The communal forest, wetland, rangeland and agricultural landscape mosaics of the Lower Tana, Kenya: A socio-ecological entity in peril

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1. Introduction

Kenya is a water-scarce country with an annual renewable supply of about only 650 cubic metres per inhabitant per year and over two-thirds of the country arid or semi-arid (less than 500 millimetres annual rainfall). Kenya is demographically dynamic and characterised by a strong urbanisation trend. As a result, water demand for city and town-based domestic uses, irrigation and industry is increasing rapidly, as is the competition for water between different sectors (often with contradictory policies). The main losers in this equation are the more diffuse rural-based traditional water use (e.g. small-scale agriculture) and the environment. At the same time funding for hydro-meteorological monitoring and analysis and for water infrastructure (including catchment management) is lagging behind while extreme events (floods and droughts) have increasing economic (Mogaka *et al.* 2006), social and environmental costs.

The Tana is the most important river in Kenya in terms of discharge, varying between 90 and 300 cumecs (cubic metres per second) or between 2.7 and 10.2 billion cubic metres per year. The Tana River (figure 1) takes its sources in the highlands (greater than 3000 metres in altitude) of the Aberdares and Mount Kenya just north of the capital Nairobi and flows for about 1000 kilometres to its mouth at Kipini on the Indian Ocean. In the upper catchment the river produces about 70 per cent of Kenya's hydropower which in itself contributes about 70 per cent to Kenya's total electricity output. Once the river descends below 200 metres altitude it meanders through a floodplain that is about 5 kilometres in width and 300 kilometres in length before entering the Tana Delta at Garsen. The last 60 kilometres of these riverine floodplains, situated between the northern limit of the Tana River Primate Reserve (approximately 1° 48' S, 40°8' E) and the Garsen-Witu road bridge over the Tana River (approximately 2°17' S, 40°8'E), are the subject of this case study (figure 2).

2. Study area

The riverine forests, wetlands and surrounding rangelands of the Lower Tana have for centuries constituted a multi-user and multifunctional area of high socio-economic value for a number of indigenous and local communities (Terer *et al.* 2004) and have maintained exceptional biodiversity value. The forests are remnants of the vast Miocene (23-5 million years B.P.) forests that covered Africa from West to East before drier spells, starting around 2.8 million years B.P. (Menocal 2004), split them up into separate blocks that went along their own evolutionary paths, contributing to the high level of endemicity, in spite of occasional reconnections during the wet phases of the Pleistocene. The forests along the Lower Tana are part of the biodiversity hotspot (Myers *et al.* 2000) of the Eastern Arc and Coastal Forests of Eastern Africa (Burgess & Clarke 2000) and therefore a global conservation priority.

The forests are characterised by the presence of numerous endemic or restricted-range species of plants (Luke *et al.* 2005), primates (Jong & Butynski 2009), birds (Owino *et al.* 2008), amphibians and reptiles (Malonza *et al.* 2006) and without doubt of other taxonomic groups that have so far been insufficiently studied. The Lower Tana River itself also harbours a number of endemic fish species (Seegers *et al.* 2003). What characterises these wetland forest ecosystems is their functional dependence on floods (Andrews *et al.* 1975) for forest regeneration and productivity (Hughes 1990), groundwater recharge, deposition of fertile loams and clay that constitute an agricultural

Figure 1. Kenya and the Tana River with as an inset the study area (adapted from Maingi and Marsh 2002)

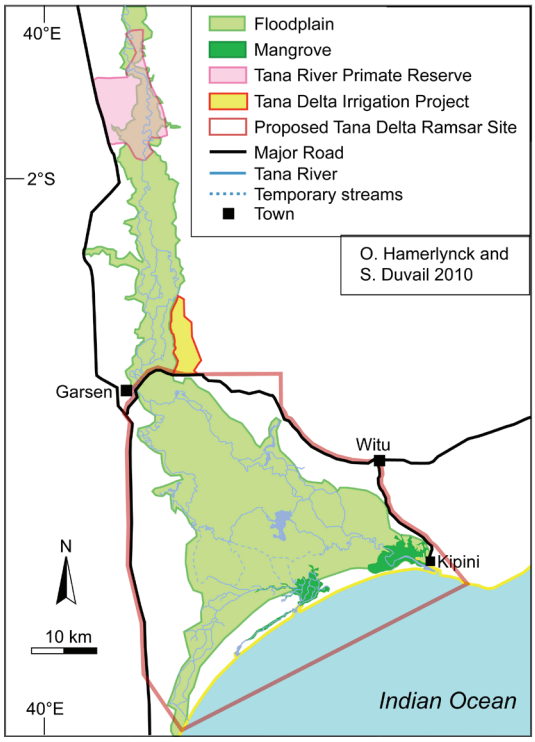

Figure 2. Map of the Lower Tana Floodplains and Delta

resource, fisheries productivity, etc. Thus the flooding regime is key to the ecosystem services they provide for human well-being.[1]

The riverine forests cover only an estimated 2600 hectares (Mbora and Meikle 2004b) and are of a very patchy nature with about 70 separate entities recognized. The forest patches range from 1 to 500 hectares but most are less than 50 hectares and they are separated by agricultural land, grassland and bushland. Five main vegetation types are recognized in the forest (Hughes 1990):

- evergreen forest on sandy levees, characterised by *Ficus sycomorus*, *Sorindeia madagascariensis* and *Sterculia appendiculata*
- evergreen Acacia forest at the outer limit of the forest belt, characterized by *Acacia eliator*
- clay evergreen forest on moist floodplain soils dominated by *Diospyros mespiliformis* and *Garcinia livingstonei*
- point-bar vegetation on the low-lying sandy inner banks of meanders developing into *Populus ilicifolia* forest
- oxbow pioneer vegetation dominated by *Terminalia brevipes* and/or *Spirostachus venenifera*.

[1] Based on the findings of the Millennium Ecosystem Assessment (2005), human well-being can be defined as the freedom of choice and action to achieve basic material for a good life, health, good social relations and security. Well-being is at the opposite end of a continuum from poverty, a pronounced deprivation in well-being.

Over 300 plant species have been recorded from the forests of which about 60 are tree species and two of those are considered globally endangered (*Cynometra lukei* and *Megalochlamys tanaensis*). Over 20 per cent of the plant species are of conservation concern and six are considered globally vulnerable: *Oxystigma msoo*, *Angylocalyx braunii*, *Dalbergia vaciniifolia*, *Chytranthus obliquinervis*, