystem and its components

Recommendations

The actions needed to save Ghana's mangroves are varied and include best forestry practice such as:

- Replanting of both *Rhizophora* and *Avicennia* and thinning of areas of dense mangrove seedlings;
- Removal of the noxious weeds *Acrostichum* within mangrove, removal of *Typha* and the dredging of waterways;
- Control of the felling of undersized and under aged trees and a leaving a buffer zone or green belt of mature trees beside waterways;

Alternative income generating activities are another initiative that could reduce pressure on mangroves such as:

- Poverty reduction measures (e.g., cottage industries), assisting with credit facilities in expanding crop and other farming activities

- Developing low impact tourism in the area
- Development of woodlots to supplement mangrove as a source of fuel wood and aid rainwater infiltration

There is a need for more information and data to feed management, while the "precautionary approach" given in the EA is adhered to, these include:

- Assessing the capacity of mangroves to produce tannins as well as the tannin quality
- Provision of observation wells for groundwater monitoring for hypersaline water
- Monitoring programme for hydrological data collection, i.e., discharge, surface run-off, water level variation
- Demarcation and detailed soil mapping of the areal extent of acid sulphate soils in mangrove area.
- Field trials by participatory approach, of the efficacy of liming acid sulphate soils with locally available raw materials.

An improved management system is needed that would address the incentives for both owners and contractors to yield maximum benefits. This could be achieved through:

- Greater interaction between the District Assembly and the stake-holders by the promotion of community based mangrove management strategies; local political structures and traditional stakeholders must be involved.
- Educate local people of the current situation on the ground on measures that must be taken to check un planned cutting of mangrove;
- Creation of environmental awareness is imperative if the above recommendations are to be successfully implemented.

References

Agyepong, G.T., P. W .K. Yankson, and Y. Ntiamoa-Baidu, 1990. Coastal Zone Indicative Management Plan. Environmental Protection Council. Accra, Ghana.

Amatekpor, J. K., 1997. Soils and land use in the Lower Volta Mangrove Project Area. Lower Volta Mangrove Project Technical Report No. 8. Series. Gordon, C. (ed.) DFID/Ghana Wildlife Department/Ghana Environmental Projection Agency, 37 pp.

Arthurton, R.S., H.H. Kremer, E. Odada, W. Salomons and J.I. Marshall Crossland. 2002. *African Basins: LOICZ Global Change Assessment and Synthesis of River Catchment–Coastal Sea Interaction and Human Dimensions*. LOICZ Reports & Studies No. 25: ii+344 pp, LOICZ, Texel, The Netherlands.

Berger, A. R. and R. A. Hodge 1998. "Natural change in the environment: a challenge to the pressure-state-response concept." *Social Indicators Research* **44**: 255 - 540.

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, 2007: *Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.

Brodziak, J.K.T. and J.S. Link. 2002 Ecosystem Management: What is it and how can we do it? *Bulletin of Marine Science* **70**: 589-611.

Christensen, N. L., A. M. Bartuska, J. H. Brown, S. Carpenter, C. D'Antonio, R. Francis, F. Franklin, J. J. A. MacMahon, R. F. Noss, D. J. Parsons, C. H. Peterson, M. G. Turner, and R. G. Woodmansee, 1996. The Report of the Ecological Society of America Committee on the scientific basis for ecosystem management. *Ecological Applications* **6** (3): 665-691.

Clark, J. R. 1992. *Integrated management of the coastal zone*. FAO Fisheries Technical Paper No. 327. Rome.

Coleman T.L., A. Manu &, Y.A. Twumasi. 2005. Application of Landsat Data to the Study of Mangrove Ecologies along the Coast of Ghana (site visited 20 June 2008) (also available at www.isprs.org/publications/related/ISRSE/html/papers/323.pdf)

Dankwa HR, Gordon C (2002) The fish and fisheries of the Lower Volta mangrove swamps in Ghana. *African Journal of Science and Technology* **3**: 25-32

De Young, C. Charles, A., Hjort, A. 2008. *Human dimensions of the ecosystem approach to fisheries: an overview of context, concepts, tools and methods*. FAO Fisheries Technical Paper. No. 489, Rome FAO. 152p

Diop, E.S., C. Gordon, A.K. Semesi, A. Soumare, A. Diallo, A. Guisse, M. Diouf, & J.S. Ayivor. 2001. Mangroves of Africa in *Mangrove Ecosystems: Function and Management* L.D. de Larceda (ed.) Springer-Verlag, Berlin 292pp

EPA/UNOPS. 2004. *Environmental sensitivity map for coastal areas of Ghana. Vol 2: Coastal Environment.* Environmental Protection Agency and United Nations Office for Project Services.

FAO. 2003. *The ecosystem approach to fisheries*. FAO Fisheries Department. FAO Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 2. Rome. 112

FAO. 2007. *The world's mangroves 1980-2005* FAO Forestry Paper 153 Rome, FAO

Finlayson, C. M., C. Gordon, Y. Ntiamoa-Baidu, J. Tumbulto and M. Storrs. 1998. *Hydrobiology of the Songor and Keta lagoons: implications for wetland management in Ghana*. Environmental Research Institute of the Supervising Scientist, Australia, 165 p.

Garcia, S.M.; A. Zerbi, C. Aliaume, T. Do Chi, G. Lasserre. 2003. *The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook*. FAO Fisheries Technical Paper. No. 443. Rome, FAO. 71 p.

Gordon, C. and J.S. Ayivor, 2003. Key Issues: Ghana. In Report on the Africa Regional Workshop on the Sustainable Management of Mangrove Forest Ecosystems. D.J. Macintosh & E. C. Ashton (eds) Centre for African Wetlands, University of Ghana, Legon, Accra, Ghana 66p February 17-19th 2003 ISME/cenTER/CAW

Gordon, C. 1998. The state of the coastal and marine environment of Ghana. In C. Ibe and S. G.Zabi (eds), *State of the Coastal and Marine Environment of the Gulf of Guinea*. UNIDO/UNDP/GEF/CEDA, 158 p.

Gordon, C. 2000. Hyper-saline lagoons as conservation habitats: macro-invertebrates at Muni Lagoon, Ghana. *Biodiversity and Conservation* **9** (4): 465-478

Gordon, C. and Ibe, C. 2006. Land based sources of pollution in West Africa: current status and trends. *State of the environment on issues related to the protection of the marine environment from land based activities*. UNEP-GPA-LBA.

Hardin, G. 1968. The Tragedy of the Commons. *Science* **162**: 1243-48.

Hens, L. and Boon, E.K. 1999. Institutional, legal, and economic instruments in Ghana's environmental policy. *Environmental Management* **24** (3): 337-351.

Kappel, C. V., R. G. Martone, and J. E. Duffy, 2006. *Ecosystem-based management*. In: Clevelan, C. J. (Eds.), *Encyclopedia of Earth*. (Retrieved February 4, 2008 also available at http://www.eoearth.org/article/Ecosystem-based_management).

Lawson, G. W., 1986. Coastal Vegetation. In: Lawson G. E. (ed.) *Plant ecology in West Africa – systems and processes*. J. Wiley and Sons, Chichester, pp. 195-213.

Marquette, C. M., Koranteng, K. A., Overå, R. and Bortei-Doku Aryeetey, E. 2002. Small-scale fisheries, population dynamics and resource use in Africa: The Case of Moree, Ghana. *Ambio* **31** (4): 324–336.

Mensah A. M. 2009 The Influence of Land-use Activities on Nutrient Inputs into Upland Catchment Streams, Ghana. PhD Centre for Development Research, University of Bonn & the United Nations University Institute for Environment and Human Security 299p

MOFEP 2007 Budget Document for the year 2057. 46p. (site visited 31st July 2009 also available at http://www.mofep.gov.gh/documents/2057budget.pdf

Ntiamoa-Baidu, Y. and Gordon, C. 1991. Coastal wetlands management plans: Ghana. Report prepared for the World Bank and EPC, Ghana, under the biodiversity component of the Accra: Environmental Resource Management Project.

Ntiamoa-Baidu, Y. and Herpburn, I. R. 1988. Wintering waders in coastal Ghana. *RSBP Conservation Review* **19** (2): 84-87.

Porter, G. and Young, E. 1998. Decentralised environmental management and popular participation in coastal Ghana. *Journal of International Development* **10**: 515-526.

Rekolainen, S., J. Kaman and M. Hiltunen 2003. A conceptual framework for identifying the need and role of models in the implementation of the water framework directive. *International Journal of River Basin Management* **1**(4): 347 - 352.

Rubin, J., Gordon, C., & Amatekpor J.K. 1998. Causes and Consequences of Mangrove deforestation in the Volta Estuary, Ghana: Some recommendations for ecosystem rehabilitation. *Marine Pollution Bulletin* **37** (8-12): 441-449

Sackey I, Laing E, Adomako J 1993. Status of the mangroves of Ghana. In: Diop ES (ed) *Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions. Part II - Africa*. International Society for Mangrove Ecosystems, Okinawa, Japan, pp 93-101

Savory, A. 1988. *Holistic resource management*. Island Press, Washington, D.C.

Singh, V.P., 1987. Assessment of soil suitability for aquaculture development in the Volta Region of Ghana. Report prepared for the Volta Region Agricultural Development Project (VORADEP), Ministry of Agriculture, Government of Ghana.

Smith R. D. and E. Maltby 2003. *Using the Ecosystem Approach to Implement the Convention on Biological Diversity: Key Issues and Case Studies*. IUCN, Gland, Switzerland and Cambridge, UK. x +118 pp.

Svarstad, H., L. K. Petersen, D. Rothman, H. Siepel and F. Wätzold 2008. Discursive biases of the environmental research framework DPSIR. *Land Use Policy* **23**: 116 - 125.

Tweneboah, E. 2003. Coastal pollution and women's health in Ada-Foah, Ghana. *Women and Environments International* **60/61**: 16-18.

Tweneboah, E. 2009 The Role of Environmental Values and Attitudes of Ghanaian Coastal Women in Natural Resource Management. Ph.D. Faculty of Environmental Sciences and Process Engineering at the Brandenburg University of Technology in Cottbus, Germany 239p

UNEP (2007) *Mangroves of Western and Central Africa.* UNEP-Regional Seas Programme/UNEP-WCMC.

United Nations Environment Programme, 2000. Decisions adopted by the conference of the parties to the Convention on Biological Diversity at its fifth meeting Nairobi, 15-26 May 2000 UNEP/CBD/COP/5/23 Annex III

World Bank. 1996. *Towards an integrated coastal zone management strategy for Ghana*. World Bank, Washington DC.

FAO REGIONAL OFFICE FOR AFRICA

Ecology and Restoration of Mangrove Forests in Kenya

James Gitundu Kairo[1] and Jared Bosire[2]

Summary

Conservation status of mangrove forests along the Kenyan coast was assessed by means of aerial photographs, intensive ground-truthing and GIS. Old growth mangrove stands in the north coast of Kenya at Kiunga had stocking rates and standing biomass of 2142.0 and 497.1 ton/ha respectively. In the south coast of Kenya, however, mangroves are more degraded through wood extraction pressure. The stocking rates of degraded mangrove stands at Gazi was 678 stems/ha with a standing biomass of 43.5 ton/ha. Natural regeneration of the secondary mangrove forests in Mida was found to be adequate thus requiring no re-stocking.

The structural development and productivity of replanted mangrove plantations was investigated at Gazi bay. A 12 years old Rhizophora mucronata plantation had a stand density of 5132 stems/ha; with a mean canopy height and stem diameter of 8.4 ± 1.1 m (range: 3.0–11.0 m) and 6.2 ± 1.87 cm (range: 2.5–12.4 cm), respectively. The standing biomass for the 12-year-old replanted forest was 106.7 ± 24.0 t/ha, giving a biomass accumulation rate of 8.9 t/ha/year.

Mangrove forestry in Kenya suffers from an inadequate knowledge of silviculture of indigenous species, of multiple-use potential of resources, and of techniques and economics of natural regeneration and reforestation. Consequently, the information generated in this study has an important role to play in gathering basic information based on field trials as a necessary input towards sustainable management of mangroves in Kenya.

Introduction

Mangroves are forests growing at the edge of tropical seas (Spalding, et al., 1997). In addition to providing a range of products that people need, including building materials, firewood, tannins, fodder and herbal medicines, mangroves are of invaluable local and global ecologic, economic and social importance (FAO, 1994). Mangroves serve as breeding and feeding grounds for many species of fish, mollusks, crustaceans and birds (Saenger, 2002). Being at the edge of the seas mangroves control coastal erosion and sea-level rise (FAO, 1994).

Kenya has over 53,000 ha of mangrove forests along her 574 km coastline (Doute *et al*., 1981). The highest concentration of these forests occurs in the area north of the Tana river, in Lamu district. There are 9 recorded mangrove species in Kenya; the principal species being *Ceriops tagal* (Perr.) and *Rhizophora mucronata* Lam., which form more than 70% of the forests (Ferguson, 1993; Kairo, 2001). Recent surveys indicate

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considerable loss of mangrove resources through over-exploitation (Ferguson 1993; FAO, 1993a, FAO, 2005) and conversion of mangrove area to other land uses such as fishponds and solar salt works (Yap and Landoy, 1986). Losses of mangrove through oil pollution have also been witnessed (Abuodha & Kairo, 2001). Degradation of mangroves is directly reflected in the increased coastal erosion (Kairo *et al.,* 2001), shortage of building material and firewood (Dahdouh-Guebas *et al.,* 2000), and reduction in fishery (Tiesongrusmee, 1991).

The present study aimed at sustaining the supply of mangrove goods and services without negatively affecting the forest ecosystem resilience. More specifically, the objectives were:

1. To conduct mapping and quantitative analysis of mangrove forests in the pilot areas,
2. To examine natural regeneration patterns of commercial mangrove species and timber potential of mangroves forests in the pilot areas,
3. To assess recovery processes, in terms of biomass increment, of mangrove plantations established since 1991.

Description of the study area

This study was carried out in three sites, containing all together five distinctive mangrove populations. The sites span the entire Kenyan coastline from the northern limit (Kiunga, 1°37'S, 41°30'E), the middle region (Mida creek, 3°20'S, 40°00'E), to the southern limit at Gazi bay (4°25'S, 39°32'E) – Fig. 1. The sites were selected in such a way that they represented different mangrove formation in Kenya ranging from fringing, riverine and basin. Based on the definition by Lugo and Snedaker (1974), fringing mangroves are those forests that occur along shoreline with elevations that are higher than mean high tide levels. Fringe forests reach a maximum height of 12m. Riverine mangroves, on the other hand, are tall forests along tidal rivers and creeks frequently influenced by freshwater input. Riverine forests can attain stand height of more than 18m. The basin mangroves occur in depressions normally receiving terrestrial run-offs and without direct influence of tidal waves. Trees in tidal forest may reach 15m tall or more (FAO, 1994).

Mangroves in the north of Kenya at Kiunga represent pristine to semi-pristine forests (Kairo *et al*., 2002a). These forests are mostly fringing mangrove formation and are located in area of low human density. Mida creek represents disturbed forest undergoing rapid natural regeneration (Kairo *et al*., 2002b); whereas Gazi mangroves area are degraded forests that would never recover naturally without human intervention (Kairo, 1995, Kairo *et al.,* 2001, Kairo *et al.,* 2008). Casual observation of mangroves in the study sites suggests that they differ in structure (physiognomy), hence quantitative description of the populations were made to give baseline information and provide a better understanding of their natural ecological patterns.

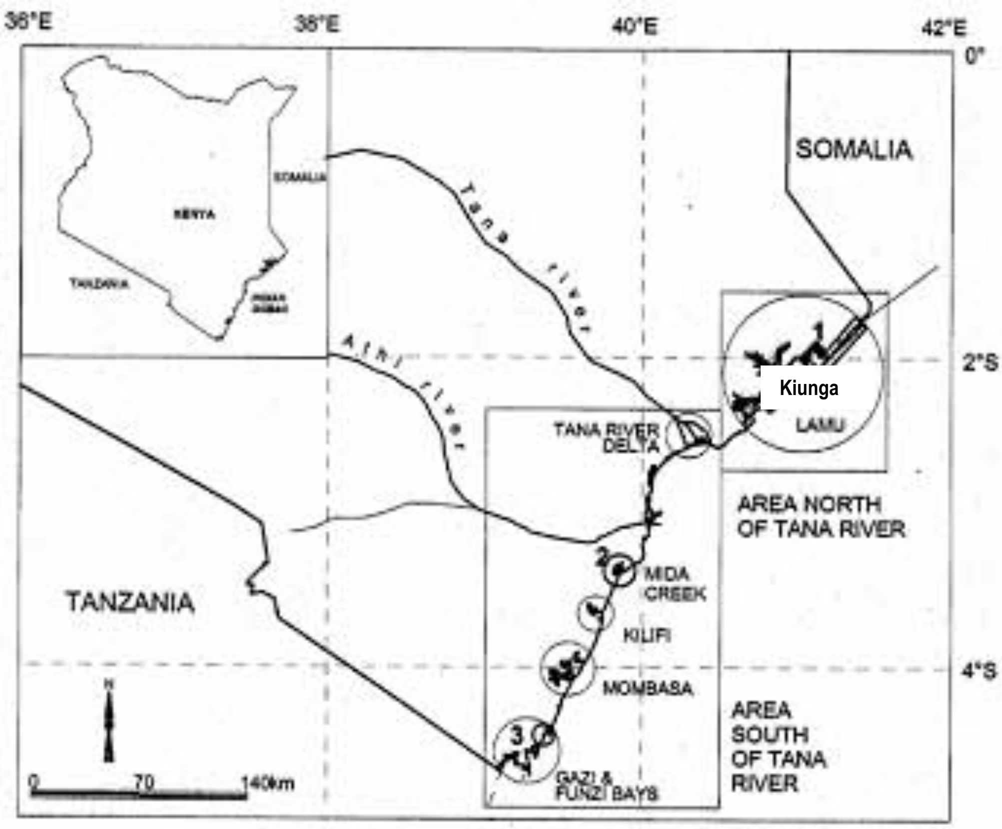


Figure1. The Kenya coastline showing major mangrove areas. In the present study mangroves of Kenya have been divided into two broad regions; area north and south of the Tana River delta. The numerical values represent pilot areas: 1- Kiunga 2 – Mida creek, 3 – Gazi bay.

Study approach and methodology

Mapping of mangroves in the pilot areas was carried out using medium scale (1:25000) aerial photographs and Geographic Information System (GIS). Stratified sampling technique was used to generate vegetation data. Measured parameters included tree height, stem diameter at breast height (dbh), crown diameter and biomass, from which were derived tree basal area, species density and frequency. The ecological importance of each species was calculated by summing its relative density, relative frequency and relative dominance (Cintron and Schaeffer-Novelli, 1984). Complexity index was obtained as the product of number of species, basal area (m^2/0.1 ha), maximum tree height (m) and number of stems/0.1 ha, times 10^{-3} in a 0.1ha plot (Holdridge *et al*., 1971). Lineral regeneration sampling (FAO, 1994) was used to assess the composition and distribution pattern of natural regeneration.

Results and Discussions

a. Survey and mapping of the mangrove resources in Kiunga

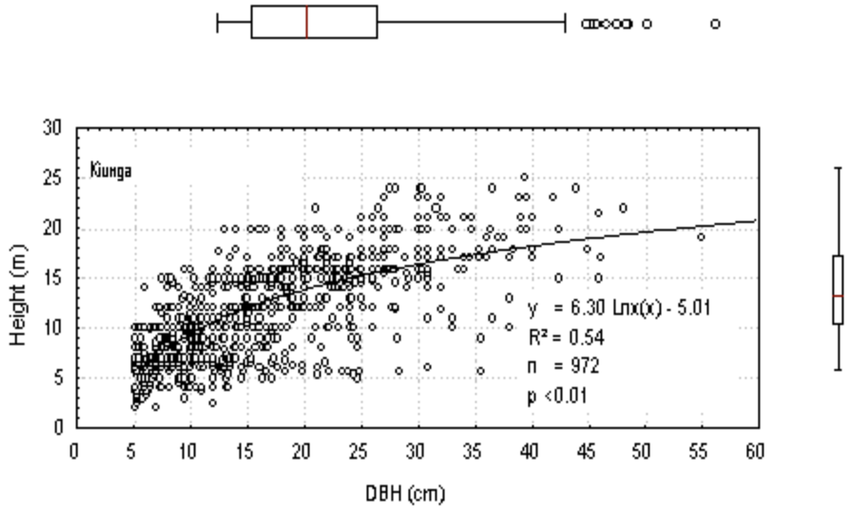
The present study revealed that the existing mangrove forests within and adjacent to Kiunga Marine Protected Area occupied a surface area of 16,035.94ha, with a standing volume of 2,354,004.85 m^3 (Kairo *et al.,* 2002a). The dominant species of mangrove in Kiunga are *Ceriops tagal* and *Rhizophora mucronata.* The average standing volume for stems above 5.0cm diameter was 145.88 m^3/ha (range: 6.85 - 710.0 m^3/ha); corresponding to 1736 stems/ha. Given its high potential productivity and natural regeneration, mangroves of Kiunga have excellent prospects for sustainable exploitation.

b. Structural characteristics

Table 1 is a summary result of the vegetation inventories of mangrove of the pilot areas. The high complexity indices (C.I.) recorded in the mangrove forests north of Tana river especially the high basal area and canopy height in Kiunga (C.I. = 62.81), as compared to the southern mangroves at Mida creek (6.97) and Gazi bay (0.35) – Table 1. In Kiunga, 50% of trees had a dbh of 16 – 27 cm (height: 9 – 17 m) while in Mida, 50% of the stems had a dbh of 14 – 25 cm (height 6 – 12 m) –Fig 2. Compared to the mangroves north of Tana river, the forests south of Tana River are highly degraded due to dense human population in the area (Kairo *et al.,* 2002a, 2002b, Dahdouh-Guebas *et al*., 2004).

Table 1. Structural characteristics of mangroves in the study areas (Source: Kairo et al., 2002a, 2002b)

Species	**Kiunga**	**Mida**	*Gazi bay*
Basal area (m^2/ha)	46.97	23.62	3.19
Stand density (stems/ha)	2142.0	1192.0	678.0
Biomass (ton/ha)	497.10	104.73	43.15
Complexity Index	62.81	6.97	0.35



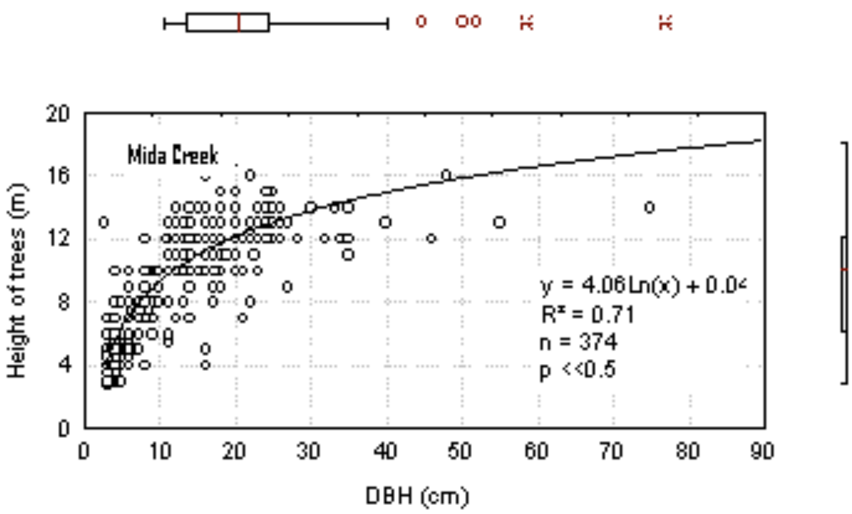


*Fig. 2.   **Height-Diameter distribution of mangrove forests in the study areas. The box-plots display percentile distribution in each case (Source: Kairo et al., 2002a, 2002b).***

c. Structural development and productivity of replanted forests

The above ground biomass was determined for 12 year old *Rhizophora mucronata* plantation at Gazi bay that were established since 1991 (Figure 3). Trees with stem diameter greater than 2.5 cm inside 100 m² were harvested, and then separated into trunks, branches, leaves and prop roots. The replanted forest had a stand density of 5132 stems/ha; with a mean canopy height and stem diameter of 8.4 ± 1.1 m (range: 3.0 - 11.0 m) and 6.2 ± 1.87 cm (range: 2.5 – 12.4 cm), respectively (Kairo *et al.,* 2008, Table 2). This is much higher than the 3330 and 3100 stems/ha that were recorded when the plantation was 5- and 8-year-old, respectively (Kairo *et al.,* 2009). The stocking rate for the 12-year-old plantation compares well with those reported for *Rhizophora apiculata* at similar age in Vietnam (FAO, 1993b). However, compared to stocking rates of natural mangrove stands in Kenya, the current stocking rate in replanted forests can be said to be excellent. The standing biomass for the 12-year-old *Rhizophora* plantation was 106.7 ± 24.0 t/ha, giving a biomass accumulation rate of 8.9tons/ha/yr.

Table 2. Yield table data for replanted R. mucronata plantation at Gazi. Source: Kairo et al., 2008).

Parameters	Utilization classes (cm)				
	Fito < 4.0	*Pau* 4.1-6.0	*Mazio* 6.1-9.0	*Boriti* 9.1-13	total
Stems/ha	559	1586	2392	327	4864
Standing biomass (t/ha)[a]	2.35	18.55	66.36	19.39	106.66 - 24
Below ground biomass (t/ha)					24.89 – 11.4

[a]*Equation used was: $y_i = 0.000016\,(D_{130}^2 H_i)^2 + 0.0454\,D_{130}^2 H_i + 0.495$; where y_i = biomass of the ith tree, D_{130} = diameter at 130 cm above the ground and H = height.*

Figure 3. A 12- year old Rhizophora mucronata plantation at Gazi bay, Kenya. The net value of such a replanted stand has been estimated at US$3000/ha/yr (Kairo et al., 2009b).

Conclusions

Recent assessments of global forest resources indicate that about 50% of the mangroves in world have been lost in the last 50 years and many mangroves worldwide risk to disappear in the following decades (FAO, 2005, Duke *et al*., 2007). The underlying root causes of the loss and modification of mangroves in Kenya are associated with the population growth in the coastal areas that leads to over-exploitation of resources, conversion of mangrove areas to other land uses such as pond aquaculture; diversion of fresh water flow, heavy siltation associated with poor land-use, and pollution. Losses of mangroves have affected local and national economies as indicated by shortage of firewood and building poles, increased coastal erosion and reduction in fishery (Dahdouh-Guebas *et al.,* 2000; Abuodha and Kairo, 2001). There is an urgent need to reforest degraded areas in order to achieve the objectives of sustainable forest management.

The quantitative findings from the present study indicate the presence of both pristine and degraded mangroves in Kenya. The pristine stands of mangrove in Kiunga are of similar structural complexity to healthy mangroves in the world undergoing sustainable exploitation e.g. Matang Forests in Peninsula Malaysia. The data generated from this study (and from other recent works) can be used in the preparations of management plans of the mangroves in Kenya. Currently Kenya lacks management plan to guide exploitation of mangrove resources. This is unfortunate, considering that mangroves provide 70% of wood requirement along the Kenya coast (Wass, 1995).

The results of this study demonstrate, as well, the potential use of reforestation as tool in returning the lost forests and thereby sustain supply of mangrove goods and services. Major goods and services from replanted mangrove plantation include: firewood and building poles, coastal protection, ecotourism, research and education, carbon sequestration and on-site fisheries. The total economic value of a 12-year-old *Rhizophora mucronata* plantation in Kenya has been estimated at $3000/ha/yr (Kairo *et al*., 2009b); most of this being accounted for by the coastal protection functions of the forest.

Acknowledgement

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References

A**buodha, P. and J. G. Kairo,** 2001. Human induced stresses on mangrove swamps along the Kenyan coast. *Hydrobiologia*: **458,** (*in press*)

Cintrón, G. and Y. Schaeffer-Novelli, 1984. Methods for studying mangrove structure. In: *The mangrove ecosystem: Research methods*. Snedaker, S.C. and J.G. Snedaker (eds.). UNESCO, Paris, France: 91-113.

Dahdouh-Guebas, F., C. Mathenge, J.G. Kairo and N. Koedam, 2000. Utilization of mangrove wood products around Mida Creek (Kenya) among subsistence and commercial users. *Economic Botany* 54 (4): 513 -527.

Doute, R.N., N. Ochanda and H. Epp, 1981. *A forest inventory using remote sensing techniques*. KREMU Technical Report, Series No. 30, Nairobi, and pp72: Department of Resource Survey and Remote Sensing

.

Duke, N.C., Meynecke, J.-O., Dittmann, S., Ellison, A.M., Anger, K., Berger, U., Cannicci, S., Diele, K., Ewel, K.C., Field, C.D., Koedam, N., Lee, S.Y., Marchand, C., Nordhaus, I., Dahdouh-Guebas, F., 2007. A world without mangroves? *Science* 317, 41–42.

FAO, 1993a. Food and Agriculture Organization. *Conservation and management of mangrove, Kenya*. Terminal statement prepared for the Government of Kenya. FAO, ROME. FO: TCP/KEN/0051.

FAO, 1993b. Food and Agriculture Organization, Mangrove for production and protection. FAO Field Document no. 43, Bangkok.

FAO, 1994. Food and Agriculture Organization, *Mangrove forest management guidelines*. FAO Forestry Paper, 117. Rome, 320p.

FAO, 2005. Food and Agriculture Organization, Status and Trends in Mangrove Area Extent Worldwide. Working Paper no. 64. Forest resource division. FAO, Rome. Unpublished.

Ferguson, W. 1993. A Land(scape) ecological survey of the mangrove resource of Kenya. Kenya Wildlife Service and Forest Department, Nairobi (Draft).

Holdridge, L. R., W. C. Greeke, W. H. Hatheway, T. Liang and J. A. Tosi, 1971. *Forest environment in tropical life zones*. Pergamon Press, N. Y. 747 pp.

Kairo, J.G., 2001. Ecology and restoration of mangrove systems in Kenya. Ph.D. Thesis. Laboratory of Plant Sciences and Nature Management, University of Brussels (VUB), Belgium.

Kairo, J. G., F. Dahdouh-Guebas, J. Bosire and N. Koedam, 2001. Restoration and management of mangrove systems with a special reference on East Africa. *South African Journal of Botany* 67:383 –389.

Kairo, J. G.; C. Wanjiru and J. Ochewo, 2009a. Net Pay. Economic valuation of mangrove reforestation in Kenya. *Journal of Sustainable Forestry*, 28:395–414

Kairo, J. G., J. Bosire, J. Langat, B. Kirui, and N. Koedam 2009b. Allometry and biomass distribution in replanted mangrove plantations at Gazi Bay, Kenya. Aquatic Conserv: Mar. Freshw. Ecosyst. DOI: 10.1002/aqc.1046

Kairo, J. G., Lang'at, J. K. S., Dahdouh-Guebas, F., Bosire, J. O and Karachi, (2008) M. Structural Development and Productivity of Replanted Mangrove Plantations in Kenya. *Forest Ecology and Management* 255: 2670 -2677.

Kairo, J.G., 1995. *Community participatory forestry for rehabilitation of deforested mangrove areas of Gazi Bay (Kenya). A first approach.* Final technical report. World Wildlife Fund-USA. And University of Nairobi (Kenya).

Kairo, J.G., B. Kivyatu and N. Koedam, 2002a. Application of remote sensing and GIS in the management of mangrove forests within and adjacent to Kiunga Marine Protected Area, Lamu, Kenya. *Environment, Development and Sustainability* 4(2): 153-166.

Kairo, J.G., F. Dahdouh-Guebas, P.O. Gwada, C. Ochieng & N. Koedam, 2002b. Regeneration status of mangrove forests in Mida Creek, Kenya : a compromised or secured future? *Ambio* 31(7/8): 562-568.

Lugo, A.E. and S.C. Snedaker, 1974. The ecology of mangroves. *Annual Review of Ecology and Systematics* 5: 39-64.

Spalding, M., F. Blasco, and C. Field. 1997. *World Mangrove Atlas*. International Society for Mangrove Ecosystems, Okinawa, Japan.

Tiesongrusmee, B. 1991. *Report on brackish water/coastal aquaculture development in Kenya,* FAO, Rome. Field Document 1.

Wass, P., 1995. (ed.). Kenya's indigenous forests: status, management and conservation. IUCN, Grand, Switzerland, and Cambridge, UK. Xii + 250 pp. 2-8317-0292-5.

Yap, W. G. and R. J. Landoy, 1986. *Report on survey of the coastal area of Kenya for Shrimp farm development*, FAO, Rome.

Management challenges of mangrove forests in Africa: a critical appraisal of the coastal mangrove ecosystem of Nigeria

Yemi Akegbejo-Samsons[1] and I. T. Omoniyi[2]

Summary

Mangroves in Africa have played significant ecological, economical and socio-cultural roles in the lives of coastal communities in the continent. This paper presents the management challenges confronting the mangrove ecosystem of a typical tropical mangrove ecosystem - the Niger delta area of maritime Nigeria. With a coastline of over 970km, Nigeria is a coastal-oriented continental nation having a coastal resource base and a concentration of population along the coast. The paper shows that the Niger delta consists of a tropical rain forest zone and a coastal area of mangrove vegetation transversed by many rivers, tributaries, creeks and lagoons. It lies at the centre of oil productive sites (off-shore and in-shore) and is a sensitive ecosystem vital to the fishing industry and local economy of the citizenry. With a view to highlighting the importance of this ecosystem to the fishing industry, this paper presents the results of investigations carried out in three coastal mangrove systems of Nigeria (Ondo, Ogun and Cross River). All the commercially important fin and shell fish assessed are shown to be either temporary or permanent residents of the mangrove area. The beneficial effects on marine fisheries are at risk from anthropogenic influences such as pollution or destruction of the mangrove ecosystem. The paper calls for a sound marine area protection programme in Nigeria, most especially due to the negative environmental impact of oil production activities in the area.

Introduction

Mangrove forests, which in West Africa cover an area of over 27 000 km^2 in deltas, estuaries and lagoons, is part of the offshore coastal ecosystem. They are regularly influenced and disturbed by seasonal freshwater and diurnal tidal flooding, thus they often exhibit features of an under-utilised ecosystem namely low species diversity and high productivity. African mangroves are very diverse morphologically and in flora and fauna. A total of 17 mangrove tree species are found in Africa with eight species unique for west and central Africa while nine species are unique to the eastern African costs. Nigeria has the largest mangrove forest in Africa. It covers an area of about 9 723 km^2, forming a vegetative band of 15 - 45 km wide above the barrier islands and running parallel to the coastline. About 305 km^2 of the mangrove forest are in reserves. The Nigerian mangrove resource is dominated by the red mangroves (Rhizophoraceae), in association with white mangroves (Avicenneaceae). The mangroves provide breeding and nursery grounds for many commercially important species of fish and shell fish. The stilt

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roots of the mangroves and the mud surface usually support a varied fauna of oysters, crabs and other invertebrates.

The Niger Delta mangroves are today threatened by various human activities such as over logging, clearance for the passage of oil pipes and seismic lines, swamp reclamation for urban development, etc. This paper presents the management challenges confronting the mangrove ecosystem of a typical tropical mangrove ecosystem - the Niger delta area of maritime Nigeria. This paper looks at the economic (fishing) and social (livelihood) importance of the mangrove ecosystem in the Niger Delta. The need for a defined and sustainable management programme of the entire coastal region of Nigeria is recommended.

The Niger Delta of Nigeria
The Niger Delta region of Nigeria covers an area of about 70 000km^2 and is inhabited by about 7 million people (NDES, 1997). Data shows that it is Africa's largest and the world's third largest delta and West and Central Africa's most extensive freshwater swamp forest. This region is a mosaic of diverse and sensitive ecosystems that traverse four vegetation zones, *viz*. freshwater swamps, mangroves, creeks, estuaries and barrier islands. The overlapping and inter-active freshwater, brackish and marine ecological zones are biologically significant for the fisheries of the Niger Delta. The brackish water zone of the Niger Delta is delimited upstream by freshwater swamps and downstream by sandy beach ridges. The mangrove swamps, where the salinity changes with each tide, contribute significantly to the high production of zooplankton thus providing sustenance for the stocks that spawn and "nursery" for fish and crustaceans there. As a result the brackish water zone appears to be the most valuable part of the Niger Delta in terms of the fisheries population.

Data analysis and Results of studies
Between 1990 and 2009, various investigations have been carried out by the staff of the Department of Aquaculture and Fisheries Management, University of Agriculture, Abeokuta. Three different studies were carried out in three coastal states of Nigeria with a view to investigate the diversity and distribution of fish species occurring along the coastal zone of the study areas. Findings from the three mangrove systems of Ondo, Ogun and Cross river estuary are summarized in this paper.

In Nigeria, over 90% of the fish catch is derived from the coastal zone (Moses, 2006). This zone has a high diversity of fish species which are of economic value to the people of Nigeria. The Niger Delta consists of many distinct ecological zones that have a diversity of finfish and shell fish of about 120 species belonging to 78 families in the brackish and marine environments. It has wetland vegetation that are comprised of taxonomically diverse, salt-tolerant tree and other plant species which thrive in inter-tidal zones of sheltered tropical shores and estuaries. Throughout the brackish water areas, crabs and mud skippers (*Periopthalmus hoelferi)* are targets of numerous subsistence operators mainly women (Ajayi,1990). Before the advent of the oil industry, in the late 1950s, the importance of the coastal zone was as a base for much of the country's artisanal fisheries. In the 1970s, yields from catches ranged from 128 000 to 170 000 metric tons per year. According to the survey, (Ibe, 1990), the following species were prominent among catches from the zone: bonga, (*Ethmalosa finmbriata), s*ardines

(*Sardinella madarensis, S. eba, S. cameornensis)* and shad (*Ilisha africana),* which were the principal targets of the pelagic and semi pelagic coastal artisanal fishery activities. Shell fish harvested by artisanal fishermen included white shrimp *(Nematopalaemon machrobrachion),* river prawn (*Macrabrachium vollenhovenii)* and juvenile pink shrimp (*Penaeus notialis, P. duorarum).* The mangrove oyster, (C*rassostra gasar)* and other molluscs were delicacies in high demand.

Mangrove forests are vital for a healthy coastal ecosystem. The forest detritus, consisting mainly of fallen leaves and branches from the mangroves, provides nutrients for marine species and supports a large variety of life in intricate food webs, associated directly through detritus or indirectly through the planktonic and epiphytic algal food chains with the trees.

Fish resources and associated biota: Ondo state coastal mangrove system

Ondo state is one of the eight coastal states of Nigeria that shares a common boundary with the Atlantic ocean. It is characterised by extensive lagoons and river delta system. It lies between latitude 6^0 N and 7^0N and longitude 4^0E and 5^0E. The state is divided into 18 local government areas (LGAs) with only 2 of the LGAs reachable and explored by boats and canoes. Investigation on the fish resources of the area was conducted between 1991 and 1995. Over 32 fish species were encountered and assessed. From the studies, the Bonga, Cichlids and the Catfish family were found to be the most abundant ones in the study area. Apart from the fish resources, the mangrove ecosystem of this area supports other associated organisms which sometimes occur in inter-tidal habitats. While some of these organisms depend upon the mangrove trees for only part of their life cycles, some are associated with them on a permanent basis. In addition, *Rhizophora racemosa, Raphia spp* and *Avicennia africana* was abundantly present in the mangrove ecosystem of the Ondo state coastal area (Akegbejo-Samsons, 1995).

Cross River coastal area

The Cross River is located at the south eastern part of Nigeria (Latitude 4^0, 25^1 – 7^0. 00^1N; Longitude 7^0, 15^1 – 90.30^1E). It is bounded in the south by the Atlantic Ocean and in the east by the Republic of Cameroon. Fish was sampled for 2 years, between May 2004 and March 2006, in 3 zones of the river. Zone I represented the upper part of Cross River characterized by dry climate with grassland floodplains. Zone II was the middle part of the river with moderate climate and mixture of forest-savannah flood plains. Zone III represented the mangrove forest area of the River which is covered by rain forest canopy. Results show that the cichlids, especially *Oreochromis niloticus* and *Tilapia* spp were more numerous in the mangrove forest ecosystem than in the other two zones. *Heterotis niloticus* dominated the zone in percentage, and was more common than in the other zones. The mangrove forest ecosystem was found to be the major habitat for all the Mormyridae, while the catfish family, especially *Clarias anguillaris, Heterobranchus longfilis, Chrysichthys nigrodigitatus* and *C.auratus,* were major commercial species in both weight and number (Offem, 2006).

Ogun state mangrove area

Ogun state is one of the maritime states of Nigeria with a short coastline of about 15 km. It is endowed with an extensive brackish water lagoon system extending from Lagos state in the west and to Ondo state in the east. It is covered by aquatic biotope that reflects its large area of wetlands. The estuarine biotopes include Yewa lagoon, Omu Moha, Makun creek etc, with a total surface area of 767 3 km^2. In addition, Ogun state coastal wetlands have about seven ‘special tidal depressions, with a total surface area of about 24.4 ha. The vegetation of the area is mangrove forest characterised by coastal swamps. There are open-tide flats, popularly known as marine beels. The study was carried out between January 2003 and December 2004 in the coastal area of Ogun Waterside local government area of Ogun state. 38 fish species belonging to 25 families were identified, out which 34 were finfish and 4 shellfish. The results are presented in Table 1.

Table 1: Relative composition and distribution of some commercially important fish species in Ogun state coastal area, Nigeria

Specie	Family	Total fish abundance	Relative abundance (%)
Ethmalosa fimbriata	Clupeidae	101524	28.87
Sardinella spp	,,	93097	26.47
Ilisha Africana	,,	62941	17.90
Pentanemus quinqurius	Polynemidae	30920	8.79
Chloroscombrus chrysurus	Carangidae	16241	4.62
Parapenaeopsis atlanticus	Penaeidae	3303	0.94
Penaeus notialis	,,	2247	0.64

The results showed that *Ethmalosa fimbriata, Ilisha aficana, Sardinella* spp*, Pentanemus quinquarius* and *Chloroscombrus chrysurus* were the most abundant of finfish, contributing 86.6% of the total fish catch. Among these, Clupeids (*Ethmalosa fimbriata, Ilisha africana* and *Sardinella* spp*)* contributed 73.2% of the total catch. The fish species richness varied from one sampled location to another, with the mangrove forest ecosystem contributing the largest (Odulate, 2004).

Discussion

Mangrove forests provide a number of ecological services, including habitat and nursery ground for a productive range of fish, crustaceans, and mollusk species that are harvested locally and in off-shore fisheries. Local residents also use mangrove trees for firewood and for dying of fishing nets. The coastal area is heavily populated, with about 20 percent of Nigeria’s residents living in one of the nine coastal states. The mangroves found here are the largest remaining tract of these ecosystems in Africa and the third largest in the world — covering an area of about 9,723 km2. The mangrove forest ecosystem provides a nursery and breeding ground for many of the commercial fishery species caught in the Gulf of Guinea. Nigeria’s coast is estimated to have about 199 species of finfish and shellfish, a number of which are used commercially. In general, artisanal fisher folk harvest a large variety of fish, crustaceans, and molluscs from the estuaries and channels and utilize mangrove and swamp forest products for a variety of domestic uses. It is evident that most of the coastal areas in Nigeria depend on the mangroves for survival, sustenance and income, in one way or the other. However many marine resources are today harvested unsustainably, both on a commercial scale and by local fisher folks with virtually no controls.

Conclusion

The major problem facing the management of mangrove forests in Nigeria is the lack of baseline data and information for the development of a comprehensive management plan and limited community participation in mangrove management. Unlike the terrestrial forestry little attention has been given to mangrove forestry. As human populations in the coastal zones of Africa continue to grow, and pressures on the environment from land-based and marine human activities increase, coastal and marine resources and their habitats will continue to be dissipated, lost or damaged. This will result to loss in biodiversity and decreasing livelihood opportunities and will further aggravate poverty in these regions. Arresting further losses of coastal and marine resources, and building on opportunities to manage the resources that remain in a sustainable way, are urgent objectives. There is limited monitoring of harvesting system used by mangrove cutters in the entire stretch of the mangrove coastline. Therefore, there is a need to step up sustainable management of this vital coastal ecosystem. This could be achieved by participatory management approach where all stakeholders, especially the local communities, are involved. Studies suggest that the Niger Delta provides an excellent case study in the effects of pollution; there are all conceivable types of pollution in the Niger Delta. There are hundreds of gas flares throughout the Niger Delta. These adversely affect plant life, pollute the air and the surface water; and as they burn they change to other gases which are harmful to the people in the environment. They also cause acid rain. Many fisheries-dependent communities already live a precarious and vulnerable existence because of poverty, lack of social services and lack of essential infrastructure. The fragility of these communities is further undermined by overexploited fishery resources and degraded ecosystems.

Recommendations

There is need to embark on major ways to stem mangrove destruction not only in Nigeria but in the entire sub-Saharan Africa. Some of the recommendations include: (a) Conduct local workshops particularly with involved NGOs, other stakeholders and government agencies to adopt and adapt various management strategies as well as make further adjustments to its context; (b) Collaborate with international NGOs, national, and multilateral organizations to gain endorsement or adoption of the Principles of adopted strategies and management options; (c) Sustained monitoring of the conversion of mangroves to other forms of land use, including agriculture, oil and gas production and mining, most of which cause significant localized damage to mangrove ecosystems; (d) Acquisition of skills, information and opportunities which are available worldwide through collaboration with international players such as FAO, UNESCO etc for more effective mangrove management and (e) Capacity development for mangrove ecosystem management, and awareness raising about mangroves in general are needed at all levels from decision makers in government, to district and municipal officials, community leaders and educational institutions (teachers, students and school children).

References

Akegbejo-Samsons, Y 1995 Ecology of the fisheries resources of the coastal wetland of Ondo state and its management implications. PhD Thesis, Federal University of Technology, Akure, Nigeria. 287pp

Ajayi, T O 1990. Global climate change and their impact on the fisheries resources of coastal Nigeria. In:Tobor, Jg and A.C Ibe (eds) Global climate change and coastal resources and installations in Nigeria: Impacts and responses. Proc. National Seminar on change, 20-21 Nov 1990, Lagos, Nigeria. Pp85-112.

Ibe, A.C 1990. Global climate change and the vulnerability of the Nigerian coastal zone to accelerated sea level rise: impacts and response measures. Technical Paper #52, February 1990. NIOMR, Lagos

Moses, B .S 2006. Fisheries and Ecotourism: A tool for National Development. FISON Conference Proceedings. Enim, UI; Chukwu, EI; Ajah,PO; Aina-Abasi, DA and Nwowu, FM (eds). Fisheries Society of Nigeria, Apapa, Lagos, Nigeria. Pp412

NDES, Niger Delta Environmental Survey Phase One Report, (1997), 1: 114.

Odulate, D.O 2004 Diversity of artisanal coastal marine fishes in Ogun State, Nigeria. Masters Dissertation submitted to the Department of Aquaculture and Fisheries Mgt, University of Agriculture, Abeokuta, Nigeria, 2004. 120pp

Offem, B. O 2006. Water quality and fish abundance in the inland wetlands of Cross River, Nigeria. PhD Thesis submitted to the Department of Aquaculture and Fisheries Mgt, University of Agriculture, Abeokuta, Nigeria, 2006. Pp 248

Oil exploitation, fisheries resources and sustainable livelihood in the Niger delta, Nigeria

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Summary

Mangroves, the coastal forests of the tropics, have traditionally provided a variety of plant products, fish and shellfish for local communities. They also provide services such as coastal stabilization, and food chain support for near-shore fisheries. This study assessed the status of the coastal area of Niger Delta, Africa's largest delta. In the Nigerian coastal environment, large areas of the mangrove ecosystem have been destroyed. The mangrove forests were once a source of both fuelwood for the indigenous people and a habitat for the area's rich biodiversity, but are now unable to survive the oil toxicity of their habitat. The harmful effects of oil spills on the environment are many. Oil kills plants and animals in the estuarine zone. Oil settles on beaches and kills organisms that live there; it also settles on ocean floor and kills benthic (bottom-dwelling) organisms such as crabs and disrupts major food chains. It also covers birds, impairing their flight or reducing the insulative property of their feathers. Oil endangers fish hatcheries in coastal waters and contaminates the flesh of commercially valuable fish. In many villages near oil installations, even when there has been no recent spill, an oily sheen can be seen on the water, which in fresh water areas is usually the same water that the people living there use for drinking and washing. Hence, the public health implication is grave. Several oil spill management policies and efforts are in place to reduce the menace of oil spill incidents in the country. However, most are poorly implemented and laws are usually not enforced. We therefore propose constant monitoring for oil spillage, stringent enforcement of laws and other policies and remediation efforts geared towards restoring the environment of the Niger Delta.

Introduction

The Niger Delta is located in Southern Nigeria and is Africa's largest delta and the third largest world mangrove forests. It covers about 70 000 square kilometers. About one-third of the delta consists of wetlands (Spalding *et al*, 1997). The Niger Delta is unique in Nigeria because it is the home of Nigeria's oil industry, with its attendant environmental hazards such as water, land, air pollution, etc., which pose great challenges to economic development of the Niger Delta. Pollution in the Niger Delta region is largely due to industrialization: petrochemical industrial waste discharge, oil spills gas flaring etc. Exposure to oil or its constituent chemicals can alter the ecology of aquatic habitats and

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the physiology of marine organisms. When oil pollutes the water, some of its components are degraded and dispersed by evaporation, photochemical reactions, or bacterial degradation, while others are more resistant and may persist for many years, especially in shallow waters with muddy sediments. Accumulation of contaminants to hazardous levels in aquatic biota has become a problem of increasing concern (Idodo–Umeh, 2002, Adeyemo, 2003, Adeyemo, 2008). It is of paramount importance that a constant assessment and monitoring of the health of the aquatic system in Niger Delta be carried out. This study focuses on the impact of oil exploitation on the mangrove forests, fisheries resources, public health and sustainable livelihood in the Niger Delta, Nigeria.

Oil Exploitation Leading to Loss in Niger Delta

Moffat and Olof (1995) observe that despite existing, abundant natural resources, the region's potentials for sustainable development remains unfulfilled while the crisis there is exacerbated by environmental degradation. The imprints of the multi-national oil corporations operating in the Niger Delta are visible throughout the region. Some of the oil industry activities that have led to mangrove vegetation clearance include construction of flow stations, pipelines, and seismic lines. Mangrove vegetation clearance causes many problems, the vegetation in the Niger Delta will take between 30 to 40 years to regenerate once removed. Very little documented information is available about the quantity of oil that is spilled by the oil industry's offshore jetties. Indirect evidence from oil washed onto coastal shorelines and beaches in the area suggest, however, that the pollution is significant. Their coastal location makes mangrove forests vulnerable to marine oil spills and on-going pollution from offshore rigs, as observed in Figure 1.

Figure 1: Urie River in Igbide-Isoko in Delta State, note the oil pollution

The oil spills in mangrove habitats permeate exposed tree trunks, accelerating the rate of decay of these precious plants and, as a consequence of their disappearance, will lead to shoreline erosion. They will also devastate fauna and other flora, organisms big and small that depend on mangroves for survival. The destructive will spiral continue down the food chain as fish populations diminish as do the fishermen´s catches. There is a need for careful and continuing environmental monitoring, the more so because of the increasing importance of fish as a source of protein for human populations and the interest in understanding the accumulation of heavy metals and polyaromatic hydrocarbons (PAHs) at the different trophic levels of the food chain, (Greig *et al*., 1978; Obasohan and Oronsaye, 2004).

Impact of Oil Exploitation on the Mangroves

Generally, mangrove forests provide a wide range of beneficial natural ecosystem goods and services for man (Nwilo and Badejo, 2005). Oil spills are a serious concern in regard to the health of Nigeria´s remaining mangrove forests. Leaked oil permeates the coastal waters and streams, coating the exposed, air breathing roots of the mangroves. It is difficult, if not impossible, for the plants' breathing lenticels to perform their essential functions when covered in oil thus, in effect, they are slowly suffocated. Massive mangrove die-off is a common phenomenon plaguing the mangrove regions where coastal oil exploitation occurs. Because oil spills often occur in remote regions, many frequent accidents may go undetected for long periods of time, and are not cleaned up in an effective and timely manner. Oil spills in the Niger Delta are attributed to oilwell blow-outs, sabotage, corrosion, equipment failure, and operator or equipment maintenance errors. In 2006, an independent team of experts from Nigeria's Ministry of Environment, World wildlife fund (WWF), UK and the IUCN Commission on Environmental, Economic and Social Policy in their preliminary findings reported that an estimated 9 million – 13 million barrels (1.5 million tons) of oil has spilled in the Niger Delta ecosystem over the past 50 years, representing an amount equivalent to about one "Exxon Valdez" spill in the Niger Delta each year, while the financial valuation of the environmental damage was estimated to be tens of billions of dollars. In the present study, we identified rapid urbanization, wood extraction, dredging activities, oil industry operations, and threats from invasive species to be the primary drivers of the loss in the mangrove forests across the Niger Delta. In addition, over 200 000 poles and wooden items are reportedly extracted annually from the mangrove forests (Figure 2).

Figure 2: Ethiope River in Sapele showing on-going logging activities

Impact of Oil Exploitation on local communities

Nigeria flares more natural gas associated with oil extraction than any other country on the planet, with estimates suggesting that 3.5 billion cubic feet (100 000,000 m³) of associated gas (AG) is produced annually, of which 2.5 billion cubic feet (70 000,000 m³), or about 70%, is wasted via flaring. AG wasted during flaring is estimated to cost Nigeria US $2.5 billion per year (World Bank, 1995; Nwilo and Badejo, 2005). Along with the inefficiency of gas flaring, another problem which gas flaring poses is the release of large amounts of methane, which has very high global warming potential. Methane losses are accompanied by another major greenhouse gas escape, that of carbon dioxide, of which Nigeria was estimated to have emitted more than 3 438 metric tons of in 2002, accounting for about 50% of all industrial emissions in the country and 30% of the total CO_2 emissions. Gas flares can have potentially harmful effects on the health and livelihood of the human communities in their vicinity, as they release a variety of poisonous chemicals. Combustion by-products include nitrogen dioxides, sulphur dioxide, volatile organic compounds like benzene, toluene, xylene and hydrogen sulfide, as well as carcinogens like benzapyrene and dioxin. Humans exposed to such substances can suffer from a variety of respiratory problems, which have been reported amongst many children in the Delta but have apparently gone uninvestigated. Flares located close to local communities portend a high public health risk (Figure 3).

Figure 3: A community around Uzere creek, with on-going gas flaring.

Impact of Oil Exploitation on Sustainable Livelihoods

During this study, human populations in the Niger Delta were found to be predominantly farmers and fishermen, living off the rich alluvial farm lands and abundant surface water-web that characterizes the basin. It is a universally known that mangrove forests act as nursery grounds for many marine fish. The Niger Delta is bordered by a deep belt of mangrove forests, which protects vast areas of freshwater swampland in the Inner Delta. The trees and roots provide rich habitats for a wide variety of flora and fauna, much of which is only just beginning to be known and understood. The Niger Delta also has the greatest extension of freshwater swamps in Africa. The region's brackish creeks, bays and tidal pools are breeding grounds for the marine life upon which many people depend for their livelihoods. It has been estimated that 60% of the fish in the Gulf of Guinea breed in the mangrove forests of the Niger Delta. Oil spillage has been found to be impacting the fisheries resources adversely (Akpofure *et al*, 2000). Aworawo (2000) commented that the economic conditions in the Niger Delta reflect unequivocally that poverty is endemic in the region and that it is getting worse as a result of oil pollution of the coastal water that provides fish consumed by the people. According to the members of communities interviewed, there has been over recent years massive reduction in fish catches by fishermen. We also observed in the present study that in rivers polluted by oil spillage, some fishes were severely coated with crude oil, making them inedible, while some others were found floating dead on the surface (Figure 4).

Figure 4: Some fishes recovered from oil polluted Uzere creek, note the oily sheen on the dead fishes.

Women and children are the worst hit, because mangrove swamp fisheries such as hand-picking of periwinkle (*Tympanotonus* spp and *Pachymenalia* spp) are mostly a job of the womenfolk in the Niger Delta. On the average, fish constitutes 40% of the animal protein intake in Nigeria. The percentage of fish consumption is generally higher for residents of the Niger Delta region. A decline in fish availability will have serious consequences on the nutritional status of the people, especially children who require adequate fish intake their development. Because of economic incapacitation, inhabitants of the Niger Delta are today living in poor health conditions and in an environmentally polluted atmosphere that constrain a good standard of living. According to WHO; "an urgent need exists to implement mechanisms to protect life and health of the regions inhabitants and its ecological system from further deterioration" (World Bank, 1995).

Sustainable Use of the Mangroves of the Niger Delta

Non-sustainable use of the mangrove ecosystems can lead to loss of the whole mangrove habitat, and associated losses of shoreline organic matter production and the disappearance of species dependent on the habitat and mangrove-based food chains.

Appropriate responses needed to ensure sustainability of the mangroves forests of the Niger Delta include:

- Stabilization and protection of shorelines;
- Filtering, trapping and removal of water-borne pollutants;
- Maintenance of nursery and feeding grounds for numerous species of finfish and prawns and habitat for crabs and molluscs;
- Provision of nesting sites for sea and shore birds.

Conclusion

Oil development occurred in the Niger delta of Nigeria without a comprehensive, strategic plan which would have protected its natural resources. Many of the oil facilities and operations are located within sensitive habitats - including areas vital to fish breeding, sea turtle nesting, mangroves and rainforests; that have often been severely damaged, contributing to increased biodiversity loss and poverty. The damage from oil and gas operations is chronic and cumulative, and has acted synergistically with other sources of environmental stress to result in a severely impaired coastal ecosystem and compromised livelihoods and health of the region's impoverished residents. Sustainability of mangrove forests and coastal ecosystems depends on collaboration by all stakeholders to introduce adjustments to industrial processes, oil spill prevention, response preparedness; restoration framework and implementation plan. Corporate Social Responsibility (CSR) and Environmental Stewardship should be required of the oil exploitation industries and enforced by the federal government.

References

Adeyemo O.K, (2003): Consequences of Pollution and Degradation of Nigerian Aquatic Environment on Fisheries Resources. Environmentalist, Vol. 23:4 pp 297-306.

Adeyemo O.K. (2008): Habitat assessment for seasonal variation of River pollution in Ibadan, Nigeria, in a geographic information systems interface. *Veterinaria Italiana*, 44 (2), 361 371.

Akpofure, E.A., Efere , M.L. and Ayawei, P. (2000): The Adverse Effects of Crude Oil Spills in the Niger Delta. Urhobo Historical Society.

Aworawo D. (2000): The Impact of Environmental Degradation of the Rural Economy of the Niger Delta' in Osuntokun, Akinjide, Environmental Problems of the Niger Delta, Lagos, Friedrich Ebert Foundation

Greig RA, Wenzloff DR, Mckenzit CL, Merill AS, Zdanowicez V.S (1978): Trace metals in the sea Scallops Pacepedent magelanicus from Eastern United States. Bull. Environ. Contam. Toxicol. 19: 326-334.

Human Rights Watch. (1999): The Price of Oil. Retrieved May 17, 2007, from http://www.hrw.org

Idodo-Umeh, G. (2002): Pollution assessments of Olomoro Water bodies using Physical, Chemical and Biological indices: PhD. Thesis, University of Benin, Benin City, Nigeria, p. 485.

Moffat, D. and Olof, L. (1995): Perception and Reality: Assessing Priorities for Sustainable Development in the Niger River Delta. Ambio Vol. 24. 7/8December PP. 527-538.

Nigeria's Ministry of Environment, WWF UK and the IUCN Commission on Environmental, Economic and Social Policy (2006): Niger Delta Natural Resource Damage Assessment and Restoration Project; Executive Summary.13pp.

Nwilo, P.C. and Badejo, O.T. (2005): Oil Spill Problems and Management in the Niger Delta. International Oil Spill Conference, Miami, Florida, USA.

Spalding, M., Blasco, F. and Field, C. (Eds.) (1997): World mangrove atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan. 178pp.

World Bank (1995): Defining an Environmental Strategy for the Niger Delta.

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Livelihoods in Cameroon mangrove areas: finding a balance between conservation and sustainable use in a fragile ecosystem

Oumarou Njifonjou[1], Mvondo Ze Antoine[2] and Ondo Sylvie Carole[3]

Summary

A socioeconomic study was conducted in the two mangroves of Cameroon with the objective of identifying all the activities and livelihoods of populations and subsequently record their impact on the conservation and sustainable management of this ecosystem. The Rio Del Rey mangrove in the South-west region (Bakassi area) and the Cameroon estuary mangrove in the Douala region, include seven species that form the wood and non-wood floristic base in this environment. These comprise six indigenous mangroves species and one species introduced from Asia, the Nipa palm (Nypa fructicans). The study underlines a multitude of sectors including those of halieutic (fishing) products, agricultural products, wood, shopkeeping and sand. Measures to manage the anarchic development of Nipa palm are suggested. For a sustainable management policy of Cameroonian mangroves, it is urgent to have laws and regulations specific to that ecosystem.

Introduction

With an estimated surface area of 277,000ha, Cameroon mangroves include three large groups: (1) the Rio Del Rey mangrove in the Bakassi area (150,000ha) stretching from the Njangassa village to the Nigerian border, as well as all the islands of the Rio Del Rey estuary; (2) the Cameroon estuary mangrove (120,000ha) stretching from the Sanaga estuary to the Bimbia Cape; and (3) the Southern mangrove (about 7,000ha) located in Campo at the mouths of the Nyong, Lokoundjé and Ntem rivers. It should be noted that this mangrove has been excessively exploited here and there, especially for young trees cut as poles and exported to Nigeria.

The coast's equatorial maritime type of climate, the differences in annual rainfall from the south to the north (4,000mm in Douala, 11,000mm in Debunscha, and 6,000mm in Rio Del Rey), a relatively high air temperature (28°C), and a low salinity (<5‰), are all favorable factors for the development of these mangroves. They are also conducive for the installation of human communities in these environments, and for economic activities that potentially have negative impacts on the biodiversity of that ecosystem. Apart from the known natural functions of mangroves, in Cameroon they are often the basis for significant economic exchanges. The economic operations thrive on the dynamics of the demand from urban areas in Cameroon as well as exchanges with neighbouring counties such as Nigeria and Equatorial Guinea.

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Universally known as an unstable and fragile ecosystem, Cameroon has adhered to the protection of mangrove ecosystems through a framework law n° 96/12 dated 05/08/96 and its Article 94. In the overall framework of defining a sustainable development policy for Cameroon's mangroves, a multidisciplinary study focusing on the participatory management and conservation of the biological diversity of mangroves was carried out during the year 2005. This paper presents a number of results of the socioeconomic aspect of the study, with a view to identifying all the activities and livelihoods of communities in mangroves areas of Cameroon, and recording their impact on the preservation and sustainable management of that ecosystem.

Materials and method

Site and materials

The study considers the Rio Del Rey estuary mangrove and the Cameroon estuary mangrove. Several villages were visited except those on the Bakassi peninsula (Idabato and Diamond) that were still experiencing armed conflicts at that time. Site visits were carried out using a 4x4 pickup vehicle and a small boat. The light equipment includes a GPS, a camera, hydrographical and tides maps, pieces of strings and survey sheets.

On-site data collection strategy

A multidisciplinary team including a socio-economist in fishery, a mangrove developer, a hydro-pedologist, a lawyer and the survey staff, was formed to conduct a participatory analysis in the communities living in the region under study.

The collection of information was primarily done at the level of the administrative centre of localities visited, after consultation with local institutions for information on the large-scale dynamics affecting the overall mangrove ecosystem. Local institutions consulted included administrative authorities, representatives of relevant technical ministries, NGOs, fishermen associations, fish traders, logging companies and lumberjacks; and sand operators. Information was collected in villages systematically visited and geo-referenced:

- At the level of focal groups and village institutions (Village Chief, heads of socio-professional associations, youth and women groups, fishing post managers, School headmaster, hospital nurse, etc) to collect information on the various aspects of communities livelihoods;
- Participatory discussions with the various socio-professional categories (fishermen, fish traders, farmers, loggers, transporters, sand and gravel operators, etc.) in 20% of villages visited. The sample embraced all the types of villages (small, average, large). The data collected enabled the team to grasp the village dynamics as regards access to resources and related conflicts, income generating activities, actors' perceptions on sustainability, environment preservation and protection, etc.

The approach used was interactive and deductive with the use of the main MARP (Methode Acceleree de Recherche Participative) tools which facilitated an identification and inventory of the floristic biodiversity and enabled detection of areas where the mangrove ecosystem is in a state of advanced deterioration. MARP (a French acronym) is very similar to Participatory Rural Appraisal (PRA).

Results and discussions

Vegetation and floristic composition of mangroves

The majority of mangrove species in Cameroon belong to three (3) families: *Rhizophoraceae,* Avicenniacea and *Combretaceae*. The associate or volunteer species are highly varied and amount to more than 19 families. Seven species are predominant, including six indigenous species gathered under the term 'mangrove' and one introduced species, the Nipa palm originating from Asia (Table 1). The 'associate species' are mainly: *Drepanocarpus lunatus, Dalbergia ecastaphylum, Hibiscus tiliaceus, Phoenix reclinata, Acrostichum aureum, Pandanus candelabrum, Raphia palma pinus*, etc. *Rhizophora spp.* is the predominant species in Cameroon with about 80% of mangrove vegetation followed by the Nipa palm (*Nypa fructicans*) with about 13%.

Table 1: The main mangrove species in Cameroon

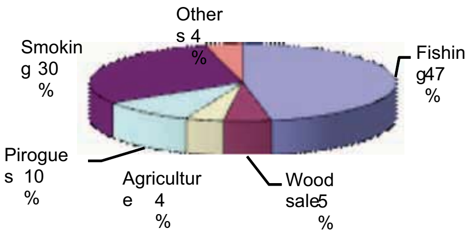
Mangrove species	Abbreviation	Family
Rhizophora racemosa	*Rr.*	*Rhizophoraceae*
Rhizophora mangle	*Rm.*	*Rhizophoraceae*
Rhizophora harrisonü	*Rh.*	*Rhizophoraceae*
*Nypa fructicans**	*Np.*	*Arecaceae*
Avicennia Germinaans	*Av.*	*Avicenniacea*
Laguncularia racemosa	*La.*	*Conbretaceae*
Conocarpus erectus	*Co.*	*Combretaceae*

****Introduced species*** **Source: Thomas, D.W. & Check M., 1992**

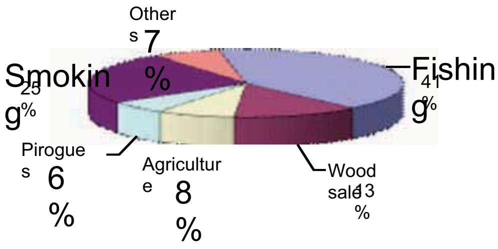
Livelihoods in the mangroves of Cameroon

The analysis of data collected on site (Njifonjou, 2005; Mbog, 2005; Mvondo Ze, 2005) underlines a great number of activities often performed seasonally. Even though the same activities are found in the entire area, some of them are more important in the Southern mangrove in view of the presence of large towns.

In Rio Del Rey, at the border with Nigeria (Figure 1.a) fishing is the most important activity (47% interviewees) followed by fish smoking (30%) and the manufacturing and repair of dugout canoes (10%), wood sale (5%), agriculture (4%) and other activities (house building, petty trading, transport of goods).



a) Bakassi area



b) Cameroon estuary

Figure 1: Distribution of populations' activities in the southern part of Cameroon

Fish smoking, manufacturing of dugout canoes, house building, and wood selling represent 48% and are all the activities related to the exploitation of mangrove wood, confirming its importance in the area under study. Wood sale is less important and located around the Bekumu fishing grounds of which the main activity is catching the small shrimp (*Nematopaleamon hastatus*) (popularly called Njanga in Cameroon) which is sold dried-smoked.

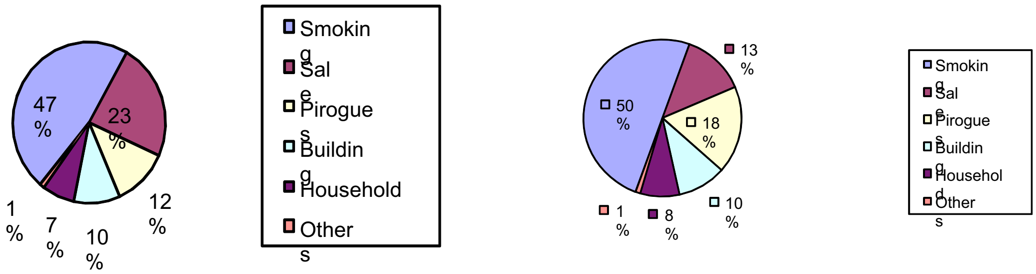
At the Cameroon estuary (Figure 1b), fishing also remains the most important activity within that mangrove ecosystem. However trade in wood (13%) is gaining importance in view of the nearness to large urban centers of Douala and Tiko (especially in Bilongue, Bonaberi and Avion Beach neighbourhoods). Fishing grounds such as Yoyo I, Youme, Cap Cameroon, Kange, Mabeta, etc. are big centers for fish smoking.

All the activities related to logging (smoking, woodwork, building) represent 46%. This confirms once again the excessive logging occurring in Cameroon mangroves in general and testifies to the need to undertake an urgent action to preserve that ecosystem. Agriculture is also more important in the south (8%) of villages located near dry land. The other activities (6%) are spread between sand exploitation (2.5%), house building and woodwork (2.0%), transport of goods and persons (1%) and trade (1.5%).

Levels of exploitation

as a a e a

Human activities in the mangrove forests of Cameroon are more focused on logging; however some species such as rattans and palms near or inside mangrove ecosystems, are also subjected to intensive harvesting. Mangrove logging has become the second activity after fishing in mangroves. Red mangrove (*Rhizophora spp.)* is by far the most solicited species: used for fuel wood, fish smoking (wood and fruits), timber. Figure 2 presents the distribution of wood use in the mangrove areas of (a) the Cameroon estuary, and (b) the Bakassi area.



a) Cameroon estuary *b) Bakassi area*

Figure 2: Categories of wood-use in the mangroves of Cameroon

There are small and large scale loggers. Regarding the small-scale loggers, the cutting is done with machetes or sometimes axes and mainly involves small areas. This system leads to the reduction of young trees of 10 to 20 cm diameter (1 to 5 years old) sought after for their easy use and transport (fish smokers, housewives, shelter builders).

The large-scale loggers use motorized chainsaw and cut big trees to be sawn as planks and used for fuel. This is an intensive and profitable exploitation even though illegal. Loggers are sometimes organized in associations (operating illegally) like the 'Firewood Cutters Union' of Cap Cameroun Village. At Rio Del Rey, mangroves suffer from excessive cutting of poles directly exported to Nigeria for use on various building sites.

Agricultural logging

In Cameroon, agriculture is secondary and highly scattered in mangroves area. It concerns only a few villages such as Ekoumamindo, Bekumu, Bamousso in the northern part of the area; Tiko, Mabeta, Manoka, Mouanko in the southern part; and these are villages benefiting from the nearness to dry land. However, there are large rubber tree and oil palm plantations belonging to the agro-industrial company Cameroon Development Corporation (CDC) that occupies large surface areas at the outskirts of the mangrove area. Rice production is missing and unknown and backyard (homestead) gardens are widespread in the villages with fruit trees and various types of food crops.

Exploitation of sand quarries

Sand exploitation is one of the important activities in areas covered by mangroves, and at the same time near large towns. Sand quarries are visible everywhere in the Cameroon Estuary, particularly around the city of Douala (Modeka Bay, Youpwe, Bonabéri neighbourhoods) where the annual mangrove sand production is estimated at 90,000 m^3. That activity is increasingly spreading in the Cameroon Estuary because of the ever increasing demand for large grain river sand exported to Equatorial Guinea.

Impact of industrial, urban and entertainment activities

The effects of urbanization and its consequences are more perceptible in the Cameroon Estuary mangrove. The perpetual increase of the population of Douala causes a systematic invasion of mangrove areas, both by populations and new factories. The result is industrial and household pollution with the dumping of waste materials such as phosphate, heavy metals (Pb, Zn, Cu, Cd, etc.), solid waste and organic matter in the environment. Hydrocarbon pollution is perceptible in the entire area, especially with the frequent dumping of oil in the sea (e.g. refinery wastes, platforms, waste oil from fishing boats, etc.)

Impact and development of Nipa palm (Nypa fructicans)
Originating from South-East Asia and typical of swampy estuaries, Nipa palm was introduced in the Gulf of Guinea from the Calabar region where the species spreads its seeds along the Guinea current. The multiplication and development of *Nypa fructicans* species in the areas disturb the optimal development of various indigenous mangrove species and became a plague in the entire region. In Asia, the plant has multiple uses (building material, basketwork, sweet sap used to prepare sugar and alcohol, kernel often consumed, etc.). In the Bakassi region and in Calabar where the palm found a good growing environment, populations use it only to build houses, weave mats and baskets, etc.

Prospects for the sustainable management of mangroves in Cameroon
Since the participation of Cameroon to the Rio de Janeiro Earth Summit (United Nations Conference on Environment and Development, 1992), the protection and conservation of the mangrove ecosystem is henceforth included in the list of priority tasks for ministerial, decentralized and other authorities. Among the current projects: the review of the legal framework for fishery and aquaculture (Project (A) : the TCP/CMR/2908(A) Project on participatory management and conservation of mangroves biological diversity, the research programme N°3-2007/IRAD/SRHOL on destruction strategies of the Nipa palm (manual destruction of fruits and sabotage of the heart of Nipa to stop its growth) and in Nigeria, funding of a demonstration project on Nipa monitoring through its use at the University of Calabar, by the Project 'Gulf of Guinea Large Marine Ecosystem (GCLME).

Conclusion and recommendations
These studies contributed to the diagnosis of the situation of major mangrove ecosystems in Cameroon, through the evaluation of mangroves resources and their potential to contribute to food security and income generation. The mangroves were exposed to a double pressure from endogenous and exogenous factors. They were subjected to various uncontrolled actions by local coastal populations, and to continuous changes of the coastal environment as well as to pollution by urban and maritime waste. Many activities were thus carried out, notably fishing and related activities, wood cutting for various uses (more than 60% of activities revolve around wood cutting), agriculture, sand extraction;
and the multiplication of Nipa palm added up to the long list of the causes of the drastic reduction of the extent of mangroves surface areas. Cameroon is thus faced with mangrove ecosystem that is anarchically exploited, not rationally managed or protected and little developed. This situation will further compromise the ecosystem's vital functions.

The results have made vital information available. Therefore the country should formulate its development plan, put in place mangrove-specific legislation and regulations, and adapt them to the latest developments that occurred in that ecosystem both at national and international level. As the primary beneficiaries of the ecosystem, local resident populations should be sensitized to make sustainable use of the mangrove ecosystem. Actions to embrace should include selective tree cutting for fish-smoking, the use of more efficient fish smoking wood-kilns, the use of young Nipa fruits to slow down its development, and the non-use of destructive practices in nursery areas, etc.

Although some initiatives have been launched on the sustainable management of the mangrove ecosystem in Cameroon, it would be advisable that concerted actions be carried out to realize the activities of the GCLME Mangrove Demonstration project on each side of the Cameroon-Nigeria border.

Bibliographic references

Ambrosse Oji, B. & Pouakouyou, D., 1998. MCP West Coast Zone Research Summary: Biological and Socio economic Base Data for Ecological Monitoring and Forest Management. *MCP Limbe.*

EMR, 1998. Environmental Impact Assessment of Plantation Expansion in Forested Lowland of the Mount Cameroon Region: CNTR97 3285A. *Report to DFID. London. FAO/DIPA N° 38, 66p.*

Folack, J., Mbome, L., Bokwe, A., Tangang, Ing. A., 1999. Profil côtier du Cameroun. Projet GEM-GOG; ONUDI, Abidjan; 113p.

Jeanrenaud, S., 1991. The Conservation Development Interface: Study of Forest Use, Agricultural Practice, and Perceptions of the Rainforest at Etinde, South-west Cameroun *ODA-London.*

Mbog, D.M., 2005. Gestion participative et conservation de la diversité biologique des mangroves : Aménagement Participatif des Ecosystèmes des Mangroves; *Rapport Projet TCP/CMR/2908 (A.*

Mvondo, Z., 2005. Gestion participative et conservation de la diversité biologique des mangroves : Volet Hydro-pédologie et étude d'impacts environnementaux; *Rapport Projet TCP/CMR/2908 (A) ; 60 p.*

Njifonjou, O., 2005. Gestion participative et conservation de la diversité biologique des mangroves : Volet pêche artisanale, aquaculture biodiversité ; *Rapport Projet TCP/CMR/2908 (A) ;40 p.*

Njifonjou O., Njock J.C., 2007. Management and exploitation dynamics of the small scale fisheries in the Bay of Biafra: An integrative analysis of the Purse Seine fishing activity. *The International Journal of Sustainable development and World Ecology*, 14: 243 – 249.

Njifonjou O., Mounch A., Fabre B., 2008. The Bakassi Land: Sovereignty and Dynamics of the cross-border fishing economy. *African Journal of Fisheries and Aquaculture*. Paper submitted on February 2009.

Payton, R.W., 1993. Ecology, Altitudinal zonation and Conservation of Tropical Rain Forest of Mount Cameroon. Final Project Report R4600. *Soil Survey & Land Research Centre, Cranfield Institute of Technology. bedford. 70p.*

Thomas, D.W. & Check M., 1992. Vegetation and Plant Species on the South Side of Mount Cameroon in the Proposed Etinde Reserve. *Report to MCP Limbe. Royal Botanic Garden, Kew, 37p.*

Watts, J. & Akogo, G.M., 1994. Biodiversity Assessment and Developments towards Participatory Forest Management on Mount Cameroon. *Commonwealth Forestry Review 73. OFI. Oxford.*

FAO REGIONAL OFFICE FOR AFRICA

Human activities; the key threat to the rich Tana delta mangrove forest in Kenya

Geoffrey Murithi Riungu[1]

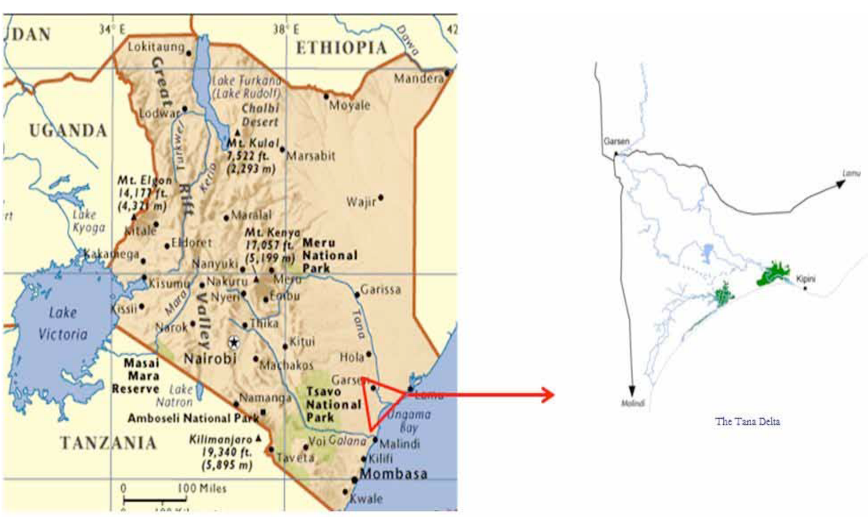
Summary

In Kenya, mangrove swamps cover an area of about 53km²(53,500 hectares) along the coast, with sixty percent, or about 33, 500 hectares, found in the Lamu Archipelago. There are ten species of mangrove along the Kenyan coast, found in estuaries such as Mida Creek, and Gazi bay. Despite the diversity of benefits attributed to mangrove, the uncontrolled exploitation and habitat destruction are reducing their coverage at alarming rate. This paper seeks to underscore the ecological role and the benefits of mangrove forest to the Tana Delta communities of kenya, the main drivers to the destruction of Tana Delta mangrove and the possible interventions to arrest future ecological collapse of this unique ecosystem.

Introduction

The Tana River Delta (Figure 1) is arguably one of Kenya's unique natural and human environments located in a semi-arid area of Garsen, Tana River district, Coast Province. It is one of the six deltaic areas off Eastern Africa and is Kenya's largest deltaic zone. It is estimated to be about 130,000ha of which 69,000 are regularly inundated. The striking feature of the Tana Delta is the prodigious variety of its wetland habitats and the richness of its biodiversity thanks to the Tana River.

Figure 1; Map of Tana Delta (source: Multiple land use model for Tana Delta)



The Tana River is the longest river in Kenya being over 1000km long and it has a catchment area of 95,000km². It discharges an average of 4000 million m³ of fresh water and about 4million tones of sediments annually into the Indian Ocean. Before entering the Indian ocean, about 30km upstream of Kipini, the Tana River forks and forms the complex of tidal creeks, flood plains, coastal lakes and mangrove swamps known as the Tana Delta.

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There are mangroves along the main river course of the Tana River between Ozi and Kipini (including large areas with tall *Heritiera littoralis* - about the only place in Kenya where these are found) and in the tidal delta south of the main river (dominated by *Avicennia marina, Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Xylocarpus granatum, Sonneratia alba)*. Other mangrove areas include Tunza, Tudar Creek, Funzi bay, Mtwapa creek, Shimoni, Majorani, Vanga-Jimbo, Ozi, Mteza and Mwache creeks.

Social, economic and ecological importance of Tana Delta mangrove

Mangrove forests in the Tana River area are of significance spanning from social-economic to ecological importance especially to the local indigenous people who over the years have created intriguing relationships with the local environment. Mangrove ecosystems have been recognized as an important food source in food chains for fish and the value of mangroves for fisheries is five times greater compared to alternative uses. Aksornkoae (1993) observed that mangrove contributes nutrients to the ecosystem, provide shelters and nurseries for fish and help support extensive aquatic species. Tana Delta is tremendously rich in fish with more than 40 species recorded in it some of which are endemic such as the feather-barbelled squeakers (Swara Newsletter, 2001). Fishing is an important source of food and employment. The local fisher folks (Malakote minority community) depend on the delta fish for their livelihoods. In Kipini, fish is consumed in almost every meal and very early, before dawn, you will see fishermen with their night fish catch walk into the village across the mangrove trees, some to their home and others to the market places but not before preserving the fish through smoking, using as fuel *Bruguiera grmnorrhiza* and *Avicennia marina* mangrove tree species.

The local indigenous people have over the years used mangrove trees as fuel wood and building materials. The most commonly used species are *Avicennia marina* and *Ceriops tagal*. These and other tree species also provide poles and rafters for the construction of traditional huts, which are commonly round in shape and made of mud. Traditionally, the mangrove tree species *Xylocarpus granatum* has been used by local medicine men to remedy various human diseases. Its stem pulp is applied to cure skin infections and rashes, and its seeds are used in treating stomach problems and in inducing abortion. However, as observed by Aksornkoae (1993), the traditional medicinal value of mangrove has not received much scientific investigation and experiments.

Other non-monetarily measurable benefits of mangroves at the local level include the provision of habitats to animals and birds and branches for beehives siting especially the *Avicennia* and *Ceriops* species. The leaves of *Avicennia marina* are used as fodder for goats, camels and cattle. They, further, offer good sites for educational and scientific research programmes and support recreation and eco-tourism activities due to their aesthetic value. Moreover, mangrove helps to stabilize shorelines of Indian Ocean and estuaries by protecting them against tidal bores and soil erosion. Other indirect benefits include filtering of nutrients, and protection of hinterlands from salt intrusion (currently witnessed in the Tana Delta due to reduction of mangrove cover).

Threats to mangrove survival

Despite the Tana Delta's value and benefits, the diversity and richness of its mangrove vegetation has faced threats of degradation and continues to be a hot spot for unsustainable commercial and sectorial economic development. In the early 1990s, a multinational company was allocated land in the Tana Delta to develop shrimp farms by the government. This allocation was followed by a wide and organized protest by the local communities and environmentalists, who referred to the negative effects this could cause to the mangrove ecosystem and which announced that this would abuse traditional land rights of indigenous local communities. The Kenyan government acknowledged these pleas and, through a Presidential decree, stopped the project. Litigation between the company and the government remains however unresolved, and there are fears that the company might restart the shrimp farm project in the future.

During the same period, a lot of mangrove forests were cleared for the development of rice plantations. Although the impacts of this activity were not established at the time, this has no doubt had negative effects on the natural ecological setup. The rice growing scheme was discontinued after the 1998 El Niño catastrophe, the severity of which has been largely attributed to climate change. Recently however the government has made plans to re-establish the rice growing scheme to remedy growing food insecurity in the country.

Further serious threats to the coastal mangrove ecosystems in the Tana River area arose in 2004 with the earmarking of the delta as prime land for two large-scale multi billion dollar sugar cane projects. In mid 2007, the *pro* conservation lobby and local communities went to court to stop one of these projects, but on 18th June 2009, the Malindi High court ruled on technical grounds in favor of the project. The contesters have expressed fears that the project will have grave negative effects, as it will result in massive clearing of mangrove forests and other natural coastal vegetation in the area and in the use of the waters of the already shrinking Tana River and related wetlands to irrigate more than 2000 km^2 of sugar cane plantations. The activities are bound to negatively impact the already economically marginalized indigenous communities and to cause adverse effects on the ecological systems downstream. Among the biodiversity that will be negatively affected are; marine turtles, sharks (3 species listed as endangered by CITIES) and birds.

Currently, a large mangrove area in the coastal province has been cleared for salt production. To-date, the area covered by the salt pans exceeds 6,500 ha, and this area shows an increasing trend. The situation in this area will further deteriorate if a proposed Titanium mining and oil exploration project in the Tana Delta were to be realized.

In addition, due to legislation inadequateness, the rampant indiscriminate illegal harvesting and unsustainable use of the Kenyan mangrove resource go uninhibited. For instance, whereas mangrove and terrestrial forest are put together under the Kenya Forest Act 2005, the Kenya Forest service puts more emphasis on terrestrial forests than the mangrove forests which are thus neglected. Mangroves of the Tana Delta are particularly vulnerable because unlike others of Kiunga, Shimoni, Vanga and Mtwapa that occur within marine protected area, they do not have a protected status.

The future of Tana delta mangrove

Unsustainable development of this region will have negative impacts on mangroves ecosystems, and may be further aggravated by effects of climate change. In this regard, unless urgent action is taken to reverse present trends, the fragile mangrove ecosystems which have been slowly recovering from the El Niño phenomena of 1998, will be affected severely by both possible climate change impacts and anthropogenic interference.

Consequences include de *facto* reduction in river stream flow and changes in water PH, negative effects from the clearing of vegetation to give way for sugar cane and other monoculture plantations, solar salt pans, and agricultural and industrial pollutants from unsound development schemes. The livelihood of indigenous and minority communities who have over the years lived and depended on the dynamism of the rich Tana Delta ecosystems will suffer as a consequence. Equally at stake is the conservation of a rich mangrove flora and fauna, which includes some species, listed as vulnerable and threatened.

There is hope on the ongoing designation of Tana Delta as a Ramsar site spear headed by the Kenya Wildlife Service. This may help in protecting this ecological region from the growing human interferences especially in curtailing the establishment of commercial plantations. This not withstanding, there is critical need for a multiple land use development master plan incorporating communities and other stakeholders' interest. The master plan should offer the guidelines in sustainable development of Tana Delta and its resource as well, respecting the rights of all groups. Contrary to such stakeholder concessions, Tana Delta will continue to be a battle field and as the old Swahili saying goes; *wapiganapo fahari wawili, siumiazo ni nyasi* (whenever bulls fight, it is the grass which suffers most). The rich resources of Tana Delta, its mangrove ecosystems included, will bear the brunt.

References

Arkornkoae, Sanit, 1993. *Ecology and management of mangroves*. IUCN, Bangkok, Thailand.

FAO, 2007. *The world mangrove 1985-2005: A thematic study conducted in the framework of the Global Forest Resources Assessment 2005,* FAO Forestry paper 153, Rome, Italy.

Swara Newsletter, September- December 2001. *The new Tana 'Squeaker'.* East African Wild Life Society, Kenya

Developing a technique to plant *Avicennia africana* at *La Somone* lagoon (Senegal)

Jean Pierre Ngor Ndour[1], Cheikh Mamina Diédhiou[2] and Mamadou Fall[3]

Summary

At La Somone, the deterioration of the mangrove is related to the recurrent drought in the 1970s and the closure of the Lagoon in 1987 (Ndour et al., 2002). In order to rehabilitate the ecosystem, combat engineering intervened to reopen the lagoon in 1987 while women had planted Rhizophora mangle in 1995. Recently, the State and its partners, including the International Union for Conservation of Nature (IUCN) and the Japanese Cooperation (JICA) have collaborated to develop a technique for planting the species. This required the selection of a site where Avicennia africana grows on sandy loam mud flats just like Avicennia officinalis in Vietnam (Untawale, 1996). However, the species also grows on sandy-clay mud flats in La Somone (JICA, 2004). The diaspore(seed) germination test resulted in 100% for the set of planting techniques. The survival rate (94.7%) of 1.5 month-old seedlings at weaning is comparable to survival rates (80 to 90%) obtained with Avicennia marina (Saenger, 1996). The growth of the species is similar to that of Avicennia officinalis according to Siddiqi and Khan (1996). The results obtained are a sign of a good extension of the technique and of important ecological and socio-economic impacts.

Introduction

The experimental site is located in the Senegalese coastal area (Figure 1) where it is still possible to observe sources during the rainy season between the dry land and the mangrove. The climate there is dry with a wet season lasting three months. The species of mangrove are *Rhizophora mangle, Avicennia africana* and *Conocarpus erectus.* In Senegal, the degradation of mangroves has reached an alarming stage (Soumaré, 1992; IUCN, 1999; Ndour *et al.*; Ndour, 2005). Aware of this degradation, the Senegalese government, populations and development partners have undertaken to restore the mangroves. Together, they have put in place cooperation and intervention mechanisms and developed restoration techniques for the degraded areas. Women greatly contributed in restoring the *Rhizophora mangle* mangrove and it is believed that the *Avicennia africana* degraded stands could also be restored using a well developed planting technique. The optimism is based on the optimal salinity of the species which is between 10 and 70‰ and can exceptionally reach 90‰ in some conditions (Schenell, 1971).

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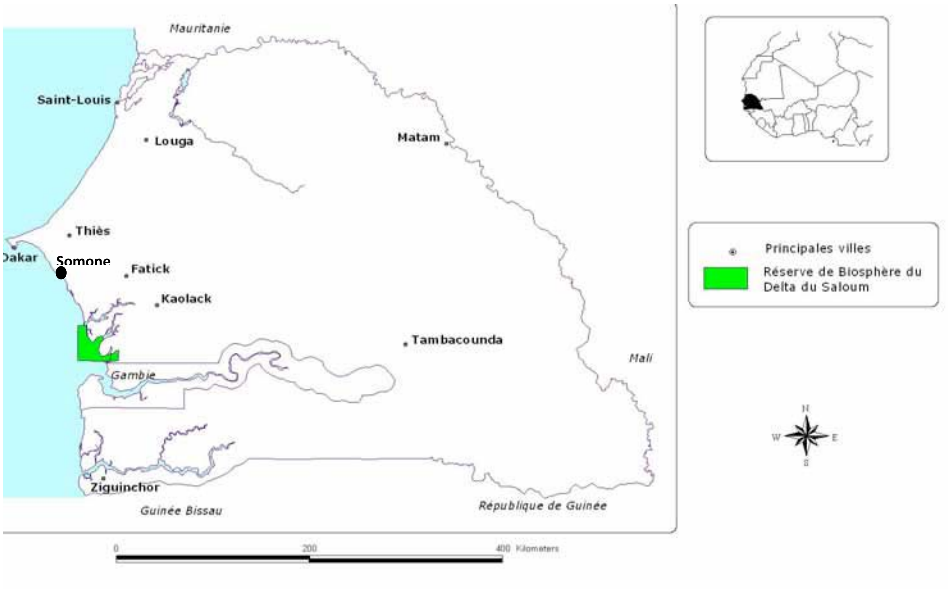

Figure 1: Geographical position of La Somone

Equipment, methods and results of the planting technique

Equipment and methods

The experimental site was selected on the basis of a study of the nature of mangrove landscape using aerial topography, water salinity measurements and observation of the frequency of mud flats submersion at various tides. The planting technique involves the establishment of a nursery at an area submerged by a high tide. The nursery should have a shade and should be fenced by a 12mm mesh net to keep fishes and crabs away from seedlings. The base of the net is buried at a minimum of 5cm depth in the mud. The seeds are then re-potted with mud up to 1cm from the edge (Roussel, 1995). This is done at least three days before sowing the diaspores (mangrove seeds) in order to facilitate the compaction and stabilization of the mud in sachets (Ndour *et al.,* 2003). Seeds are harvested between July and September, coinciding with the seed maturation period. During harvesting, the best quality seeds are selected based on their tegument color. They are then pre-processed by immersion of their water permeable content in the tidal land area for 4 to 7 days to trigger their germination. According to Evenari (1961), this procedure is justified by the fact that germination ends with the beginning of the extension of the radicle. Following the selection, seeds are sown inside pots in seed holes cut in the middle and having the same dimension with the radicle. The radicle is then pushed into the seed hole which is firmly closed to prevent the seed from being torn out by tides. Monitoring the nursery involves controlling the development of seedlings, recording the number of germinations, the constraints to germination and verifying the functionality of the nursery protection mechanism.

The weaning of seedlings was done 1.5 months after sowing (Figure 2) on a protected site by a net having the same dimensions with that of the nursery and with the same installation techniques. The reason is that the leaves of the seedlings are tender at that age and palatable to fish (carps) and oxen. The gap between seedlings and the lines is 2m wide; while the height of the maximum submersion of planting sites is 35 cm. The forms of life and habitat on the sites are recorded in order to establish the baseline reference regarding bioecological conditions of the area.

Figure 2: Seedlings weaning at 1.5 months of age

Monitoring the planting involves checking the stability of the fence and recording the height and diameter of seedlings using a measuring tape every month during the experiment. The existing forms of life and the development of their population afterwards are recorded in order to perform a quality or quantity assessment of ecological impacts. The monitoring-evaluation of plantations also involves assessing the socio-economic impacts related to the development of mangrove resources. This monitoring-evaluation was organized two years after planting in the context of the support to research with funding from IUCN on behalf of the Institute of Environmental Sciences (IES) of the Cheikh Anta Diop University of Dakar (UCAD).

Results of the experiment

Mud flats on the planting site are sandy-clay and submerged during all high tides. The submersion which varies between 16 and 35 cm is often null during high tides in the dry season. The salinity of the river varies from 28 to 40 g/l. The highest values are recorded during the dry season. Quality seeds are characterized by a yellow tegument color that changes to grey after falling to the ground. When the tegument color changes to black, the diaspores' (seeds') viability reduces in view of the irreversible dehydration (Figure 3).

Figure 3: Black seeds on the left; yellow seeds on the right.

The germination of *Avicennia africana* diaspores in the above mentioned conditions resulted in a 100% success rate. The main constraints to the germination of seedlings are the sea currents which destabilize diaspores sowed in pots, while terrestrial crabs (*Cardisoma armatum*) pull or cut seedlings stems which subsequently die. The diaspores pulled out by sea currents are generally trapped by the nursery fence. Collected during the monitoring, they are once again sowed in the pots. Seedlings that escape these challenges are grown in nurseries for 1.5 months. Their average size during transplantation in actual habitat was 16.2 cm and their survival rate was 94.7%. A stability index of more than 90% for the survival rate of seedlings was recorded 5 months after transplantation. The monitoring-evaluation performed in 2005 shows that seedlings reached an average growth of 51.1cm/year. With an average height of 1.18m, the appearance of the plantation's landscape begins to change (Figure 4).

Figure 4: Landscape of the Avicennia Africana plantation

Regarding ecological impacts, there is a proliferation of fiddler crabs (*Uca tangeri*) and land spiders in the area. There is also a proliferation of pneumatophores, creating a barrier conducive to the retention of seed of fertile root stocks. This facilitates the proliferation of the species given that the young stocks start yielding fertile seeds after one year (Figure 5).

Figure 5: Young fertile stock

The production of seeds by plants at 3 years of age, is a favorable result to the *in situ* regeneration of the species. Among other impacts, there is the compacting of mud flats by a creeping root system (pneumatophores) minimizing the erosion of mud flats on the plantation site. No socio-economic impact was recorded during the monitoring-evaluation. However, during the lean period, oxens visit the reforested sites to graze the leaves of the young seedlings. The teeth of cattle cause damages viewed as one of the major constraints to the success of plantations.

Discussions

The mangrove in La Somone plays the role of ecological niche for various species, spawning ground for fishes, and shelter and habitat for water birds. At socioeconomic level, it is a site for fishing and for the collection of cockles and oysters. It represents one of the main tourist attractions of the area with an ever-growing space in view of the plantations.

For purposes of comparison, *Avicennia africana* in Senegal grows on sandy-clay mud flats just like *Avicennia officinalis* which grows in the same type of environment in Vietnam (Untawale, 1996; Ndour *et al.*, 2004; IUCN, 2004; JICA, 2004). The maximum submersion height at which *Avicennia africana* was planted is 35cm. However, it reached 65cm at the beginning of plantation trials in 2002. It was concluded that the lower the mud flats submersion heights, the better the results. This situation corroborates the trend of the species to cover lower slope sites in mangrove areas. That preferential position inherent in the biophysical and anatomical nature of the seed, partly explains the distribution of the species in the mangrove ecosystems (Ndour *et al*., 2003). In Senegal, *Avicennia africana* seed should be harvested between the months of July and September. That period coincides with the harvest of *Avicennia alba* or *Avicennia officinalis* seeds in Vietnam according to Hong, 1996.

Regarding the quality of seeds, even though species are different, the identification criteria of good diaspores are almost similar in Senegal and in Vietnam. Goods seeds are identified by their yellow tegument when mature and their easy removal from the seed tree (Ndour *et al*., 2003; Hong, 1996).

The germination rate of seeds obtained in 2003 is 100% for all the plantation techniques. The survival rate (94.7%) of seedlings aged 1.5 months at weaning is similar to the survival rates (80 to 90%) obtained in Australia with *Avicennia marina* (Saenger, 1996). Regarding survival rates of seedlings before weaning, the various experiments show that the longer their stay in nurseries, the lower their survival rates during transplantation. Therefore, the technique of *Avicennia africana* plantation through raising seedlings followed by a transplantation of 1.5 month-old seedlings was the most successful technique. Among other techniques, there is the direct sowing, on mud flats, on balls and in pots followed by transplantation at more than 1.5 months (Ndour *et al.*, 2004).

Regarding height growth, the best results (49 to 51.1cm/year) were obtained with seedlings raised for 1.5 months before transplantation. The rates obtained with other techniques are more reliable (15 to 44.2 cm/year). According to studies by Siddiqi and Khan in 1996, these annual growth rates are close to those obtained with *Avicennia officinalis* (34 to 65 cm/year), Avic*ennia marina* (36 to 53 cm/year), and *Avicennia albida* (32 to 47 cm/year).

Other forms of life of apart from plants that appeared with the rehabilitation of the mangrove ecosystem are the seedling devouring grasshoppers and spiders that spin webs to catch and consume insects. This rehabilitation is also followed by the arrival of water birds.

Among the constraints to the restoration, could be mentioned tidal currents, predators (crabs and carps) and the cattle (oxen). Among other constraints, there are stony or sandy soils that are not favorable to the survival of seedlings (Ndour et al., 2004). In spite of these obstacles, the results obtained are a sign of good prospects for the extension of restoration practices of the species on the coastal areas of Senegal.

Recommendations

The prospects of ecological and socio-economic impacts of plantations deserve a monitoring of plantations for at least 10 years for a better knowledge of the silviculture of species. In some cases, there is a need to examine the necessity to first restore the hydrographical network in order to improve the outcomes of mangrove plantations.

References

Roussel, J. (1995) – Pépinière et plantations forestières en Afrique Tropicale sèche, 434p.

Ndour, N.; Sarr, M.; Fall, M. (2003) – Rapport sur les techniques de reboisement d'*Avicennia* à la Somone, 32 p.

Ndour, N.; Diédhiou M.C.; Fall, M. (2004) – Techniques de reboisement d'*Avicennia* sp. pour une restauration des peuplement de l'espèce au Sénégal, 47 p.

Evari , M. (1961) – A survey of work done in seed physiology bay the department of botany Hebrew, University, Jerusalem (Israel), proc. Int. Seed. Test. Ass., 26, 4, 597-658.

Diédhiou, M. (2005) – Suivi – évaluation des actions de reboisement de la mangrove au niveau de la Réserve de Biosphère du Delta du Saloum et à la Somone, 50 p.

Saeger, P. (1996) – Mangrove restoration in Australia. A case study of Brisbane international Airport, pp. 36-51 *in* Restoration of mangrove ecosystems, 250 p.

Hong, P. N. (1996) – Restoration of mangrove ecosystems in Vietnam. A case study of Can Gio District, Ho Chi Minh City, pp. 76-96, *in* Restoration of mangrove ecosystems, 250 p.

Sidiqqi, N. A.; Khan, M. A. S. (1996) – Planting techniques for mangroves on new accretions in the costal areas of Bangladesh, pp. 143-159 *in* Restoration of mangrove ecosystems, 250 p.

Untawale, A. G. (1996) – Restoration of mangroves along the central West Coast of Indiana, pp. 111-125, *in* Restoration of mangrove ecosystems, 250 p.

Ndour, N. (2005) – Caractérisation et étude de la dynamique des peuplements de mangrove de la Réserve de Biosphère du Delta du Saloum, 180 p.

Soumaré, A. (1992) – Evolution géomorphologique récente des paysages de mangrove du Delta du Saloum, Mémoire de DEA, Université Cheikh Anta Diop de Dakar, 61p.

UICN, (2004) – Rapport d'activités annuel 2004 – projet de mise en œuvre du plan quinquennal de gestion intégrée de la RBDS, 91p.

UICN, (1999) – Etude de la biodiversité, synthèse de connaissance ; plan de gestion de la RBDS, 104p.

JICA, (2004) – Etude pour une gestion durable de la mangrove de la Petite Côte et du Delta du Saloum de la République du Sénégal – Projet pilote et production de plants d'*Avicennia* / Essai de plantation – Projet de rapport final, 65 p.

Schenell, R. (1971) – Introduction à la phytogéographie des pays tropicaux. Les problèmes généraux, phytogéographiques de l'Afrique Occidentale. Les groupements et les unités géobotaniques de la république de Guinée pp. 41-235. In mélanges botaniques, N°18, IFAN, 334p.

Rehabilitation of mangroves between Fresco and Grand-Lahou (Côte d'Ivoire): Important fishing areas

Mathieu Wadja Egnankou[1]

Summary
Even though Côte d'Ivoire is one of the most botanically studied francophone African countries, mangroves are not well known. In spite of the important ecological and socio-economic role they play, they do not enjoy the attention they deserve and are deteriorating at a disturbing rate along the coastline. The mangroves lying between the cities of Fresco and Grand-Lahou play a vital role in supplying fish to the population centers of Abidjan (with about 5 million inhabitants) and Yamoussoukro. These wetlands which feed 60% to 80% of coastline communities are threatened with extinction by the indiscriminate logging and by poison fishing.

Twenty years ago, the mangroves between Fresco and Grand-Lahou boasted a surface area of 15,000ha. Today however, they hardly reach 6,000ha. Red mangroves (Rhizophora racemosa) and white mangroves (Avicennia germinans) tree formations are increasingly being replaced by a herbaceous stratum (Paspalum vaginatum) or shrub stratum (Drepanocarpus lunatus and Dalbergia escastaphyllum). In view of this deterioration, during recent years, there has been a reduction in fisheries productivity, exacerbating poverty among the communities, particularly among the youth and women.

In order to rehabilitate the ecosystem and restore fish stock, we carried out silvicultural activities on that section of the Ivorian coastline. These activities included enrichment planting.

Introduction

Known as mangroves, the forest ecosystems of tropical tidal areas are spread along the Ivorian coastline, from East to West, from Assinie-Mafia to Bliéron. They are located approximately between longitudes 2° 50' and 7° 59' west and latitudes 4° 30' and 5° 40' north.

They have played and still play an important role on the entire Ivorian coastline: their wood is used in building houses and in arts and crafts, in manufacturing tools for making fishing nets and especially as fuel wood. The bays and numerous channels are vital fish reserves. Water bodies and the rich biodiversity of these wetlands provide significant income through the development of tourist activities.

Unfortunately, the ecosystem is threatened with extinction by severe anthropogenic pressures: anarchic logging, poison-fishing and the closing of passages linking lagoons to the marine environment. In spite of scientific progress achieved in the knowledge of Ivorian forest ecosystems, mangroves still remain unknown. Indeed, authors such as Adjanohoun, 1962 and 1965; Guillaumet, 1967; Ake-Assi, 1982 and Paradis, 1988 have devoted a few 'studies' on the subject, but these were too few and limited to provide key

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information on the ecosystem. These authors studied the physiognomy of savannah formations, floristic composition of coastal forest and the development of aquatic and sub-aquatic groups. For example, the cartography that could have enabled researchers and natural resource managers to have an overview of its scope and consider adequate development has not been realized yet and the ecosystem is gradually deteriorating along the entire coastline.

Egnankou, 1985 and 1987 drew attention to the issue of extinction of the mangroves. The consequences of that potential extinction and the disorganization of physicochemical data on fisheries were studied in 1997 by the same author who also analyzed the possibilities for its development. The study underlined the predominant role of lagoons' outlet in the development of mangroves along that section of the Ivorian coastline. Actions carried out by the NGO SOS- Forêts from 2001 to 2003 have maintained the opening of the N'Gni Lagoon passage in Fresco up to this day. They still had to rehabilitate the tree cover in order to fulfill the needed ecological conditions for the restoration of biologic diversity.

This study is the first of a series the author has planned to carry out to improve the knowledge base of Ivorian mangrove ecosystem including those of its wildlife, fisheries and water resources comprising the rich bionetwork.

Geographic location of the study site

The study is about the section of the coastline between the cities of Fresco and Grand-Lahou. It is located approximately between longitudes 5° 38' and 4° 50' west and latitudes 5° 6' and 5° 20' north. (Figure1).

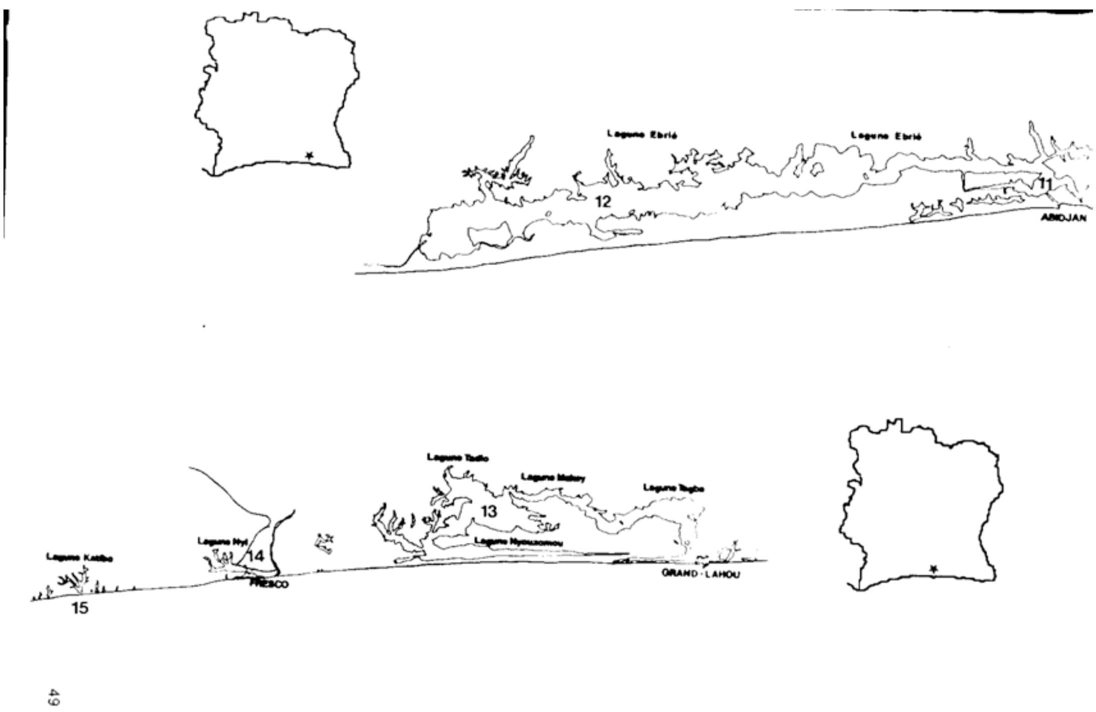

Figure 1. Location of study site: coastline between the cities of Fresco and Grand-Lahou in Côte d'Ivoire Scale : 1/1 000 000 Source : (Egnankou et al, 1989)

Equipment and methods

For successful silvicultural activities, basic data should be known and controlled. Data concerning the chemistry of the water and its physical characteristics, the vegetation and the hydrological network, were examined in a preliminary study. The equipment used was as follows:

- An Atago salinometer; 0 – 28% calibrated at 28°C at the Botanical laboratory. The water sampling is done with a syringe at a depth of 20cm. The interstitial water is also collected at a depth of 20cm but in holes dug in the mud.
- pH measurements were done with a pen-type pH-meter with a precision of more or less 0.5pH. The pH is directly obtained by dipping the pH-meter in the sampled water in conditions similar to those of the salinity measurement;
- The study of vegetation was done through the Duvigneaud topographic transect method. Sampling is done on each side of a rope stretched on the open water surface to the temporary or permanently flooded banks on a surface deemed sufficiently homogenous. The research team then identified all the plant species along the rope, by carefully sampling some of them for verification at the laboratory. The use of aerial photos the researchers took on board a CESNA single-engine aircraft enabled them to have data for drawing a map of the mangroves of that section of the Ivorian coastline.
- The sites for reforestation (enrichment planting) were chosen on the basis of their daily and regular submersions by brackish-waters;
- The red mangrove *Rhizophora racemosa* (Rhizophoraceae) was preferred to other mangroves [e.g. *Avicennia germinans* (Avicenniaceae) and *Conocarpus erectus* (Combretaceae)] because the harvesting of single-species mangrove involves only that species of which the excellent quality wood is used for various purposes;
- In view of the viviparity of *Rhizophora racemosa*, the harvesting, storage and/or transport of seedlings were carried out as follows: (i) Propagules are either harvested on the tree (according to a maturity index based on the color of the seed and especially on resistance to touch, because when mature, the seed falls when touched), or harvested while floating on the water; (ii) when transportation is over a long distance, the research team performs the first processing of the seeds and their storage in a shaded area subject to high tides and low tides during 5 to 15 days; seeds (germinating seeds or seedlings)are then sown at about 1m intervals. To assess the germination capacities of seeds, 5,000 seeds were directly harvested on trees; 3,000 of them were already germinating and were uprooted to be transplanted in experimental lots and 2,000 floating seedlings were collected.
- The monitoring of the plantation is done regularly through measurements and the counting of vegetative organs (e.g. leaves) and of the number of surviving seedlings.

Results

The results concerning the salinity, flora, vegetation and mangrove reforestation are as follows:

Water salinity

Water salinity is reported in Table 1 below. The pH is indicated in Table 2.

Table 1: Water salinity in the mangroves of Fresco and Grand-Lahou (in g‰)

Distance to the passage (in km)	IMMERSION WATERS		IMMERSION WATERS	
	Fresco	Fresco	Grand-Lahou	Grand-Lahou
	Dry season	Rainy season	Dry season	Rainy season
0.50	28‰	10‰	25‰	8‰
4.00	22‰	8‰	22‰	6‰
6.50	20‰	6‰	18‰	6‰
8.00	15‰	2‰	17‰	4‰
10.00	10‰	00	5‰	1‰
15.00	00	00	00	00
20.00	00	00	00	00

Table 2 : pH of waters

Distance to the passage (in km)	IMMERSION WATERS		IMMERSION WATERS	
	Fresco	Fresco	Grand-Lahou	Grand-Lahou
	Dry season	Rainy season	Dry season	Rainy season
0.50	8.00	7.29	7.00	6.00
4.00	7.20	7.18	7.00	6.00
6.50	7.00	7.90	7.00	5.50
8.00	7.00	6.55	5.50	5.00
10.00	7.80	6.90	5.00	6.50
15.00	7.90	7.00	6.50	7.00
20.00	7.90	6.20	6.20	7.00

A study of Table 1 shows that salinity decreases from the estuary of the water bodies or the outlets of lagoons towards more remote sites. On the other hand the pH variation is disorganized thus showing the possible influence of other parameters to be underlined by other studies.

Flora and vegetation

The study of vegetation through transects revealed 3 types of association between mangroves. These associations are as follows:

- A mono-specific mangrove of *Rhizophora racemosa* (Figure 2), a deteriorated mangrove of *Avicennia germinans* only accompanied by *Paspalum vaginatum* (Poaceae) and a mangrove of two species of *Avicennia germinans* following *Rhizophora racemosa* toward the land. These mangroves formations are found both in lagoon mangroves (all around Fresco and Grand-Lahou lagoons) and in estuarine lagoons (at the estuary of the Bolo, Niouniourou and Bandama rivers);
- A herbaceous formation where *Paspalum vaginatum* (Poaceae) represents, depending on the site, between 95 and 100% of the vegetation cover. This include: *Mariscus ligularis*, *Cyperus articulatus*, *Pycreus polystachyos* (Cyperaceae), *Ethulia conyzoides* (Asteraceae), *Echinochloaz pyramidalis* (Poaceae), *Sporobolus virginicus Fimbristylis thonningiana* and *Fuirena umbellata* (Cyperaceae) species;
- A *Drepanocarpus lunatus* and *Dalbergia ecastaphyllum* formation in upper-mangrove contains numerous shrubby and tree species among which are: the *hibiscus tiliaceus* (Malvaceae), *Acrostichum aureum* (Adiantaceae), *Ceasalpinia bonduc* (Ceasalpiniaceae), and *Nauclea latifolia* (Rubiaceae).

Figure 2: A mono-specific mangrove swamp of Rhizophora racemosa in Ebonou, west of Grand-Lahou lagoon complex (Photo EGNANKOU, 2007)

Reforestation
Concerning reforestation, five months after the seedlings had been transplanted, the following results were recorded:

- Of the 5,000 germinating-seeds harvested on trees, only 1,000 germinated and continued growing, representing a 20% success rate;
- Of the 2,000 floating-seedlings harvested on the water, 1,500 developed leaves during the first three months and continued growing, representing a 75% success rate;
- Of the 3,000 wildlings (seedlings growing on forest floor through natural regeneration) uprooted and transplanted on reforestation sites, 2,950 continued growing, representing a 95.66% success rate.

The best yields were obtained with seedlings growing wild on forest floor (wildlings) followed by the seedlings collected on the water surface (germinated seeds floating on water). In spite of their maturity and the precautions taken, germinating-seeds harvested on trees were only 20% successful, leading us to opt for the use of established seedlings. These seedlings are obtained either by natural regeneration (wildlings collected under trees) or by the establishment of nurseries (Figure 3). Thus, after installing experimental stations in the south of the N'Gni lagoon, the research team led the reforestation of a total of one hundred hectares of mangroves along the Ivorian coastline.

Figure 3: Rhizophora racemosa nursery at Fresco (Photo EGNANKOU, 2006)

Discussions

Ivorian mangroves in general and those lying between Fresco and Grand-Lahou in particular, are threatened with extinction due to a lack of knowledge. As a result of large-scale logging, entire stands have disappeared and have been replaced by *Paspalum vaginatum* grasslands. Others are in the process of disappearing; in the 1960s, the city of Grand-Bassam was characterized by huge forest ranges along lagoons mainly made up of 25 meters high *Rhizophora racemosa* red mangroves (Rhizophoraceae). The Azuretti mangrove near Grand-Bassam used to contain an important fringe of *Conocarpus erectus* grey mangrove (Combretaceae) in upper-mangrove and of beautiful *Avicennia germinans* white mangrove (Avicenniaceae) (Ake-Assi, 1987). Today these mangroves in the Eastern part of the Ivorian coastline are represented only by sparse red and white mangroves. The grey mangrove is absent in these regions where coconut groves and other building sites have considerably encroached on the mangrove ecosystem. In Fresco and Grand-Lahou, it is noted that the reduction of the mangrove ecosystem surface area has led to the reduction of fisheries resources in the zone through the reduction of catches by fishermen (Egnankou, 1989 and 1997).

The level of degradation of mangroves is now obvious in the coastline between Fresco and Grand-Lahou, and has led the author and his team to start rehabilitation activities by reforesting.

The high percentage of success achieved through the use of wildlings motivated the team to establish more mangrove nurseries with wildlings. Indeed, while more than 95% of wild seedlings uprooted and transplanted have continued growing, the germinating-seeds harvested on trees and seedlings harvested on the water (i.e. seeds germinated while still attached to tree, then falling into water for further development) have respectively yielded 20% and 75%. As suggested by Baglo, 1989, seedlings harvested on the water present above average germinative qualities, however, it is necessary to underline that the transition through nurseries can represent an efficient method in reforesting mangroves. It increases the germination rate and also enables the nursery worker to perform a first selection; poor quality seedlings are thus eliminated in the nursery. Moreover, nurseries have a double advantage: they not only enable to increase the success rate but are also an efficient method to preserve seedlings in all seasons for a large-scale and all-season reforestation.

Conclusion

Mangroves play a vital role for coastal communities. They ensure the richness of fisheries and provide communities with wood to build their houses and many other products. They are suitable for the reproduction of many aquatic animal species, be they marine or inland waters.

This highly productive ecosystem, however, is subjected to the negative effects of human activities in Côte d'Ivoire in general and in that section of the coastline in particular. These activities have eventually destroyed about 50% to 70% of these coastal wetlands.

In spite of numerous botanical studies on Côte d'Ivoire, mangroves are still not well known. They do not enjoy the protection they deserve and are gradually being degraded under the combined and constant pressures of over-logging and unsustainable use of aquatic resources.

With a view to restoring the biological diversity of the mangrove ecosystem in Côte d'Ivoire, the team carried out these research and reforestation operations. Today, about one hundred hectares of mangroves have been reforested. The research team intends to draw the complete cartography of all the mangroves in Côte d'Ivoire. Moreover, the team aims to establish a Geographical Information System in order to provide relevant biological information to policy-makers for the development of the coastline area.

Bibliography

Achard, F., 1989, Etude des rythmes saisonniers de la végétation en Afrique de l'Ouest par Télédétection. Thèse de Doctorat troisième cycle –ICIV, UPS, Toulouse, 242 pages.

Adjanohoun, E., 1962 – Etude phytosociologique des savanes de Basse Côte d'Ivoire (savanes lagunaires). *Vegetatio,* XI (1-2) : 1-38

Ake Assi, L., Paradis G, 1982 – Malacofaune et flore holocènes d'un forage en bordure de la lagune Adjin (Côte d'Ivoire). *Géobois,* Lyon, 15 (1) : 43-52

Aubreville, A. – 1964 – Problèmes de la mangrove d'hier à aujourd'hui ; Adansonia Ser. 2, 4 Nogent sur - Marne.

Baglo, M.A – 1989 – La Mangrove du Bénin, grands équilibres écologiques et perspectives d'aménagement. Doct. 3ème Cycle-Ecologie ; UPS-Toulouse III, N° 2329 ; 200pages

Blasco, F. – 1982 – Ecosystèmes mangroves : Fonctionnement, utilité, évolution. Communication présentée au SILCO/UNESCO tenu à Bordeaux, 8-14 Sept. 1981. Océanologica Acta N° SP : 225-230

Egnankou, W.M. – 1985, Etude des Mangroves de Côte d'Ivoire : aspects écologiques et Recherches sur les possibilités de leur aménagement. Thèse de Doctorat troisième cycle –ICIV, UPS, Toulouse III, 167 pages.

Egnankou, W.M. – 1987 - La Mangrove ivoirienne en voie de disparition. Annales de l'Université d'Abidjan, Série E, Tome XIX, pp 09-29.

Egnankou, W.M.- Recherches sur les Possibilités d'Aménagement des Mangroves de Côte d'Ivoire. Annales de l'Université d'Abidjan, Série E, tome XIX ; pp 30-50.

Egnankou, W.M. 1989 - Importance de l'écosystème mangrove dans la productivité des lagunes ivoiriennes – 1989 – Communication présentée au Symposium International de Yamoussoukro (Côte d'Ivoire), du 25 au 29 juillet 1989.

Egnankou, W.M., Nicole, M. - 1994 - *A Preliminary Inventory of Coastal Wetlands of Côte d'Ivoire. The IUCN Wetlands Programme. 80 pages.*

Egnankou, W.M. – 1994 - Le Développement du Littoral ivoirien et ses Conséquences sur l'Ecosystème mangrove ; Communication présentée au Forum International d'Abidjan sur la Forêt ; du 24 au 27 mai 1994.

Egnankou, W.M., 1997– La fermeture de la passe de Fresco et ses conséquences sur la productivité de la lagune N'GNI : *In Mangrove Ecosystem in Latin America and Africa – Unesco, ISME and US Forest Service (Dpt of Agricult.)* pp 271 – 283.

Hamilton, L. and Snedaker, S.C. – 1984 – Handbook for Mangrove area management, Env. And Policy Institute East West Center, 1777, Esat West Road. Honolulu, Hawaï 96848 U.S.A. 123 pages.

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Salinity fluctuations in mangrove forest of Gazi bay, Kenya: lessons for future research

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Summary

Studies on mangrove ecosystems that deal with the interaction of organisms and their environment very often draw conclusions based on only a restricted number of soil water salinity measurements. As inundation by salty water is the most typical characteristic of the mangrove environment, the authors addressed the temporal and spatial fluctuation of soil water salinity at seven locations in the mangrove forest of Gazi Bay, Kenya. As a pilot study, the research team measured soil water salinity twice a month, at neap tide and at spring tide, during one year. It can be concluded that the soil water salinity in mangrove forests can be highly variable in time as well as in space and depends on a complex interaction between inundation frequency, canopy closure, fresh water input and soil texture. Mangrove researchers should therefore pay attention to the differences in local site conditions inside the mangrove forest and conduct salinity measurements that cover the temporal and spatial fluctuations before drawing conclusions on the relationship to this environmental condition.

Introduction

As mangrove ecosystems are ecologically and economically of high importance but fast disappearing and degrading (Duke, *et al.*, 2007), it is important to conduct scientific studies - fundamental as well as management based – to obtain the necessary knowledge to preserve, to protect and to restore mangrove forests. Ideally, such studies should not only deal with the organisms of the mangrove ecosystem – fauna as well as flora - but also with the interaction between these organisms and their environment. The most characteristic elements of the mangrove environment are a frequent inundation and saline water (Tomlinson, 1994), both not only strongly determining the life of the mangrove inhabitants (e.g. Fratini, *et al.*, 2004, Schmitz, 2008, Robert, *et al.*, 2009) but also, by selection, nature's diversity and assemblage composition.

Studies dealing with the relationship between organisms and their environment often generate conclusions from a restricted dataset – spatially and/or temporally – of environmental parameters. The purpose of this research is to study the variability of the soil water salinity on a spatial as well as on a temporal scale in the mangrove forest of Gazi Bay, Kenya, a well studied site as concerns mangrove research. The results of the study are intended to evaluate the fluctuation of one of the key parameters of the mangrove environment on an intra-annual scale and this for different study sites situated relatively close to each other.

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Study area

Study sites

The study area is situated in Kenya, in the mangrove forest of Gazi Bay (39°30'E, 4°25'S), which covers about 600 ha (UNEP, 2001, Neukermans, *et al.*, 2008) and is situated approximately 50 km south of Mombasa. The mangrove forest has a tidal amplitude of about 3.8 m with a maximum of 4.1 m (Kenya Ports Authority tide tables for Kilindini, Mombasa) and is characterized by a sloping topography (Matthijs, *et al.*, 1999). Seven sites spread over the mangrove forest (Figure 1) were studied with as common characteristic the occurrence of the mangrove tree species *Avicennia marina*.

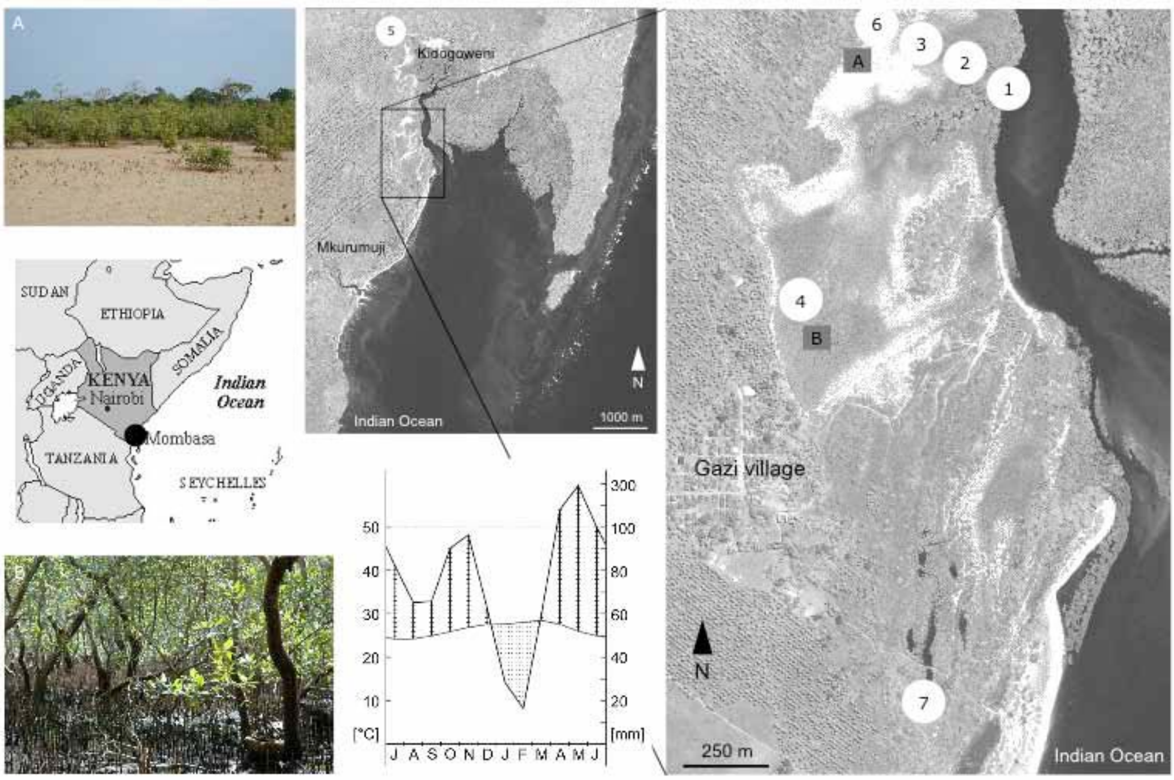

Figure 1: Description of the study area. Map of east Africa (left middle) *showing the location of Gazi Bay on the Kenyan east coast (black dot) and two QuickBird satellite images of Gazi Bay (Kenya) (middle up and right), acquired in 2002 (Neukermans, et al., 2008) situating the seven study sites in the mangrove forest of Gazi Bay and the location the pictures A and B (left up and left down) have been taken. The two seasonal rivers that provide freshwater to the mangrove forest are indicated on the satellite image in the middle. Climate diagram (middle down) of Mombasa (adapted from Lieth, et al., 1999) representing the climate of the African east coast. Temperature (°C) is shown on the left and precipitation (mm) on the right vertical axe. Precipitation scale is reduced to 1/10 above the horizontal line. Pictures: Nele Schmitz and Elisabeth Robert.*

Climate description

The climate along the Kenyan coast is characterized by a bimodal distribution of the precipitation (Figure 1). A distinct dry season (January - February) is followed by a long (April - July) and a short (October - November) rainy season (Figure 1). During the wet season, the rivers Mkurumuji and Kidogoweni (Figure 1) provide an important freshwater source for the mangroves of Gazi Bay. The average temperature at the Kenyan coast ranges from 22 to 30°C, with a mean relative humidity of 65% to 81% (annual averages of minimal and maximal values for Mombasa for the period 1972 - 2001, data from the Kenyan Meteorological Department, Mombasa, Kenya).

Material and methods

Environmental data collection

For each of the seven sites (i) soil texture was determined by standard field characterization methods (GLOBE, 2005) and (ii) height above sea level and inundation frequency were calculated based on the Kilindini Harbour tide tables (Kenya, 39°39'E, 4°04'S). The local flooding level was measured with tracing paper impregnated with ecoline dye. For study site seven the exact height above datum and inundation frequency could not be determined. Here, the mangrove trees grow in a basin and are disconnected from the rest of the basin type forest by a raised road. Consequently, the inundation frequency differs in rainy and dry season since the water level reaches more frequently the height of the road during the former.

From April 2007 to February 2008, the salinity was measured at each site with a hand-held refractometer (ATAGO, Tokyo, Japan / 0 – 100 ‰). Here for, soil water was sampled two times a month, once during neap tide and once during spring tide, at approximately 25 cm depth and at three positions scattered over each of the seven study sites. This was done with a punctured plastic tube connected to a vacuum pump or by digging a hole of the same depth when fine soil particles clogged the filtering tissue wrapped around the punctured plastic tube. Soil water salinity has only been measured at 25 cm depth so that the variation in soil water salinity with depth is not within the scope of this study.

Data analysis

To show the variation in soil water salinity, median, minimum and maximum values were calculated. However, at three of the seven sites no soil water could be extracted at certain dates (Figure 2, black stars). In these cases, the highest soil water salinity measured during fieldwork expeditions in the rainy season of 2005 and 2006 and the dry season of 2007 and 2009 was taken. For the basin forest the highest salinity of the water in the puddle was taken. Monthly rainfall data were averaged for the period 1966-2006 and are from the Kenyan Meteorological Department, Mombasa, Kenya.

Results

The seven study sites, although situated in one mangrove forest, differed seriously in environmental conditions (soil texture – height above sea level – inundation frequency) (Table 1). The annual average salinity as well as the pattern of variation of the soil water salinity over the year was different in different study sites (Figure 2).

Discussion

The study could not indicate one factor as being the main environmental characteristic determining soil water salinity. Instead, different environmental factors contribute to the annual average salinity as well as to the pattern of variation of the soil water salinity over the year. But although no clear-cut relationships between soil water salinity and environmental characteristics could be deducted from Figure 2, some trends were observed.

Table 1. Environmental description of the seven study sites in the mangrove forest of Gazi Bay, Kenya.

Location	Soil Texture	H_{asl} (m) †	Inundation frequency ‡ (days/month)
site 1	silty clay	2.18	30
site 2	sandy loam	2.84	23
site 3	loamy sand	3.25	14
site 4	clay loam	3.35	12
site 5	clay loam – loamy sand	3.49	8
site 6	sandy loam – loamy sand	3.63	5
site 7	loamy sand – sandy loam	3.66-3.80*	5-3*

† Height above sea level.
‡ Inundation frequency based on the Kilindini Harbour tide tables of 2009.
* See 'Material and methods – Environmental data collection' for more information.

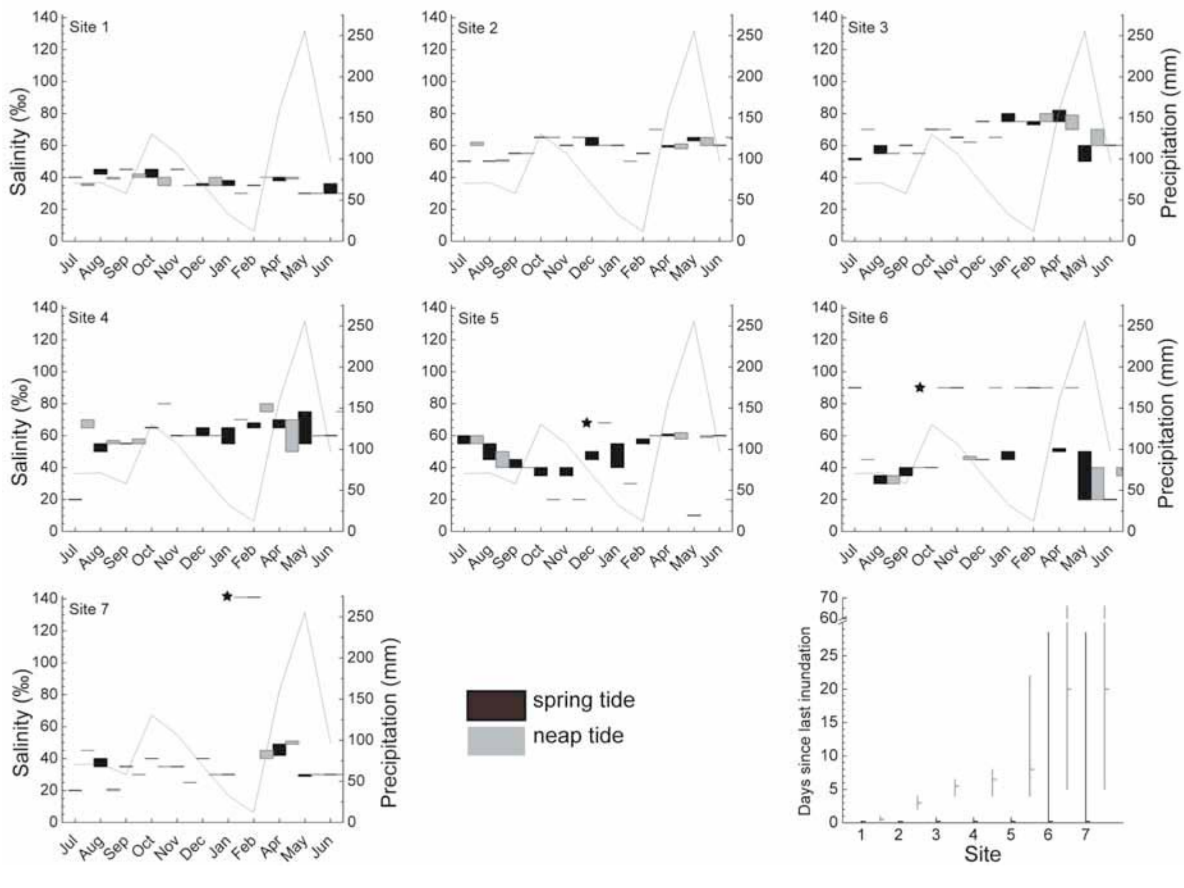

Figure 2: Spatial and temporal variation in soil water salinity in the mangrove forest of Gazi Bay, Kenya. *Bars represent the salinity range of three measurements on the day when the high tide was highest during spring tide or lowest during neap tide. Black stars indicate moments when no soil water could be extracted and the highest soil water salinity measured in the period 2005-2009 was plotted (see also 'Material and methods – Data analysis'). The number of days since the last inundation on the day of measurement was plotted for each site as a monthly average (min-median-max).*

First, study sites that are daily inundated have a rather constant soil water salinity compared to study sites that are inundated only a few days a month (Figure 2, site 4-7 *vs.* 1-3). Non-frequent inundation implies longer dry periods during which the soil water evaporates leading to an increase in soil water salinity as alternating with periods of dilution by rainwater and salinity decrease. In contrast, frequent inundation permanently saturates the soil with water of seawater salt content. A similar effect was expected from the monthly tidal rhythm. At neap tide, study sites experience a drought period for one day up to more than two months (Figure 2). At spring tide, all sites are flooded at least once a day except for the most landward site and the site that is disconnected from the sea by a road (Figure 1 and 2, site 6-7) which experience drought periods of maximum one month. However, no link was found between tidal period and soil water salinity.

Second, the annual average salinity increased with decreasing inundation frequency in the seaward study sites (Figure 1 and 2, site 1-3). Further landward this trend broke down for the annual average but not for the maximum salinity, with study site 5 as an exception. In general, the disrupted trend with inundation frequency in site 4 to 7 could be related to changes in fresh water influence, canopy closure and soil texture. While site 3 is an open forest (Leaf Area Index of 0.23) with small trees (mean tree height: 2m) (Schmitz*, et al.*, 2008), the mangrove forest at study site 4 has comparably a closed canopy (Leaf Area Index of 1.18) (Schmitz*, et al.*, 2008) and a muddy soil (Table 1), both counteracting evaporation and thus also counteracting increase of soil water salinity. In study sites 5 and 6 fresh water input affects the soil water salinity. Site 5 is situated upstream the Kidogoweni river causing soil water salinity to match the precipitation curve. Site 6 is located at the border of the mangrove forest experiencing high amounts of freshwater run-off during the rainy season, leaching the sandy soil (Table 1). Due to the sandy soil in combination with an open canopy (Leaf Area Index of 0.62) (Schmitz*, et al.*, 2008), it is also study site 6 in which drought has the biggest impact. In study site 7 the main factor determining soil water salinity is the topography, which is like a basin. Seawater is thus standing and the salinity in the puddle gradually increased from the surface to the bottom. Stratification of the puddle water can thus explain why evaporation or fresh water input did not directly affect soil water salinity. Only in the middle of the dry season - around February - values up to 140 ‰ were measured in the last bit of water before the basin dried out completely.

Soil water salinity has a direct effect on the water relations in trees as high and fluctuating soil water salinity makes high demands on the water transport system by creating high risk of air blocking the water transporting canals (Cochard, 2006, Naidoo, 2006). This is especially true for mangrove trees inundated by saline water regularly to twice a day. Spatial differences in soil water salinity influence the species distribution of the mangrove forest due to differences in the ability to support high and fluctuating salinity between mangrove trees (Verheyden *et al.*, 2005, Schmitz, 2008, Robert *et al.*, 2009). Tree species distribution on its turn influences *e.g.* seedling dispersal (different root complexes act differently in propagule dispersal and establishment – Di Nitto *et al.*, 2008) and mangrove fauna (*e.g.* Smith, 1987), so that we can conclude that salinity is one of the major factors influencing and structuring life in the mangrove ecosystem.

Conclusion

The variability of the mangrove forest in terms of soil water salinity as observed in the mangrove forest of Gazi bay (Kenya) should alert all those involved in mangrove studies. The factors contributing to this dynamism in time as well as in space, their interactions and the magnitude of the resulting fluctuations will vary between mangrove forests all over the world. Nevertheless, the message learnt from this study is of general importance. Soil water salinity cannot be predicted from inundation frequency alone and the additional influencing factors such as canopy closure, topography, fresh water input and soil texture can vary significantly within only a few hundred meters. The great number of micro-environments a mangrove forest can consist of should be taken into account to get better understanding of the functioning of the mangrove ecosystem and to be able to make high-impact conclusions that go beyond specific mangrove sites.

Recommendations

Soil water salinity, inundation frequency and soil texture can be determined with cheap and fast methods. The authors recommend that it should be standard practice for mangrove researchers to carefully compare different locations of a mangrove forest for these environmental parameters given their importance to obtaining a reliable reflection of the variation in soil water salinity. Moreover adequate number of measurements has to be carried out to cover the local variation not only in space but also in time. In the event that this is not possible, the limitations of the soil water sampling strategy should be reported and considered when drawing conclusions.

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References

Cochard H. 2006 Cavitation in trees. *Comptes Rendus Physique* 7: 1018-1026.

Di Nitto D., Dahdouh-Guebas F., Kairo J. G., Decleir H., Koedam N. 2008. Digital terrain modelling to investigate the effects of sea level rise on mangrove propagule establishment. *Marine Ecology-Progress Series* 356:175-188.

Duke N. C., Meynecke J. O., Dittmann S., Ellison A. M., Anger K., Berger U., Cannicci S., Diele K., Ewel K. C., Field C. D., Koedam N., Lee S. Y., Marchand C., Nordhaus I. & Dahdouh-Guebas F. (2007) A world without mangroves? *Science* 317: 41-42.

Fratini S., Vigiani V., Vannini M. & Cannicci S. (2004) *Terebralia palustris* (Gastropoda; Potamididae) in a Kenyan mangal: size structure, distribution and impact on the consumption of leaf litter. *Marine Biology* 144: 1173-1182.

GLOBE (2005) *Soil Characterisation Protocol. Field Guide.* GLOBE website at http://www.globe.gov/.

Lieth H., Berlekamp J., Fuest S. & Riediger S. (1999) *CD 1 - Climate Diagram World Atlas*. Backhuys Publishers, Leiden.

Matthijs S., Tack J., van Speybroeck D. & Koedam N. (1999) Mangrove species zonation and soil redox state, sulphide concentration and salinity in Gazi Bay (Kenya), a preliminary study. *Mangroves and Salt Marshes* 3: 243-249.

Naidoo G. (2006) Factors contributing to dwarfing in the mangrove *Avicennia marina*. *Annals of Botany* 97: 1095-1101.

Neukermans G., Dahdouh-Guebas F., Kairo J. G. & Koedam N. (2008) Mangrove Species and Stand Mapping in Gazi bay (Kenya) using Quickbird Satellite Imagery. *Spatial Science* 53: 75-86.

Robert E. M. R., Koedam N., Beeckman H. & Schmitz N. (2009) A safe hydraulic architecture as wood anatomical explanation for the difference in distribution of the mangroves *Avicennia* and *Rhizophora*. *Functional Ecology* 23: 649-657.

Schmitz N. (2008) *Growing on the edge: hydraulic architecture of mangroves: ecological plasticity and functional significance of water conducting tissue in* Rhizophora mucronata *and* Avicennia marina*.* PhD Thesis, Vrije Universiteit Brussel, Brussels, Belgium. 135 p.

Schmitz N., Robert E. M. R., Verheyden A., Kairo J. G., Beeckman H. & Koedam N. (2008) A patchy growth via successive and simultaneous cambia: key to success of the most widespread mangrove species *Avicennia marina*? *Annals of Botany* 101: 49-58.

Smith T. J. III. (1987) Seed predation in relation to tree dominance and distribution in mangrove forests. *Ecology* 68: 266–273.

Tomlinson P. B. (1994) *The Botany of Mangroves*. Cambridge University Press, Cambridge. 433 p.

UNEP. (2001) *Eastern African Database and Atlas Project (EAF/14). The Eastern African Coastal Resources Atlas: Kenya*. United Nations Environmental Program.

Verheyden A., De Ridder F., Schmitz N., Beeckman H. & Koedam N. (2005) High-resolution time series of vessel density in Kenyan mangrove trees reveal link with climate. *New Phytologist* 167: 425-435.

Development of Mangrove paddy fields in Casamance Southern Senegal

Boubacar Barry[1]

Summary

Mangroves areas in Casamance have been traditionally used for rice growing, fishing, fish culture, shell picking and wood. Senegal has been affected by drought since 1963 and this has had an adverse effect on the mangroves leading to a decrease in the total area. Intensification of agriculture and increasing population pressure has resulted in increased erosion and siltation. Given the shortage of rainfall due to recurrent droughts over the last three decades, one can easily observe a tendency towards increased salinity of soils and the underlying water table. Site development has become the only solution to the salt intrusion problem since early 1970s.The present paper focuses on the different types of site development such as the traditional polder and anti-small dams and their role in increasing rice production.

Background

The West African country of Senegal (Figure 1) is primarily an agricultural country. Agriculture accounts for about 28% of the GNP and provide employment for 80% of the economically active population.

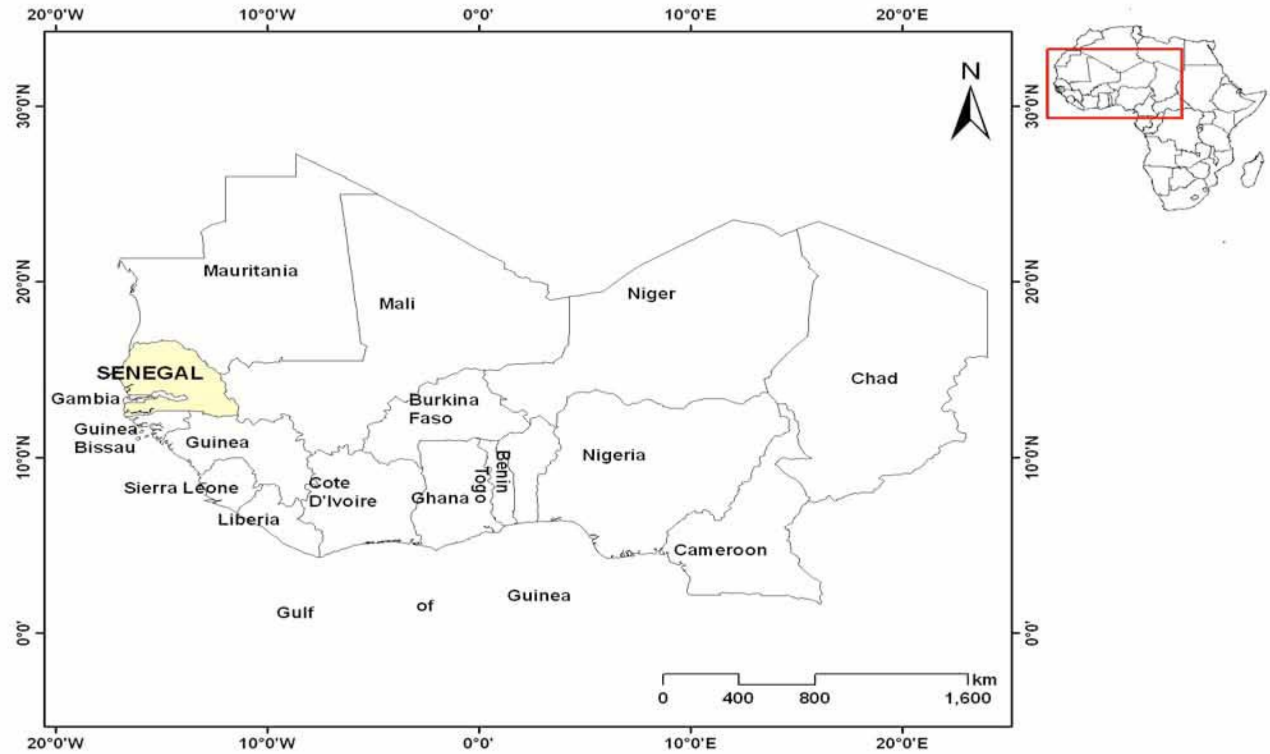

Figure 1: Map of Africa and West Africa showing Senegal

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In recent years, cereal production especially rice has not been sufficient to meet growing needs. Currently there is a deficit of about 200 000 tons of cereal grains each year. During the late sixties and early seventies, due to rapid growth of urban areas as a result of population migration especially the young from rural to urban areas, the failure_of food production caused by policies favoring cash crops, the instability of world prices, and the frequent Sahelian droughts, the country became painfully aware of its dependence on imported food, notably rice. Since 1977, due to generalized drought, Senegal has imported more than 600,000 tons of cereals every year. At present time, domestic rice production covers only 15 to 30 % of the country's annual needs.

Because of economic instability arising from the combined factors of heavy dependence on imported food largely due to unstable rainfall patterns, agricultural development in the mangrove area in Casamance has become a main priority along with irrigation and full water control for agricultural production along the major rivers. An ambitious programme of soil and water management was developed during the early 1980's in the mangrove area of Casamance to improve food production.

For many years, the Casamance region was a food self-sufficient region. In recent decades, this region has experienced food deficits. In the Casamance region the annual rainfall has decreased from 1 500 mm to less than 1 000 m. Most strikingly, during the period from 1966 to 1980, there was a more than 20% reduction in annual rainfall, and over the period 1980-1990 the average was even lower.

Characteristics of Mangrove Areas in Casamance

The mangrove area of Casamance in the South-West of Senegal consists of intra-tidal flats with riverain mangrove forest and 'tannes', *i.e.* saline marshes partly containing bare surfaces. The soils are acid sulphate soils, very shallowly developed on peaty sulphidic mud clays and sands, and subject to tidal flooding. The mangrove area is concentrated in the estuary of the Casamance River. Since the mangrove area in Casamance is only marginally suited for rice cultivation, a reduction of 20 to 30% in rainfall has been disastrous for paddy yields. With insufficient rainfall, there is inadequate leaching of the polders and as the salt level increases the production of rice becomes nearly impossible.

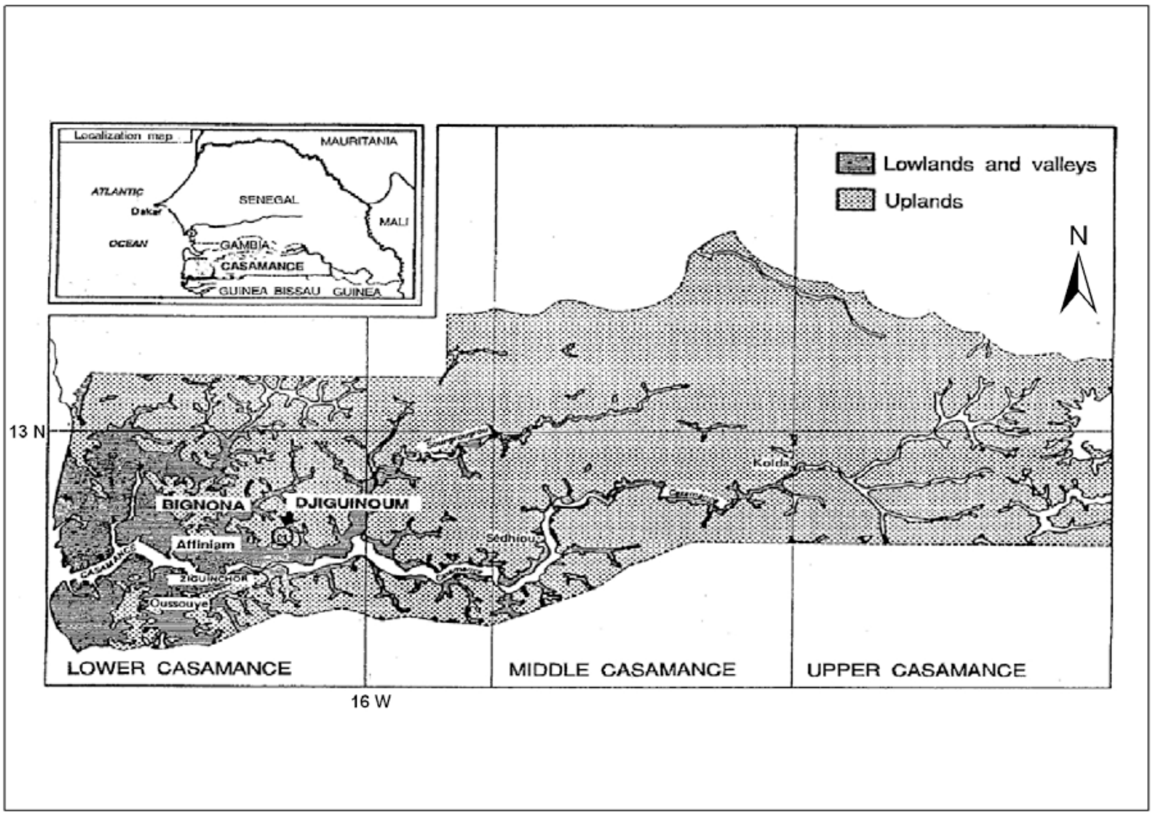

Figure 2: Map of the Casamance Region of Senegal

Geographically, the saline proportion of the Casamance River estuary extends 220 km into the country; salt water regularly rises as far as 130 km inland. Salt content reaches its maximum level in June and its minimum level in October. The salinity at the town of Ziguinchor varies between 19 and 37 grams of salt per liter. The maximum amplitude of the tide is approximately one meter, and all of them are subject to the seawater infiltration,. Since the region is quite flat, all of the backwaters (marigots and bolons) are also affected by salt over much of their length.

Another result at the level landscape is a lack of runoff. On average, only 6% of the rainfall in the Lower Casamance goes into runoff, thereby helping leach mangrove rice fields. Given the shortage of rainfall during the 1970s, 1980s and late 1990s, the increasing accumulation of salt in the soil, combined with conflicts and political turmoil has led to the declined of mangrove rice production. Thus the number of abandoned mangrove rice fields has increased over the last two decades all over the Casamance Region. Along the tidal portions of the river basins, there is a tendency not only towards increasing salinity of the river beds themselves, but also toward increase of the underlying water table. This salinization process occurs at the end of the rainy season as a result of high tides which feed the water table. Consequently, not only the polders, but also the rice fields located on the first level of terraces, are negatively affected by the shortage of rainfall and the problem of salinization. In the mangrove areas the continental bedrock, mainly sandstone, is found under unconsolidated mud clays and sands, and has a depth of up to 20 meters. The chemical composition of the mud varies little along the estuary. The mud is relatively poor in Ca, K and trace elements.

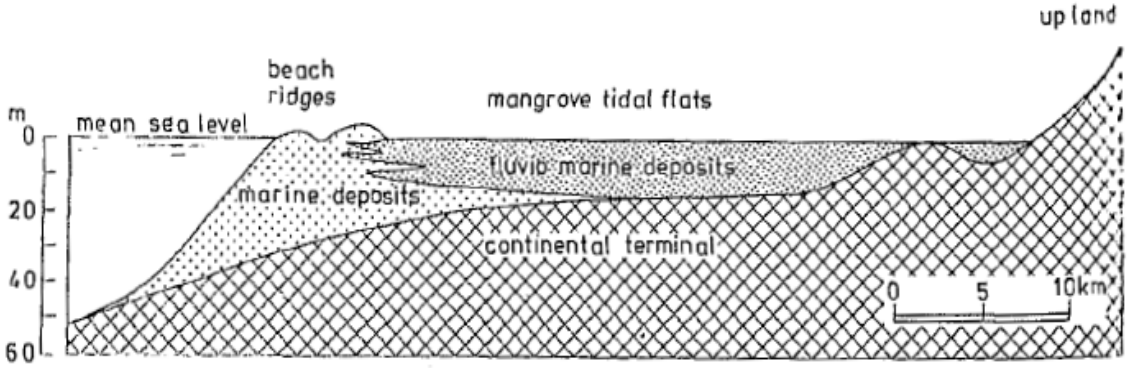

Figure 3: Typical relations between continental terminal and marine and fluvio-marine soil deposits of the mangrove area

Agricultural Development of Mangrove Areas in Casamance

Mangrove rice cultivation has been practiced in the Casamance region by farmers for centuries. The traditional Diola system for reclaiming mangroves is based on the judicious use of the movements of the tide. In the absence of free water, farmers managed earlier to leach the salt from their fields without lowering the pH. This was done by allowing a continued re-admission of salt water during the dry season. In years with abundant rainfall, fields could produce as much as 3 tons of paddy rice per hectare with no fertilizer and, in many cases, no weeding. The double dyke systems, which makes it possible to tap all the resources of the mangrove (wood, charcoal, fish, pasture, rice farming), has been widely adapted but requires a great deal of labor. Given the high frequency of years with low annual rainfall and the flight of young people toward the cities, the future of mangrove rice cultivation is now in question.

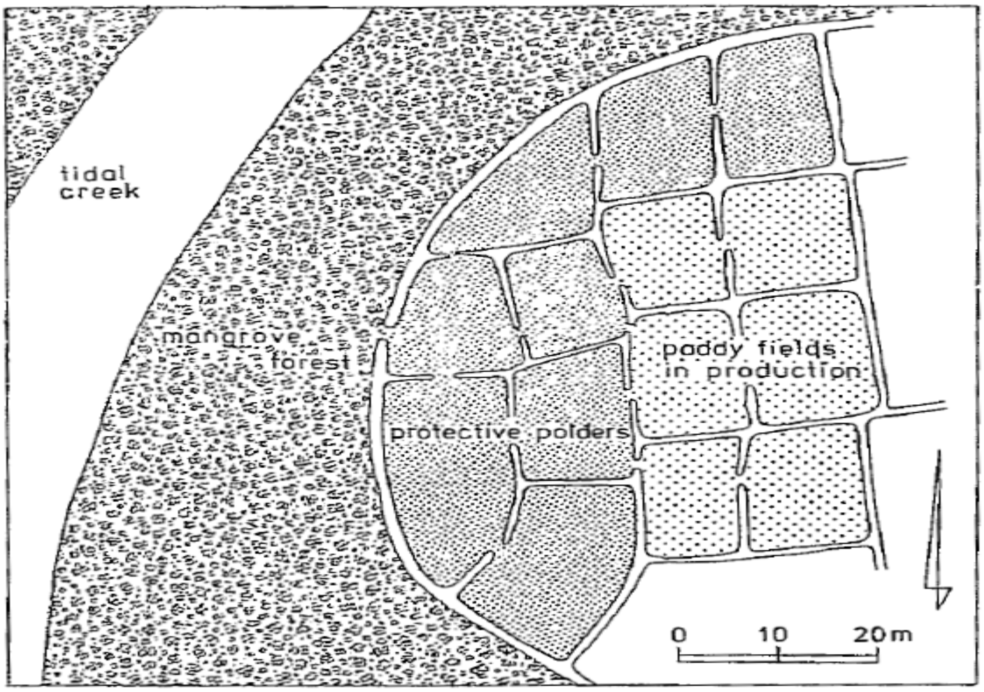

Figure 4: Traditional site development

Site development (polders, drains, anti-salt dams) in Casamance focuses on the removal of the salt by means of fresh water retention and partial exclusion of brackish water. The difficulty encountered in these systems includes finding a reasonable balance between the exclusion of saline water and the drying out of the soil which may provoke a drastic decline of pH.

The low level of rainfall in recent years has dramatically reduced the amount of fresh water available for leaching the salt out of these fields, and thus diminished the possibility of site development. Research results from different sites (Madina, Tobor, Djibelor and Guidel) show that site development helps convert the surface horizons from acid sulfate soil to a para-acid sulfate soil and, with more fresh water (greater rainfall levels, fresh water retention dykes), the polders could again become viable for rice production (Beye,1977, Marius, 1980 and Barry, 1991). That is why the Government of Senegal launched, in 1994, an important soil and water programme in Casamance, aimed to improve rice production in the region. The construction of small anti-salt dams in most of the valleys remains the primary objective.

It is estimated that a total of 100 000 hectares of mangrove land could be developed for agriculture in Casamance. Most of this potential lies in the Lower Casamance region, along the main tributaries of the Casamance River. These programmes are less ambitious than the national programmes of Soil and Water Conservation (SWC), which are designed for large watersheds of several hundreds of square kilometers, and involve sophisticated water control systems. The small anti-salt dams are directed toward small watersheds, not larger than several hundreds of hectares, and are built and managed by smallholder farmers of one or, at the very most, a group three villages. Most of the fields protect by the anti-salt dam are not strongly affected by the salt and the main problem encountered is to keep a sufficient depth of fresh water in the plots during the whole growing season.

The anti-salt dam consists of a dyke and one or two reinforced concrete structures. The dykes are 400 to 1 000 meters long, 4 to 6 meters wide at the bottom, and 2 to 4 meters wide on the top. Their height varies between 1.5 to 2.5 meters. In many cases, the dyke is built by farmers who share the land upstream and downstream of the dam. In general, a road which crosses the valley is used as a foundation bed. This also presents the advantage of facilitating the access to many villages during the rainy season, mainly during the floods.

A reinforced concrete structure located in the affluent bed consists of two or four gates (1.5 m wide); each gate is designed to have a rectangular weir of 20 centimeters high and 60 centimeters wide at the bottom. In order to retain water behind the dam, farmers must close the gates by installing two lines of planks on the weir, and fill the spaces in between them with mud. The planks are placed one on top of the other. The number of planks depends on the farming calendar. Each plank is 20 cm in height and is slightly longer than the gate width. At the beginning of the rainy season, farmers use two planks to retain a certain amount of water to flood the lowest paddy field and to dissolve the salt. Water will then be flushed out by removing the planks. This type of operation has to be done as many times as needed to get good conditions for growing rice, in many cases, repeatedly until mid-July, when farmers start plowing their plots. After the rice transplanting operation, which begins mid-August, farmers use more planks to retain additional water as the rainy season ends. Only after big storms is excess water released to avoid flooding the plants. During the dry season, the gates remain closed; sea water is not admitted.

In accordance with the location of their plots on the topo-sequence, farmers decide whether or not to release a part of the water behind the dam. Often there is no agreement among landowners, or a final decision is made too late. Sometimes the problem of how much water to release from the reservoir can be more complicated, as in when paddy fields downstream from the dams do not get enough water to leach the salt out.

Today, more than 100 dams have been built in Casamance in order to protect mangrove paddy fields against sea water intrusion during the high tides of the dry season and to store fresh water during the rainy season. It is estimated that more than one third of the mangrove paddy fields were earlier abandoned in Casamance because of the high salinity of the water table. The fresh water stored behind the small ant-salt dam has helped over the years leach the salt out the mangrove paddy fields and has facilitated rice growth after reclamation of the abandoned paddy fields. In most of the valleys where small anti-salt dams have been built, rice production has substantially increased. Perhaps the best example of this increase is the Katoure valley located 10 km south east of Ziguinchor, where for more than one decade, the mangrove paddy fields affected the salt water intrusion were simply abandoned. Only two years after the construction of the dam, however, the average rice paddy yield in those same fields was 3.5 tons per hectare.

References

Barry, B. 1990: Groundwater flow and Quality behind an anti-salt dam in Lower Casamance Senegal (West Africa). MSc Thesis, Michigan State University USA.

Beye, G. 1973: Bilan de Cinq Annees d'Etudes du dessalement des sols du polder de Madina. Mimeo ISRA/CRA Djibelor, Senegal

Marius C. and M. Cheval 1980 : Note sur les sols de Guidel. ORSTOM Dakar, Senegal.

Variability in the abundance & recruitment of *Fenneropenaeus indicus* and *Metapenaeus monoceros* postlarvae and juveniles in the Ambaro bay mangroves of Madagascar

Marguerite Voahirana Rasolofo[1] *and O. Ramilijaona*[2]

Summary

*The Malagasy shrimp sector is currently focusing on shrimp farming in view of a drastic reduction in fisheries production. To better understand the recruitment of penaeid shrimps in maritime fisheries, research was conducted on Fenneropenaeus indicus and Metapenaeus monoceros species in two rivers at the Ambaro Bay: the Ambohinangy and the Ambazoana Rivers. The variations in abundance of size categories (postlarvae, small juveniles and large juveniles) and the migration of shrimps were sampled from September 2004 to August 2005 with a net known as “**sihitra**” used in traditional fishing. The influence of environmental factors (rain, salinity and temperature) on the recruitment is analyzed. A cross section of 4,198 individuals (58% F. indicus, 42% M. monoceros) were sampled and the predominance of small juveniles confirms the nursery role of the area under study. The seasonal development of size categories in the sample is almost similar for the two species with a pronounced abundance of postlarvae at the beginning of the wet season and the dry season; while the large juveniles are more abundant at the beginning and during the wet season. A strong rainfall intensity inhibits the immigration of F. indicus postlarvae and the temperature of mangrove waters promotes the emigration of large M. monoceros juveniles. The research examines the effects of climatic factors and the impacts of shrimp farming on mangroves, with some recommendations for the development of a sustainable shrimp resources management.*

Introduction

In Madagascar, mangroves cover a surface area of 303,814 ha (FAO, 2007). These ecosystems are high productivity areas for the coastal aquatic environment and provide preferred habitats for juveniles of animal species looking for shelter (Robertson & Duke, 1987, Sasekumar *et al*., 1992). Animals residing in the intertidal area play a significant role in the production of detritus and trophic flow in mangroves. Detritus are the primary food for penaeid shrimps and through the food chain are closely linked to the productivity of these areas. Mangroves used by shrimps as habitat during the juvenile phase of their biological cycle are called nursery areas[3].

In Madagascar, shrimp fisheries occupy a predominant position in the national economy with a turnover of € 68 million for industrial fishing in 2002 (Rajaosafara, 2006). For some years, shrimp fishing has drastically reduced in terms of profitability and currently, the Malagasy shrimp sector is oriented towards aquaculture to meet the ever-growing

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[3] Nursery: Area in which the juveniles of a species gather to feed themselves.

global demand for seafood. However, it should be noted that the ecological impacts of aquaculture activities on mangrove ecosystems are tremendous: deforestation of mangroves, modification of water quality in environments receiving the wastes, salinization phenomenon, and reconversion of tannes causing a loss of habitats, particularly for the avifauna. These mangrove and coastal aquaculture-related problems generally originate with aquaculture management practices and with the poor enforcement of environmental regulations. In the area of shrimp captures, the reasons for fluctuations may be linked to environmental factors. These have an impact on the survival or mortality at younger stages (larvae and postlarvae) thus influencing the recruitment of shrimps in maritime fisheries.

Our study on the dynamics of young shrimps in mangrove areas is conducted following the hypothesis that interannual and seasonal variations of the recruitment at sea of penaeid shrimps depend on the availability of young shrimps in nursery areas under the influence of environmental conditions. The aim of the study is to determine the abundance, distribution and movement of young shrimps in estuaries. The survey was conducted through experimental observations on the basis of *Fenneropenaeus indicus* and *Metapenaeus monoceros* samplings, the most common species in fishery captures. As one of the main fishery zones of the West coast of Madagascar, the Ambaro Bay was selected as the study site.

Equipment and methods

Study area

The Ambaro Bay is located on the North-west coast of Madagascar between longitudes 48°30’ and 48°53’ East and latitudes 13°15’ and 13°30’ South (Figure 1). The bay is lined with mangroves along the intertidal zone over a few kilometers upstream from the estuaries. The zone under study experiences a sub-humid tropical climate characterized by a dry and cool season, from the beginning of May to the end of October, and a rainy and hot season, from early November to the end of April. As for the entire Western part of the coastal area, the tide at Ambaro Bay is semidiurnal and regular. The tidal range varies from 3 to 3.5m.

Sampling

Samplings were done from September 2004 to August 2005 in the two estuaries of the Ambohinangy and Ambazoana Rivers located in the southern part of the bay (Figure 1). Three sampling stations were established along the rivers; Station 1 is located at the opening of the river; Station 2 and Station 3 were established at 1km and 3km upstream from Station 1 respectively. In each station, temperature and salinity measurements have been carried out at a depth of less than 0.50m under the surface of the water. Rainfall data are provided by the weather station of the Nosy-Be airport located 30km to the west of the zone under study.

Samplings were taken every fortnight during spring tides. The biological material was sampled using a rectangular pocket-shape net named **sihitra** with an aperture size of 1.0 to 2.0mm. The net has the advantage of being usable within mangrove areas. It is pulled against the current by two men; the lower edge is maintained just above the water level.

The sampling takes place one to three hours before the low tide, following a one-minute haul. Penaeid shrimps are sorted from vegetable debris and other organisms.

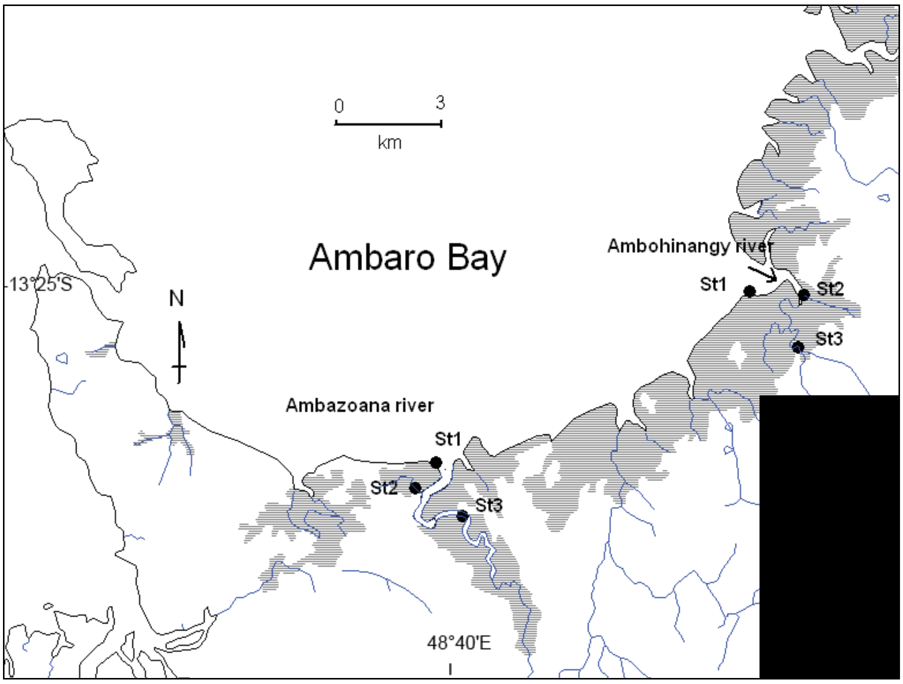

Figure 1: Location of sampling stations at the Ambaro Bay. Hachured sections represent mangrove ecosystems (St1: Station 1; St2: Station 2; St3: Station 3)

At the laboratory, each specimen was identified according to Motoh & Buri (1980) and the cephalothoracic length (CL)[4] of shrimps was measured using binocular magnifying glasses for shrimps with a CL<3mm and a caliper was used for the largest ones. The shrimps were grouped in 3 size categories: *postlarvae* (CL<3mm) *small juveniles* (3mm<CL<7mm) and *large juveniles* (CL>7mm).

Data processing

The abundance is expressed by the density ($n.m^{-2}$) which is the number of shrimps captured by m^2 on a surface swept by the device. Immigration in mangrove areas was estimated according to the percentage of postlarvae abundance. Emigration was examined based on the percentage of large juveniles density. The correlation between the environmental parameters and migration indexes is translated by the Pearson's coefficient.

Results

Specific composition and numbers of samplings

Among samplings, the most numerous penaeid shrimps were the *Metapenaeus stebbingï*, *Fenneropenaeus indicus*, *Metapenaeus monoceros*, while *Penaeus semisulcatus* and *Penaeus japonicas* were less numerous. A cross section of 4,198 individuals (58% *F.*

[4] LC : Cephalothoracic length is measured between the orbital cavity and the back edge of the shell.

indicus, 42% *M. monoceros)* were captured during the sampling period. The CL size of young shrimps is between 0.8mm and 22.0mm.

Abundance

The average density of *M. monoceros* (0.37 $\pm$ 0.23 shrimps.m^{-2}) irrespective of categories, has a low representation as compared to *F. indicus* (0.60 $\pm$ 0.133 shrimps.m^{-2}). The category of small juveniles dominates in abundance as compared to the total number of young shrimps. Moreover, the large juveniles are more numerous as compared to postlarvae.

a) Spatial variation

Between the two rivers, the analysis of the average density variations for the different size categories did not show any significant difference between the two species (P = 0.599 for *F. indicus* and P = 0.933 for *M. monoceros*). However, in the stations, the abundance distribution showed differences among *F. indicus* ($0.01<P<0.05$).

b) Seasonal variations

The seasonal development of abundance is almost similar for the two species. Postlarvae are abundant at the beginning of the wet season (October-November), at the beginning of the dry season (March to May) and during the dry season (July to August). Small juveniles are constantly available year round and the large juveniles follow almost the same monthly development as the small ones. Growth periods are displayed by a simultaneous increase of size categories and are observed at the beginning of the wet season (Figure 2).

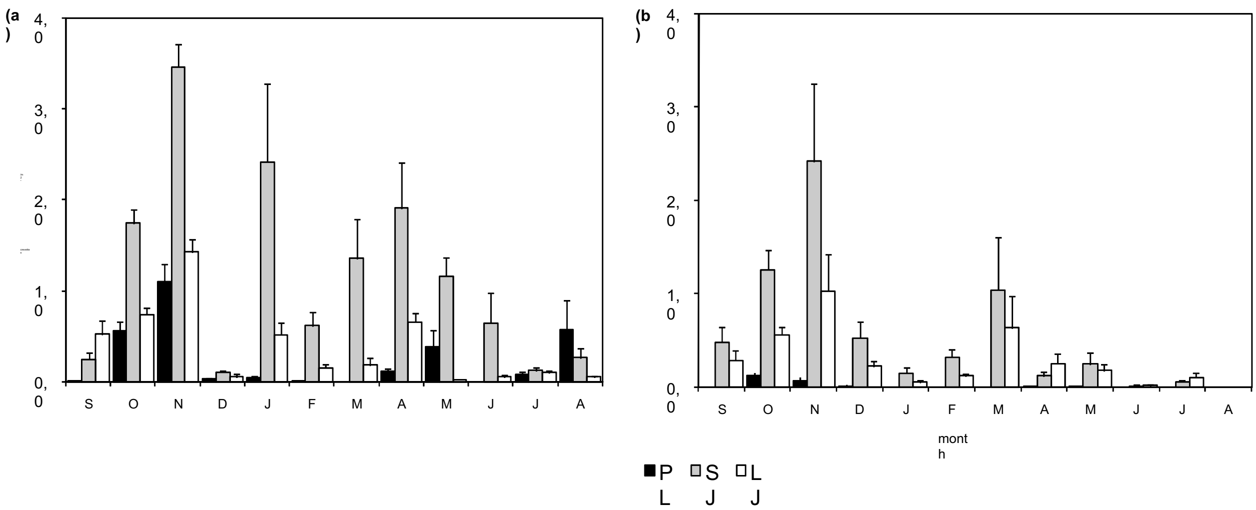

Figure 2. Abundance monthly average (n° of shrimps.m^{-2}) of various size categories (PL: Postlarvae, SJ: small juveniles ; LJ : Large juveniles) of (a) F. indicus and (b) M. monoceros

Recruitment

The introduction of *F. indicus* postlarvae (Figure 3a.) in mangrove waters is done gradually but mainly at the beginning of the wet season (October-November), at the beginning of the dry season (April-May) and during the dry season (July-August). The emigration of *M. monoceros* large juveniles from mangrove zones are more intense at the beginning of the wet season (October-November); continue at the end of the wet and hot season (March to May) and are less intense during the dry season (July to August) (Figure 3b.).

The rains occurring fifteen days before the samplings are negatively linked (Figure 3a.) with the immigration of postlarvae (r= -0.62 for *F. indicus* and r= -0.34 for *M. monoceros*). Mangroves water salinity does not show any significant correlation with the movement of young shrimps. Among *M. monoceros*, the correlation between water temperature and emigration of large juveniles (r = 0.54) is significant (Figure 3b.).

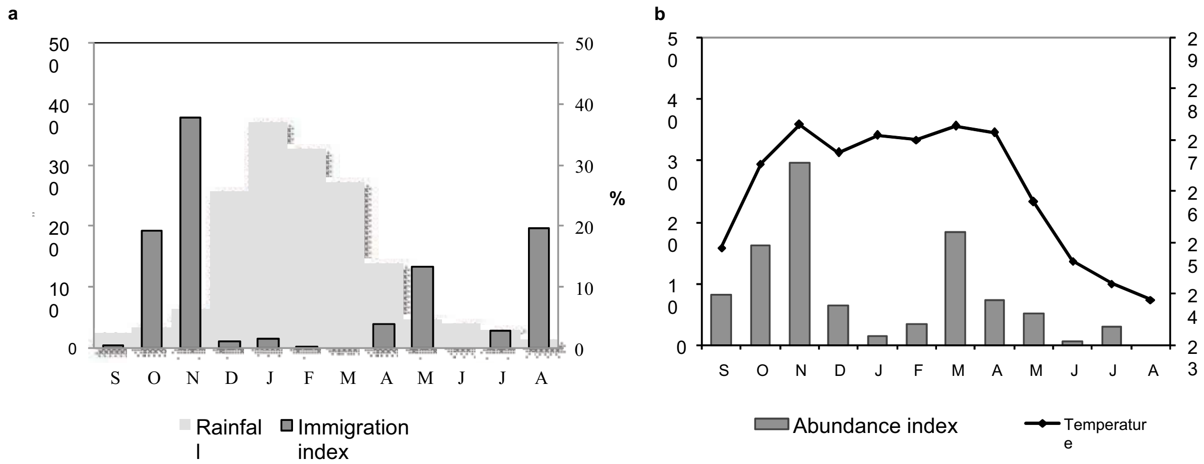

Figure. 3. Seasonal variations of a) Immigration index of F. indicus postlarvae and rains b) Abundance index of M. monoceros large juveniles and water temperature

Discussions

The constant abundance of small juveniles in the samplings confirms the role of nursery played by the Ambaro Bay. With the same methods and sampling sites, the number of shrimps captured in this survey is low as compared to the number obtained in previous works (Rasolofo, 1990). However, the estimated density values are comparable to those of other studies carried out on the same species (Rönnback *et al*, 2002; Macia, 2004). The marked low density values among *M. monoceros* are a result of often null postlarvae captures. Even though the sampling methods were not the same, the biannual common recruitment among penaeid shrimps (Ahmad-Adman et al., 2002) was found in the present study with the emergence of two main recruitment periods in mangrove zones. The immigrations of postlarvae at the beginning of the wet season for the two species, clearly show the reproduction peeks (egg laying period) defined in previous works by Le Reste (1978) and Rafalimanana (2003).

The inhibition of the coming of postlarvae during the wet season could result from the increase of flows in the rivers after heavy rains, by retaining postlarvae in marine waters. The study showed a significant correlation between climatic factors (temperature and rains) and the recruitment of young shrimps. Moreover, the climatic changes such as the increase in temperature and the increase of rainwater can affect the natural stock of shrimp resources in coastal areas. Moreover the inherent development of shrimp aquaculture in Malagasy mangroves runs the risk of compromising the habitats (nursery zones) of young shrimps and consequently of shrimp fisheries.

Conclusion

The evaluation of the abundance of small juveniles indicates the importance of mangroves in the Ambaro Bay as a prospective nursery zone. In spite of the reduction of the campaign to only one annual sampling cycle, the analysis of abundance variations identified two main abundance and recruitment periods with a season dynamics almost similar for the two species.

Perspectives for research and development

In future research, it will be important to have a better knowledge of ecological structures and functions of nursery zones, by focusing research on a characterization of mangroves, considering possible changes of environmental factors as well as the negative effects of the development of shrimps aquaculture on coastal ecosystems.

For mangroves, it is vital to practice an integrated approach for a sound exploitation of resources. Development activities should thus make provision for the protection of specific biological stages (larvae, postlarvae) and the critical habitats for their development. Exploitation standards should be put in place and followed by an actual enforcement for the sustainability of shrimp and other natural resources and their exploitation. Finally, a participatory consultation is advisable following the example of the ZAC projects (Concerted Development Zones) which have had impacts at the Ambaro Bay.

References

Ahmad-Adam, N.; Loneragan, N.R. & Connolly R.J., 2002.Variability of, and the influence environmental factors on, the recruitment of postlarval and juvenile *Penaeus merguiensis* in the Matang mangroves of Malaysia. Marine Biology 141, 241-251.

FAO, 2007. The world's mangrove 1980-2005, - A thematic study prepared in the framework of the global Forest Resources Assessment 2005. Forestry paper 53.

Le Reste, L., 1978**.** *Biologie d'une population de crevettes Penaeus indicus H. Milne Edwards sur la côte nord-ouest de Madagascar*. Travaux et documents Orstom 99, 291 pp.

Macia, A., 2004. Juvenile penaeid shrimp density, spatial distribution and size composition in four adjacent habitats within a mangrove-fringed bay on Inhaca Island, Mozambique. WIOMSA Journal of Marine Sciences 3 (2), 163-178

Motoh, H., Buri, P., 1980. Identification of the post larval Penaeus (Crustacea, Decapoda, Penaeidae) appearing along shore waters. Southeast Asian Fisheries Development Center 4, 15-19.

Rajaosafara, S., 2006. Performances économiques de la filière crevettière sur les 5 dernières années, Actes de l'atelier « Aménagement de la pêcherie crevettière », 111-129

Rafalimanana, T., 2003. Les crevettes exploitées sur la côte ouest de Madagascar : Variabilités spatio-temporelles des paramètres biologiques et dynamiques des populations. Thèse ENSAR, 2003-17, H51, Rennes, France. 268 pp.

Rasolofo, V.M., 1990. Etude de la répartition et de la disponibilité des crevettes pénéides dans les mangroves de la Baie d'Ambaro. Archives CNRO 6/7, 117-125

Robertson, A.I. & Duke, N.C., 1987. Mangroves as nursery sites: comparison of abundance and species composition of fish and crustaceans in mangroves and other near shore habitats in tropical Australia. Marine Biology 96, 193-205

Ronnbäck, P.; Macia, A.; Almqvist, G.; Schultz, L.; Troell & M., 2002. Do penaeid shrimps have a preference for mangrove habitats? Distribution pattern analysis on Inhaca Island, Mozambique, Estuarine Coastal and Shelf Science 55, 427-436

Sasekumar, A.; Chong, V.C.; Leh, M.U.& D'Cruz, R., 1992. Mangrove as a habitat for fish and prawns. Hydrobiologia 247, 195-207.

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Biological characteristics of the Schlegel's goby, *Porogobius schlegelii,* in the mangrove – nipa ecosystem southeast of Niger delta, Nigeria

Mfon T. Udo[1]

Summary

A study of some aspects of the biological characteristics of Porogobius schlegelii [Gobiidae], in two different estuarine swamp creeks within Qua Iboe River estuary, Nigeria, was carried out between January and December 2004, to determine impact of replacement of mangrove by nipa palms. A total of 729 specimens of the fish were examined; out of which 50.2 % were mangrove sample [size 3.6–11.8 cm TL] and 49.8% nipa collections [size 3.7–11.4 cm TL]. In this study it was found that Schlegel's goby fish, Porogobius schlegelii from the mangrove creek area of Nigeria did not ingest the phytoplankton species Biddulphia spp., the crustacean and mollusc Tympanotonus fuscatus, whereas the algae Gyrosigma spp. and Navicula spp., dipteran larvae and insect remains were absent from dietaries eaten by the nipa creek counterparts. Despite the similarity in the rank-order of the food objects [p < 0.002], there was dissimilarity in the proportions of the food objects. Feeding intensity was higher in nipa vis-à-vis the mangrove creek area. Bi-sexuality existed in sex ratio between the creeks but with females' dominance in each creek. Males and females from the mangrove creek increased in body weight over those of the nipa. The mangrove creek specimens were higher in the reproductive (gonadosomatic and condition indices) investment. Mean fecundity of 8,466 and 10,164 eggs from the mangrove and nipa creeks respectively, were not statistically different. The mangrove Schlegels' were higher in power of the length-weight relationship. In brief, this study highlights the depressive influences from potent succession of the native and 'deterministic' mangrove ecosystem cum biota by the 'stochastic' alien nipa palm [Nypa] in the Qua Iboe River estuary, Nigeria.

Introduction

Vast mangrove forest dominates the coastal estuarine swamps of Qua Iboe River. As one of Nigeria's forest reserves, the estuarine mangrove ecosystems of Qua Iboe River, Cross River, Imo River and Niger Delta along with their creeks and tributaries represent a rich source of wood supply for various domestic and industrial purposes [Ekundayo, 1985]. The fertilizing effects from the decay of the mangrove macrophytes have been reported (Moses, 1985). In the same estuarine swamp creeks of Nigeria lives the Schlegel's goby fish, *Porogobius schlegelii* [Gobiidae]. At present, the aforementioned estuaries are now covered by nipa palms in large expanse of the adjoining inter-tidal swamps and only isolated residual patches of the original mangrove vegetation remains [King and Udo, 1997, Udo, 2002a,b; Udo *et al*., 2008]. The nipa has only recently been introduced from Singapore originally as an ornamental plant into the Nigerian towns of Calabar [1904] and Oron [1912].

To understand the changes in some aspects of the biology of the species, some aspects of the ecology of the fish populations in two spatially and ecologically separated creeks [mangrove and nipa palms] were studied in the Qua Iboe River estuary, Nigeria; the characteristics included in the study were, *inter alia,* diet and feeding behaviour, sexual

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dimorphism, sex ratio, reproductive investment/breeding, fecundity and length-weight relationship.

Materials and methods and results

The study was conducted in the estuarine swamps of Qua Iboe River around Ibeno Local Government Area, Akwa Ibom State, Nigeria. The Qua Iboe River system ($7^{0}\ 30' - 8^{0}\ 20'$ W; $4^{0}\ 30' - 5^{0}\ 30'$ N) is one of the major hydrographic features of Akwa Ibom State.

Monthly samples of the Schlegel's goby were obtained from subsistence catches of some fisherfolks for a period of 12 months (January – December, 2004). To investigate the impact of replacement of the mangrove by the introduced nipa palms on the ecology of *P schlegelii*, fish samples were obtained separately from swamp that is predominantly covered by the original mangrove vegetation at Iwuochang (referred to as mangrove creek); and swamp that is composed mainly of introduced nipa palms at Upenekang (referred to as nipa creek). The samples were preserved in 10% formalin. The fish specimens were sexed (Udo, 2002a), measured, weighed and dissected. Quantitative dietary importance of different food objects based on Udo (2002b), were evaluated using the following indices: 1. Gut repletion index (GRI %) and 2. Mean of gut fullness (MGF) (Hyslop, 1980). The following parameters were computed according to the equations: 1. Modify food object number: MFON = $m_x + t_x$ 100/(A U B); 2. Relative gonad length: RGL = GL.100/SL; 3. Somatic weight: SW = TW – GW; 4. Gonadosomatic index: GSI = GW.100/SW; 5. Condition index: K= GW.100/TL^3; 6. Hepatosomatic index: HSI = LW.100/TW – LW; 7. Fecundity estimates: $F = {}_{a}\ {}_{i}^{b}$

Dynamics of diet

Of the 729 specimens of *P. schlegelii* examined for food and feeding intensity, 366 (50.2%) were sampled from the mangrove ecosystem (size range 3.6 – 11.8 cm TL) and 363 (49. 8%) from the nipa ecosystem (range; 3.7 – 11.4 cm TL). The vegetation-dependent change in the food dietaries of *P. schlegelii* is presented in Table 1. The phytoplankton species *Biddulphia* spp., the crustacean and the mollusc *Tympanotonus fuscatus,* were not found to have been ingested by the fish in the mangrove creek; whereas the algae *Gyrosigma* spp. and *Navicula* spp., and dipteran larvae and insect remains were not present in the dietaries eaten by the fish in nipa creek. As can be seen in Table 1, despite the similarity in the rank-order of the food objects ($p < 0.002$), proportions of different foods ingested in the two ecosystems were dissimilar.

Dynamics of feeding intensity

There was a significant increase in GRI% of *P. schlegelii* from the area dominated by nipa palms ($p < 0.001$) as compared to the mangrove creek, whereas there was no creek-dependent variation in MGF ($p > 0.05$). The result is indicative of higher feeding intensity in nipa creek individuals of *P. schlegelii* than in those in the mangrove creek.

Table 1. Spatial-based variability in trophic spectrum of P. schlegelii in Qua Iboe River estuary, Nigeria

	Modify food object number [MFON %]	
Food item	Mangrove creek	Nipa palm creek
Algae		
Baccillariophyceae		
Biddulphia	-	0.09
Coscinodiscus	0.31	0.14
Gyrosigma	0.04	-
Navicula	0.20	-
Chlorophyceae		
Spirogyra	1.12	1.25
Crustacea		
Decapoda [crabs]		
Sesarma alberti	4.24	2.72
Sesarma remains	17.36	22.01
Decapoda [shrimps]		
Penaeus notialis	15.41	14.10
Penaeus remains	17.50	21.40
Detritus		
Coarse detritus	1.38	1.13
Fine detritus	1.05	1.13
Fish [prey]		
Gobioides ansorgii	0.94	0.43
Pellonulla sp	4.82	1.30
Porogobius schlegelii	17.33	9.42
Fish remains	10.54	19.20
Unid fish	2.88	1.02
Insecta		
Dipteran larvae	0.22	-
Insect remains	0.60	-
Macrophyte matter	2.25	0.52
Mollusca		
Neritina glabrata	0.09	0.14
Tympanotonus fuscatus	-	0.17
Nematoda	0.16	0.35
Sand grain	1.56	1.35
Overall total =	**100.00**	**100.0**

Sexual dimorphism

There was no significant intersexual change in the length size of fish ($p > 0.05$) between the mangrove and nipa creeks. However, there were increases in weight of the males and females ($p < 0.05$) in the mangrove creek as compared with their counterparts in the nipa creek.

Sex ratio

Generally, the sex ratio depicted female preponderance in both areas studied.

Changes in reproductive investment

Females from the mangrove creek were higher in GSI ($p < 0.001$) and K ($p < 0.001$) than the nipa creek females. However, there were no significant increases in ovary length and HSI ($p > 0.05$ in each case) between the two creeks. The results suggest that reproductive investment was higher in the mangrove than the nipa creek. From the analyses, the mangrove creek males were higher only in k ($p < 0.001$) than the nipa creek male-samples while no differences occurred in GSI, gonad length, and HSI ($p > 0.05$ in all the cases) between the creeks.

Fecundity
Mean absolute egg production of 18 specimens of the Schlegel's goby from the mangrove creek (size range 5.3 – 9.9 cm TL) was 8,466 ± 4,060 eggs (range 3,000 – 19,000 eggs). Average absolute fecundity of 16 specimens of the Schlegel's goby from the nipa creek (range 5.7 – 10.1 cm TL) was 10,164 ± 5,924 eggs (range 5,300 – 27,400 eggs). In both areas fecundity increased with fish size (length and weight), with functional equations of the forms - Mangrove: $F = 36.8723\ TL^{2.6983}$, $F = 2491.7244\ TW^{0.9109}$; Nipa: $F = 25.0001\ TL^{0.4944}$ and $F = 2577.145\ TW^{0.8835}$. However, despite the observed high number of eggs in the nipa creek area, there was no significant statistical difference ($p > 0.05$) in fecundity estimates between the two study areas.

Allometric relations
The length-weight regressions of *P. schlegelii* in the vegetation types were: mangrove: $BW = 0.011197^{2.869}\ TL$ ($r = 0.969$); and $BW = 0.011017TL^{2.812}$ ($r = 0.967$) nipa. The length exponent in each of the creeks was not different from the expected cube law. However, there was increase of the power of the exponent by the mangrove specimens ($t = 6.706$, 727 df, $P < 0.001$) over their nipa creek individuals.

Discussion
The ranking in relative importance of each food objects ingested by *P. schlegelii* were the same in the two creeks. However, individuals from the nipa creek were higher in feeding intensity than individuals in the mangrove creek. The reason for the observed higher feeding in the nipa creek area is not clear, but the observation agrees with the 'optimal foraging theory'. The theory (Schoener, 1971; Angermeier, 1982) states that, the breadth of the diet will become enlarged during periods of shortage of supply and abundance. The observation in nipa creek presents the depressive influences and ecological implication(s) of vegetation change to coastal estuarine fisheries. The exotic nipa palm does not have the advantageous fertilizing effect usually provided by decay of the mangrove vegetation and also does not provide as good a substrate for attachment of food organisms as the original mangrove vegetation (Moses, 1985; King and Udo, 1997; Udo, 2002b). This is probably due to the fact that the nipa creek is relatively a homogenous ecosystem with limited variety of microhabitats to support different food resources (cf. King and Udo, 1997). Thus, the fish in the nipa creek area must therefore eat what is available in order to grow and survive. This observation indicates further that the fish in the nipa creek will have to feed intensively to compensate for the shortage and/or irregularity in available food supply. The feeding habits of such fishes will involve an ecological switch from a specialist to a generalist diet as the nipa palm ecosystems are structurally less complex than the mangrove swamp ecosystems and thus lack the enormous differences in microhabitats that these latter ones have and which support a greater variety of food resources (Udo, 2002b).

Sexual dimorphism demonstrated larger and heavier females over the males in both swamps. This is in line with Darwin's 'fecundity advantage' model (Darwin, 1874 p.332;

see also p.275 for a similarly worded argument) which states that, in most species of animals, females attain larger body sizes than males.

The spatial cum temporal changes in breeding intensity of *P. schlegelii* highlights that there is an increase in its intensity in the mangrove specimens as compared to the fish from nipa creek, including in the seasonality in breeding. The observations made on the breeding patterns probably indicate that the living conditions in the mangrove swamp ecosystem are more suitable for the fish than those in the nipa; they also suggest that there is an ecological difference between the native, unperturbed (mangrove) and the perturbed (nipa) biotopes consisting of introduced species.

In brief, the importance of the native mangrove swamp ecosystem to fish and fisheries and richness of other resources, as compared to the introduced nipa palm ecosystem, cannot be over-emphasized. Reports also abound (Moses, 1985; Udo, 2002a, b) that, where the mangrove macrophytes have been removed and/or destroyed, fin and shellfish output has declined considerably. Thus, the mangrove swamp creek is a biotope typified by better living conditions for biota. Efforts and supporting policies are needed to maintain and protect the original ecosystems in the Niger delta area (Udo *et al*., 2008).

References

Angemeier, P. L. 1982. Resource seasonality and fish diets in an Illinois stream. *J. Env. Biol. Fish.* 7 (3): 251 – 264. Darwin, C. R. 1874. The descent of man and selection in relation to sex. Pp,. 275,332. John Murray, London.

Ekundayo, J. A. 1985. The challenges of the mangrove ecosystem. *In:* Mangrove ecosystem of Niger Delta. Proceedings of a workshop (ed. By B. H. R. Wilcox and C. B. Powell). University of Port Harcourt, Port Harcocurt, Nigeria. 357p.

Hyslop, E. J. 1980. Stomach contents analysis. A review of methods and their application. *J. Fish Biol*. 17, 411-429.

King, R. P. and M. T. Udo. 1997. Vegetational sucession mediated spatial heterogeneity in the environmental biology of *Periophthalmus barbarus* (Gobiidae) in the estuarine swamps of Imo River, Nigeria. *Netherlands J. Surf. Min. Reclam. Env.* 11: 151-154.

Moses, b. S. 1985. Distribution, ecology and fisheries potential of Nigeria wetlands. *In:* Nigeria Wetlands (edited by Akpata, T. V. I. and D. U. O. Okali). Printed by Offset Lithography, Ibadan. 167p.

Schoener, T. W. 1971. Theory of feeding strategies. *J. Ann. Rev. Ecol. Syst*. 2: 269-404.

Udo, M. T. 2002a. Morphometric relationships and reproductive maturation of the mudskipper, *Periophthalmus barbarus* from subsistence catches in the mangrove swamps of Imo Estuary, Nigeria. *Journal Environment Science.* Vol. 14, No. 2, 221-226.

Udo. M. T. 2002b. Trophic attributes of the mudskipper, *Periophthalmus barbarus* (Gobiidae: Oxudercinae) in the mangrove swamps of Imo River estuary, Nigeria. *Journal of Enviromental. Sciiences* Vol. 14, No.4: 508-517.

Udo, M. T., A. W. Akpan and A. O. Ekwu. 2008. Observations on the indices of fecundity of the mudskipper, *Periophthalmus barbarus* [Gobiidae] in the Qua Iboe River estuary Southeastern Nigeria. *Ecol. Env.& Cons*. 14 [2-3]; 255-262.

Mangroves v1.0: a new taxonomic tool to characterize mangroves
The case of South East Indian and Sri Lankan mangroves and potential application to African mangroves

Juliana Prosperi[1] , Pierre Grard[2] and Denis Depommier[3]

Summary

In this paper we present an innovative tool for plant identification conceived to reinforce the national capacity building in taxonomy. We introduce ***Mangroves v1.0****, built up on a species identification system called IDAO (Identification Assistée par Ordinateur). This software allows the identification of 50 mangroves species of South East India and Sri Lanka, with the perspective to adjust and extend to other of the world. This software provides and facilitates dissemination of scientific and traditional knowledge. Corollary, it appears as a good support to training, research and development actions and its applications, from awareness to practical management of trees and the ecosystem, could benefit African mangroves and contribute to their renewed interest.*

Introduction

Ecological and socio-economic importance of mangrove trees and forests has been largely acknowledged in various coastal areas of the tropical zone, especially in Asia and Africa where mangroves are the most extensive (21 and 39 %, respectively of the world mangrove area, FAO, 2007) and rich in plant and animal species.

In these areas, they notably contribute in the protection of the marine and terrestrial environment and are a major source of food, fuel, timber, fodder, medicine, etc, for the local communities -especially fishermen who are among the poorest people (Dahdouh-Guebas *et al*., 2006). Mangroves in the Tropics are also characterized by a high human pressure and their poor management: overexploitation, of the trees notably, conversion of mangroves to other land use systems (prawn ponds, rice and salt fields…), pollution, etc.

Adequate legislation – or effective application of it - to protect, conserve and manage the mangrove in a sustainable manner are still missing in many African countries. On the other hand, although important studies have been carried out during these last decades to better know about the unique and fragile ecosystems these mangroves constitute, a lot remains to be done regarding their functioning and dynamics, in relationship with their exploitation and the possible impact of climatic changes. Therefore, scientific knowledge is needed to guide and rationalize the management of mangroves, their exploitation and reforestation, and adequately preserve their biodiversity.

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Finally, available information is not sufficiently disseminated, and the existence of several local languages makes the task more difficult (Taylor *et al.*, 2003). In this framework, lack of species identification capabilities is a major handicap for implementing the measures recommended by the Convention on Biological Diversity (CBD) in many parts of the world. The drastic reduction in the number of taxonomists throughout the world and the irremediable loss of their knowledge has made the task more difficult for ecologists and non specialists. This 'taxonomic impediment' is a serious issue hindering the full implementation of the CBD.

In mangrove ecosystems, one of the most urgent needs, despite major contributions from great diversity of disciplines (ecology, eco physiology, hydrology, soil science …), remains the identification and education on species biology. Without knowledge base containing information on this particular flora, one cannot assess its biodiversity and define priorities in terms of species conservation and, as a whole, sustainable management of mangrove.

To answer this challenge, at least partly, we conceived ***Mangroves v1.0*** that was built up on a species identification system called IDAO (*Identification Assistée par Ordinateur*, Grard, 1996). It was applied to the mangrove of South East India and Sri Lanka - with the perspective to adjust it and extend it to other mangroves of the world.

Mangroves v1.0 (Prosperi *et al.* 2005*)* was developed by the French Agricultural Research Centre for International Development (CIRAD) in co-operation with the French Institute of Pondicherry and the University of Andhra, India, and the University of Ruhuna in Sri Lanka, partners in the European funded project "Assessment of mangrove degradation and resilience in the Indian subcontinent: the cases of Godavari Estuary and South-West Sri Lanka".

Materials and methods

Classical keys for plant identification are difficult to use for non specialists. Their systems are mainly based on flower characters (not always easy to obtain when collecting samples), use technical terms and they impose the choice as well as the order of questions to obtain the identification.

IDAO is different from other computer-based species identification systems because

- It uses only drawings instead of technical jargon and provides users the freedom to choose the character that needs to be described.

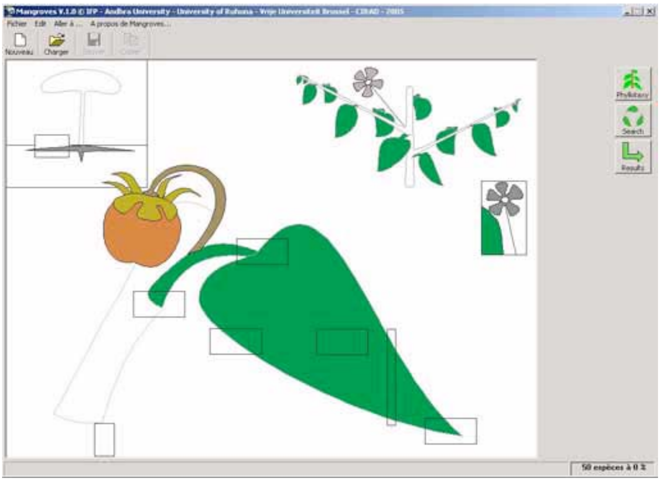

Figure 1: Mangroves v1.0 user interface

- Missing information or data are permitted, thus allowing for the identification of incomplete samples.
- A certain level of observational error is also tolerated and, at each step of the identification process, a probability of resemblance is calculated for each species. Thus, species are sorted by decreasing order of similarity.
- The users can access the photos, the description and the botanical illustrations of the species at any moment. In case users encounter doubt in the choice of characters (for description), they could ask the program for the most pertinent one. If the probability of a species identified is less than 100 per cent, the program indicates the characters that contain observation errors by the user.
- The descriptions of the species can be available through the Internet website with any type of browser.

Results

The identikit

In this article we will concentrate only on the characteristic of the "identikit" that is quintessential to the software. It comprises all the characters and all the states of these characters and helps the end-user to cross-match any character to any others, making all kinds of combinations possible. The realization of the "identikit" requires a fine expertise of the botanical characters between listed species in order to select the most pertinent vegetative and sexual ones. It uses a graphic interface based on a system of layers, which reconstitutes the plants using vectorized drawings. For *Mangroves v1.0* we have analyzed and drawn 108 botanical characters states belonging to 15 characters, representing the different layers (Table 1), and 5400 drawings necessary to identify 50 species of mangroves. These species belong to 34 genera and 26 families; they cover proper and associates mangroves species.

Table 1: Identikit characters of Mangroves v1.0

1- Habit	9 - Stipule types
2 - Roots	10 - Leaf or leaflet apex
3 - Pneumatophores	11 - Leaf or leaflet base
4 - Leaves arrangement	12 - Leaf or leaflet margin
5 - Leaves types	13 – Leaf or leaflet section
6 - Inflorescences	14 - Venation
7 - Flower colour	15 - Exudation - Sap
8 - Fruit types	

The identikit is organised around three zones represented by three main drawings of the interface: the habit, the stem with leaves and a closer view of the leaf and fruit. These drawings are simple, generic and theoretical in order to be easily comprehensible by the users, and help them in the process of plant identification. We have privileged the vegetative characters (80% of all characters, mainly linked with leaves and stems) because they are always present and more accessible than sexual ones.

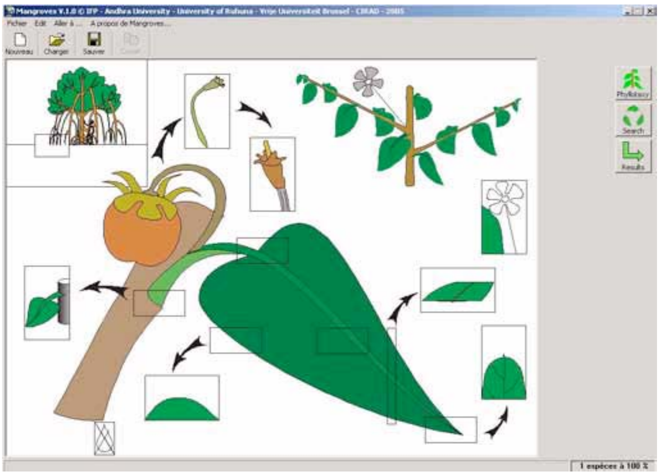

Figure 2: Mangroves identikit for the identification of one species of Rhizophora

This system allows the user to access of these characters by three ways of "point and click":

- the rectangles represented on different organs of the plants
- the colours covering bigger surface in the identikit
- the buttons placed at the right side of the identikit

During the process of identification, the user clicks on the identification screen drawings to select one character corresponding to the plant he/she wants to identify. The software based on the calculation of similarity coefficients, provides a probability of similarity calculated for each species.

The users can access the photos, the description and the botanical illustrations of the species at any moment during the process of identification. Among 50 species, the users can learn more about botanical aspects checking with more than 500 pictures and 21 botanical plates. The description file of each species includes information about: diagnostic characters, botany & morphology, regeneration, reproductive biology, ecology, distribution and uses (see http://umramap.cirad.fr/amap2/logiciels_amap/Mangrove_web/Mangrove_list.html). All the technical terms used in the description file are highlighted and, at a click, a hypertext illustrated definition is accessible.

Mangroves v1.0 is available on CD-ROMs for personal computer platforms, through the net and we are working towards developing an open source web-based application in a Scalable Vector Graphics (SVG) format (see http://www.ifpindia.org/Identification-des-plantes-de-mangroves.html).

Conclusion and perspectives of application to African mangroves

The many students, scientists and development agents who used the taxonomic tool ***Mangroves v1.0*** we developed for the mangroves of South-East India and Sri Lanka found it innovative, easy to operate and appreciated very much its interactive iconographic component allowing the user to quickly get a reply in an illustrative and educative manner.

The identikit – and its discriminating process to identify a species- is certainly the most original part of the software, thanks to its graphic interface. And at any moment, comprehensive information on each of the 50 mangrove species can be accessed independently from the important data base we constituted.

An interesting point related to the capacity of this software and the constituted data base is the integration of both scientific and traditional knowledge – of which the multiple uses of the species. The restitution is voluntarily given in a synthetic way (species description files), but could be developed, enriched or corrected, if needed, in next versions of ***Mangroves v1.0***.

Since Ellison (2000), and others before him, reminded us the need for mangrove information clearing houses, development of international databases and improved communication among researchers, managers, planters and residents, making use of the world wide web and related information technologies, ***Mangroves v1.0*** appears as an appropriate contribution to this challenge. It notably may help managers in planting a larger number of tree species as planting methods in mangrove restoration projects focus on only a few species – hence allowing, through improved richness, to get more products and services and better conform to the original ecosystem.

From this South Asian experience, and considering the advantages of this tool in terms of information exchange, learning and capacity building, support to research and decision making for the restoration and management of mangroves, one could favourably extend its application to other mangroves and notably to African mangroves which are among the most degraded and are locally very much endangered where they have not vanished. Incidentally, ***Mangroves v1.0*** covers most of the mangrove species of Africa, and all the 16 East African and Middle East species identified by Spalding *et al*. (1997) and Saenger (2002).

Practical applications of this tool to African mangroves, through appropriate development of its data base and integration of specific information could include:
- awareness on environmental and socio-economic importance of mangroves tree and ecosystem;
- diffusion and popularization of tested techniques of tree plantation and mangrove rehabilitation;
- integration of scientific and traditional ecological knowledge with the view to promote best practices of management and long term values of the ecosystem;
- large dissemination, worldwide and notably African wide, of the data collected, processed and made available through networking, exchanges of information, case studies, etc;
- policy, rules and regulations regarding mangroves, along with information for decision makers.

The very structure of the Web (Internet, notably) offers new opportunities for information organization and provide universally accessible, hyperlinked, multimedia information, and offer an appropriate niche for the development of this tool and its various applications.

In the perspective of a renewed interest in African mangroves and to initiate the process, major issues such as baseline information needed for environment impact assessment and management plans, dissemination of information and education, could be discussed through workshops with the assistance of international organizations, like FAO, and concerned stake holders. In this framework, ***Mangroves v1.0*** could be presented and discussed for its possible development and applications in Africa.

References

Dahdouh-Guebas F., Collin S., Lo Seen D., Ronnback P., Depommier D., Ravishankar T. & Koedam N. *2006. Analysing ethnobotanical and fishery-related importance of mangroves of the East-Godavari Delta (Andhra Pradesh, India) for conservation and management purposes***.** Journal of Ethnobiology and Ethnomedicine*, 2(4), 1-22.*

Ellison A.M. 2000. Mangrove restoration: Do we know enough? *Restoration Ecology* 8(3), 219-229.

FAO. 2007. The world's mangroves 1998-2005. A thematic study prepared in the framework of the Global Forest Resources Assessment 2005, Forestry Paper 153, Rome, 77 p. http://www.fao.org/docrep/010/a1427e/a1427e00.htm.

Grard P. 1996. Contribution à la méthodologie de l'identification des plantes assistée par ordinateur, Université Montpellier II, Montpellier, France (Thèse de doctorat).

Prosperi, J., Ramesh, B. R., Grard, P., Jayatissa, L.P., Aravaly, S., Depommier, D., 2005. Mangroves v1.0: A multimedia identification system of mangroves species [CD-Rom]. Pondichéry: IFP / CIRAD. (Collection Ecologie, vol. 52). http://www.ifpindia.org/Identification-des-plantes-de-mangroves.html

Saenger P. 2002. Mangrove Ecology, Silviculture and Conservation. Kluwer Academic Publishers. Dordrecht, Netherlands. 360 p.

Taylor M., Ravilious C. & Green E. P. 2003. Mangroves of East Africa UNEP, WCMC Biodiversity series N°13, 24 p. http://www.ourplanet.com/wcmc/pdfs/mangroves.pdf.

Spalding M.D., Blasco F. & Field C.D. (Eds). 1997. World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan. 178 pp.

COUNTRY FOCUS: Madagascar

Hajanirina Razafindrainibe[1] talks to Nature & Faune

Madagascar (Malagasy Republic) in the Indian Ocean is the world's 4th largest island (after Greenland, New Guinea, and Borneo) covering 587,931 square kilometres. According to Aditya Maheshwari and Ricketts[2] Madagascar has a population of about 17 million people, the population growth rate is 3.03% and about 88% of the people work in the agriculture sector with 13.5 million people living on only what they produce in farms. In terms of wildlife, about 85% of the animals in Madagascar only exist in Madagascar. There are 8 species of Carnivores on the island and 40 species of flightless birds. The country has the third largest mangrove forests in Africa. Between year 2000 and 2005 the annual change in forest cover: -37,000 ha; Annual deforestation rate: -0.3%. Change in deforestation rate since '90s: -41.9%; Total forest loss since 1990: -854,000 ha and total forest loss since 1990:-6.2%[3].

To obtain better insight on the relevance of Mangrove forests to Madagascar's wildlife, water resources and fisheries, *Nature & Faune* interviewed Hajanirina Razafindrainibe, a technocrat in SAGE (Service d'Appui à la Gestion de l'Environnement) Madagascar.

Nature & Faune: What is the extent and diversity of the mangrove ecosystem in Madagascar?

Hajanirina* Razafindrainibe*: Madagascar has about 320,000 ha of mangroves, with only 8 species. Ninety eight percent of the mangroves are along the west coast of the

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[2] *Websites: http://www.freewebs.com/madagascar-wildlife/aboutmadagascar.htm of 5th August 2009 http://www.wildmadagascar.org/wildlife/; http://www.wildmadagascar.org/; http://www.cactus-madagascar.com/madagascar-wildlife/madagascar-wildlife-flora.htm; http://animals.jrank.org/pages/3068/Mongooses-Fossa-Herpestidae-DIET.html http://www.thewildones.org/Animals/lemur.html) Travel guide- Ottawa Citizen. Books: Cultures of the world Madagascar, Jay Heale; Madagascar, Mary N. Oluonye.*

[3] *FAO. 2005b. State of the World's Forests 2005. Rome (also available at www.fao.org/docrep/007/y5574e/y5574e00). http://rainforests.mongabay.com/20madagascar.htm*

country and can be grouped into two major types: estuarine mangroves localised in bay entrances, river mouths and deltas and the second type is the coastal mangrove which develops in areas inundated by fresh groundwater.

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Nature & Faune: How do the mangrove forests impact on the fishery, water resources and wildlife sectors in Madagascar?

Hajanirina* Razafindrainibe*: Mangroves are extremely rich ecosystems and play key roles for various aquatic and terrestrial species. They serve as nurseries and or habitat for many marine and estuarine species, such as the peneid shrimp, mud crab, numerous fish species and molluscs, thus their existence and health are amongst key conditions for the regeneration of these resources. For Madagascar, shrimp fishery is the most important country-based commercial fishery and contributes significantly in to the country's foreign exchange earnings. At international level, demand for mud crab has increased considerably over the past 10 years. Even if their distribution is not restricted to mangrove forests, some endemic and or threatened birds use these ecosystems as refuge or feeding areas; examples of such birds include the ankoay (*Haliaeatus vociferoides*), the vivy (*Anas bernieri*), the heron cendré. The Nile crocodile (*Crocodylus niloticus*) is still seen in some delta mangroves, while wild boars seek shelter in mangrove edges in deforested areas. Mangroves have other critical functions in protecting coasts against marine erosion, fixing sediments from upstream erosion thus protecting coral reefs from sedimentation, regulating water flows thus protecting the landscape in times of floods.

Nature & Faune: Are there any unique characteristics displayed by Madagascar's mangrove forests as compared to those in other parts of the tropics?

Hajanirina* Razafindrainibe*: It is difficult for me to say that our mangroves have unique characteristics as I am not quite sure I know other countries' mangroves. However, I think that the extent of coastal mangroves developing in areas where fresh groundwater regularly inundated the trees is quite low. Also, I think that Madagascar has the mangrove sites at lowest latitude in the area. If mangroves dynamics can be categorized in terms of siltation and site eutrophication, I would say that in Madagascar we observed a natural recovery of a mangrove site after many years of complete degradation!

Nature & Faune: Tell us briefly about the major research carried out in the Madagascar mangrove ecosystems. What are the research needs for this ecosystem?

Hajanirina* Razafindrainibe*: Not so much research have been done in Madagascar mangroves compared to other ecosystems such as the rainforests; but we can list among major research carried out: mangrove mapping, mangroves structure and biogeography, ornithology (birds inventories), stock assessment and biology of commercial marine resources (shrimp, mud crab); wood availability assessment, fisheries.

My view is that, research should now be extended to assessing various aspects of mangrove ecosystem namely: (i) the capacity of mangroves to regulate pollutant flow from a variety of sources (pesticides, waste waters from coastal industries etc.); (ii) the regeneration capacity in the context of charcoal production and fuel wood use; (iii) the unexpected recovery from extremely degraded condition; (iv) dynamics of mangroves in-country. In addition there should be more focused studies and inventories for ecotourism purposes. Attention should be paid to the importance of mangroves for endemic and migratory birds. Coastal communities in some areas report the presence of silk worms which were exploited "years before" for thread production for feeding the looms; their stocks should be assessed for their eventual valorisation.

Nature & Faune: What are the challenges in protecting, conserving and sustainably utilizing the mangrove forests in Madagascar?

Hajanirina* Razafindrainibe*: I think that the major challenges are containing the pressure on mangroves resulting from: the urban demand for household energy (fuel wood, charcoal), conversion into rice fields, urbanization including demand in land for building, infrastructure (roads), and sand dune progression. To some extent, coastal demand in timber wood may also become a challenge specifically as natural forests are depleted in many areas. Cattle grazing were also reported to having contributed to mangrove degradation in the South of Madagascar. Sometimes popular perception can lead to mangrove destruction such as a case in the South where the communities considered mangrove as home to mosquitoes and, thus, source of malaria, and simply cut them down. But a common challenge I would stress is the inadequate enforcement of regulation due to weak forestry administration, as access to mangrove sites are mostly difficult. And not least, it seems that the discovery and extraction of potentially high value gems (diamantoids) in close proximity to mangrove ecosystems threatens the mangrove.

Nature & Faune: What are the management objectives for the mangrove forests in Madagascar and how are they enforced? What practical steps has the administration taken (or plan) in safeguarding the country's mangrove forests? Are there any governmental regulations at the community, industry and private levels?

Hajanirina* Razafindrainibe*: Overall, management objectives for mangroves tend to focus on conservation and non extractive valorisation. Mangrove ecosystems are classified as sensitive areas in Madagascar, thus, at industry level, any investment that may impact on them is submitted to the completion of a full EIA. Efforts to establishing protected areas are intensified, some sites being classified as of critical or national importance, while some remain at a lower level. Along side with protection and whenever possible, ecotourism is developed in and around these protected areas to add an economic and social sense to this protection. Madagascar is also promoting contract and community-based management of natural renewable resources through an official transfer of management to local communities. The contract includes a simplified management plan drawn in participatory manner by communities and approved by the Department of Forestry and or Fisheries.

The law on Secured Local Management (GELOSE) has been in operation since 1996. GELOSE is originally a French acronym for "Gestion Locale Sécurisée". The word has been widely adopted by local communities to refer to transfer of natural resources management authority from government to local resident populations or community based groups. This law concretises community empowerment, as the Government's managerial role is officially transferred to communities that apply for it. To be eligible, a community has to be legally formalised as a "local resident community group" (communauté locale de base) whose constitution must respect three principles: (i) residence/proximity to the resources (all members must be resident in the area of the resource location); (ii) voluntary and (iii) non discrimination (all community members fulfilling the two previous criteria cannot be discriminated against). The first contract runs for three years, after which an evaluation is carried out and the contract can be renewed for ten years if performance is satisfactory. The contract is usually signed between the "local resident community group", the District and the Government represented by Forestry and or Fisheries Administration. Since the introduction of the GELOSE law there has been an increase in the awareness of the importance of mangroves and the requisite skills for managing it sustainably.

Nature & Faune: How are the other stakeholders (including the indigenous inhabitants of the mangroves) responding to the challenges of protecting, conserving and sustainable use of the mangrove ecosystem in the Malagasy Republic?

Hajanirina* Razafindrainibe*: I think that, overall, stakeholders and people are responding positively specifically to mangrove protection, except those whose livelihood is based on charcoal production. Most of marine protected areas include the adjacent mangroves; and mangrove is the first ecosystem that coastal communities want transferred under their management. In northern Madagascar for example, all mangrove sites are managed by local communities with or without a contract of transfer of management. The reason why coastal communities apply for transfer of management of mangroves is that they believe mangroves play a key role in marine stock regeneration. And these are resources upon which their livelihoods depend on. Mangrove restoration has become common. We can assume that the extent of mangrove forests have not decreased (since the empowerment of communities despite some extractive use), as compared to other forest ecosystems. This fact demonstrates the high level of success achieved by this change in management approach.

Notwithstanding the successes achieved by the indigenous inhabitants, it is still common practice to see conversion of mangrove sites into hotel resorts or private residence in many coastal cities. Cutting of mangrove trees for fencing poles is another popular culprit for decimation of mangrove ecosystem in Madagascar.

Nature & Faune: What lessons has Madagascar learned so far with regards to management of its rich mangrove forest heritage?

Hajanirina* Razafindrainibe*: Establishing a social and economic sense for protection helps a lot to achieve a stronger commitment from local communities. Developing mangrove-based market channels strengthened this attitude. Mangrove protection and conservation should be undertaken at a "large" scale to avoid shifting of pressure. Communities and individuals should be informed about specific species that are found in these ecosystems, and the various roles this ecosystem plays in their wellbeing and livelihoods.

Nature & Faune: Thank you Haja, for discussing these pertinent issues with Nature & Faune.

Dying Mangroves on the North East Coast of Africa: the case of Sudan

Michel Laverdiere[1]

Background

Sudan is the largest country in Africa with a population currently estimated at 41 million people. Its GDP per caput is around US $ 2 000. The country's revenues are largely dependent on petroleum production and also on industries, agriculture and livestock. This country has a relatively long border with the Red Sea, which maintains a few hectares of mangroves; the main species being *Avicennia marina* (Figure 1).

Figure 1. Mangroves in Red sea area of Sudan

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The FAO Subregional Office for Eastern Africa (SFE) is based in Addis Ababa Ethiopia. It provides expertise in the main sectors of FAO: Agriculture, Livestock, Fisheries, Forestry, and Natural Resources. SFE is mandated to provide expertise and resources to 8 countries: Burundi, Djibouti, Ethiopia, Kenya, Rwanda, Somalia, Sudan and Uganda

The general marine water and fisheries situation

The marine fisheries of Sudan are less developed, although waters within the jurisdiction of Sudan on the Red Sea contain a diverse assemblage of fauna and flora. Cartilaginous fishes include 30 species of sharks and 21 species of skates and rays. The reported bony fishes amount to 250 species. Molluscs and crustaceans (shrimps) are of commercial importance. Over 90 species of coral have been recorded in the fringing reefs, barrier reefs and atolls, in addition to other resources. Current exploitation emphasis is focused on finfish, mollusks and crustaceans. Apart from finfish, no stock assessment data is available for these resources. Fishing activities are primarily confined to coastal areas in lagoons and bays, boat channels, fringing reefs and the outer barrier reef. Recent annual finfish landings amount to 5 000 tons out of an estimated potential of 10 000 tons/year. Wild mollusk production is in the area of 450 tons/year. Statistics on shrimp catches are rather discordant, suggesting an estimate that does not exceed 20 tons/year while foreign trawlers operating under license agreements harvest some 130 ton/year. Mangroves are important for the production of sea food including crabs (Bage et al, 2009)

The forestry situation

Sudan is home to a variety of forest ecosystems. The North is largely desert; a relatively small area is covered by thinly stocked savanna woodland, with some tree plantations of mostly Acacia and Eucalyptus species. The South is more forested and still has significant forest resources in dense savanna woodlands. The main problem in the North is lack of trees for construction and energy. For the latter, small cookers operating on LPG gas are used as substitute, thereby alleviating the pressure on wood extraction. However fuel wood is still necessary for the poor segment of the population and also for the production of charcoal. A major issue for the management of the forest resources is the need for an updated forest inventory. The country also needs to improve the control of the invasive Mesquite (*Prosopis chilensis*) and the management of its mangroves.

The mangroves

There are about 500 hectares of mangroves left, scattered on the Red Sea Coast over hundreds of kilometers, both North and South of Port Sudan, the capital of the Red Sea State (Forestry National Corporation of Sudan, Khartoum). In general these mangroves are small stands of trees (Avicennia sp) left in a very degraded state (Figure 2). Very little attention is being paid to these mangrove stands consequently over- grazing by camels and wood cutting for fuel wood have become the norm. Moreover there is also the practice of stoppage of the flow of fresh water to the mangroves perpetrated by salt production companies, highway construction firms and by communities that build dams to collect fresh water. The impacts of this practice need further investigation. It appears that the majority of mangroves are under threat and are likely to disappear in the coming decade.

Another cause of degradation of mangrove in Sudan is linked to fishermen fishing for Sea Cucumber who collected firewood from mangrove forests for processing the catch. At present, however, fishing for Sea Cucumber is prohibited in Sudan.

Figure 2: Mangrove forest in degraded condition in the Red Sea State of Sudan

Mangroves play crucial ecological role in coastal ecosystems by protecting against tropical rain storms, anchoring the shifting mud and thus preventing erosion of coastal land and providing shelter and habitat for fish and other marine life. Mangrove also contributes to offshore fisheries by acting as nurseries and shelter. In India it is estimated that 60 per cent of economically important fish resources breed in the mangroves and that prawn and shrimp catch at sea is seen to be directly proportional to mangrove area. In Sudan the shrimp resource is at present mainly exploited by Egyptian trawlers working under license agreements. This represents the most important source of foreign currency income in the fisheries sector. Additionally mangrove is the habitat for the Mangrove Crab, a high value species collected by hand by the fishing communities and sold to restaurants and super markets.

There had been a project on coastal management (PERSGA), funded by Saudi Arabia which tried to improve the conservation of mangroves. However it ended in 2005 without resolving the many issues causing the degradation of mangroves. There seems to be some difficulty in getting the many stakeholders (camel owners, Port Sudan Harbor Authority, Sea salt producers, fishermen) to agree on the mangrove ecosystem management and the result is the absence of a management regime and consequently a lack of sustainable use of the resource.

A vision for better management of Sudan's mangroves

Mangroves are an important transition ecosystem between the land and the sea; they play a capital role on fisheries, water purification and coastal protection, as well as source of fodder and fuel wood. Despite being scarce, in a poor state and dwindling in area, the

Food and Agriculture Organization of the United Nations (FAO) finds it important for Sudan to conserve, improve and sustainably manage its mangrove resources.

FAO is committed to providing technical support to Sudan, and to learning from previous experiences to strengthen national efforts in the development of mangroves. As a knowledge-based Organization, FAO's role will include drawing from project experiences in neighbouring Egypt to assist Sudanese authorities and other stakeholders to sustainably manage mangrove ecosystem resources along the Red sea.

References

Mangrove Conservation and management in the Sudan, GCP SUD 047 INT, Ministry of Environment and Tourism, FAO, Khartoum 1995

Ahmed, K.M.S. Mangrove on the Sudanese Coast, Red Sea University, 1999

Bage, H., Malo. M and Laverdiere, M. Unpublished document 2009. Forestry National Corporation of Sudan, Khartoum.

FAO Supports Management of Mangrove Ecosystem Biodiversity in Cameroon

FAO Representation in Cameroon executed a project on the participatory management and conservation of mangrove ecosystem biodiversity in Cameroon. Within the framework of this project, studies were carried out on two major mangrove sites in the country namely Ndongoré (Rio Del Rey Estuary) and Douala-Edea (Cameroon Estuary). The project was implemented from January to December 2005, at the end of which the cartography of the mangrove areas in Cameroon was produced as well as a policy and strategy document for the participatory management of mangrove ecosystems in the country. In addition, a project proposal on the sustainable management of mangrove ecosystem for the Central African sub region was prepared and is awaiting implementation upon availability of funds.

For detailed information on this project, please contact: *FAO Representation in Cameroon. P.O. Box 281, Yaoundé. Physical address: 335 Rue 1810 Bastos, Yaoundé Cameroon. Email FAO-CM@fao.org Telephone: +237 22211242; +237 7486009*

LINK

The African Mangrove Network (AMN)
The African Mangrove Network (AMN) was established in Cameroon in May 2003. Its mission is to foster regional collaboration to save African mangroves from further destruction and to collectively work to bring the mangrove agenda to the fore in national and international arenas. Current membership comprise 22 countries, including; Mauritania, Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon, Sao Tome& Principe, Congo, Democratic Republic of Congo, Angola, Kenya, Somalia and Tanzania.
For details, visit: http://www.mangrove-africa.net
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Status and conservation of mangroves in Africa
Ajonina G., Ndiame, D. and Kairo, J. 2008. Current status and conservation of mangroves in Africa: An overview. *World Rainforest Movement Bulletin 133*.

Mangrove information at FAO
Websites: http://www.fao.org/forestry/mangrove/en/

Commemorating the International Day for the Mangroves – the history!
In 2000, July 26th was first chosen as a day for the mangroves based on its great significance for the movement in Latin America led by Red Manglar (Mangrove Network). July 26th commemorates that day in 1998 when a Greenpeace activist from Micronesia, Hayhow Daniel Nanoto, died of a heart attack while involved in a massive protest action led by FUNDECOL and Greenpeace International. During this action the local community of Muisne joined the NGOs in dismantling an illegally built shrimp pond in an attempt to restore this damaged zone back to its former state as a mangrove forest. Since Hayhow's death, FUNDECOL and others have commemorated this day as a day to remember and to take renewed action to Save the Mangroves! In 2003, MAP (Mangrove Action Project) and Red Manglar joined forces to encourage fisherfolk from around the world to join them on Mangrove Action Day to form cooperative flotillas to protest the destructive expansion of shrimp farming in their areas. This call to action got positive responses from Bangladesh, India, Malaysia, Ecuador, Brazil, Colombia, Mexico, Honduras, Nigeria, Senegal, Kenya, Europe and the USA. Since then, every July 26th has become an annual global commemorative day for the mangroves. *Article based on information by Alfredo Quarto, Mangrove Action Project (MAP), e-mail: mangroveap@olympus.net, http://www.earthisland.org/map/map.html*
Source: WRM's bulletin Nº 109, August 2006
For full article, visit: www.wrm.org.uy/bulletin/109/Mangrove.html

Climate Change Shrinks Some of the World's Largest Rivers
Many of the greatest rivers in some of the world's most populous regions are losing water, according to a new study of stream flow in 925 large rivers. Led by scientists at the National Center for Atmospheric Research in Boulder, Colorado, USA, the study indicates that the reduced flows are associated with climate change and could threaten future supplies of food and water. Several of the rivers channelling less water serve large populations, such as the Yellow River in northern China, the Ganges in India, the Niger in West Africa, and the Colorado River in the southwestern United States.
For full article, visit: http://www.ens-newswire.com/ens/apr2009/2009-04-21-01.asp
Link culled from: Environment News Service (ENS) 2009

CITES will meet from March 13-25, 2010, in Doha, the capital city of Qatar
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) governs international wildlife trade. Every two and a half to three years, delegates from more than 170 countries gather together at the Conference of the Parties to CITES to discuss and decide the fate of many of the world's wild species. From March 13-25, 2010, CITES will meet for the fifteenth time, in Doha, the capital city of Qatar.
Link: http://www.cites.org/eng/disc/CoP.shtml
Source: http://www.evana.org/index.php?id=48210&lang=en

New 2009 REDD Paper on: Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements
If global policies intended to promote forest conservation continue to use the definition of "forest" adopted in 2001 by the United Nations Framework Convention on Climate Change (an area of >0.05–1 ha with >10–30% cover of plants >2–5 m tall at maturity), great quantities of carbon and other environmental values will be lost when natural forests are severely degraded or replaced by plantations but technically remain "forests." While a definition of "forest" that is globally acceptable and appropriate for monitoring using standard remote-sensing options will necessarily be based on a small set of easily measured parameters, there are dangers when simple definitions are applied locally. At the very least, we recommend that natural forest be differentiated from plantations and that for defining "forest" the lower height limit defining "trees" be set at >5 m tall with the minimum cover of trees be set at >40%. These changes will help to reduce greenhouse gas emissions from what is now termed forest "degradation" without increasing monitoring costs. Furthermore, these minor changes in the definition of "forest" will promote the switch from degradation to responsible forest management, which will help mitigate global warming while protecting biodiversity and contributing to sustainable development.
Available at: http://www3.interscience.wiley.com/journal/122515795/abstract
Link culled from: Nophea Sasaki, Harvard University. http://harvardforest.fas.harvard.edu/

In the Hand's of the Fishers (IHOF) Workshops

In the Hands of the Fishers (IHOF) is *Mangrove Action Project*'s (MAP) premier program. It was launched in 1999 through a close collaboration with the Yadfon Association of Thailand and the Small Fishers Federation of Sri Lanka.

IHOF is a series of workshops designed to bring together village leaders, fisherfolk, and grassroots NGOs from developing nations where mangroves are found. It is an innovative format which facilitates experience sharing and networking, enhances problem solving, and disseminates solutions and research findings amongst local stakeholders. In addition to the workshops, follow-up projects are undertaken at the participating villages, which then serve as sites or nodes for modeling sustainable, low-intensity development alternatives. Since 1999, MAP has led 12 regional IHOF workshops, involving 3 or more countries each, in Asia, Africa, and Latin America.

Read more at: http://www.mangroveactionproject.org/map-programs/fisher-workshops. Contacts: Mangrove Action Project. P.O. Box 1854, Port Angeles, WA 98362. Phone/Fax: (360) 452-5866. info@mangroveactionproject.org

FAO REGIONAL OFFICE FOR AFRICA

Theme and deadline for Next Issue

The theme for the next issue is *"Natural resource tenure systems and their implication for nature conservation in Africa"*. The upcoming edition is set to explore land, tree and water tenurial issues at the community, national and regional levels, focusing on their practical applications and implications for sustainable nature conservation in Africa.

Security of tenure influences the sustainability of nature conservation measures. It is increasingly taking centre stage in the discussions around REDD (Reducing Emissions from Deforestation and Degradation) as well as a fundamental right to livelihood, especially for the poor. The next edition of *Nature & Faune* seeks to contribute to the debate.

Nature & Faune invites you to submit manuscript(s) on any issue related to the theme. In order to facilitate contributions from potential authors, we have created guidelines for the preparation of manuscripts for Nature & Faune. Short and succinct papers are preferred. Please visit our website or send us an email to receive a copy of the *'Guidelines for Authors'*. Email: nature-faune@fao.org or Ada.Ndesoatanga@fao.org
Website: http://www.fao.org/africa/publications/nature-and-faune-magazine/

Deadline for submission of manuscript(s) and other contributions is 30th December 2009

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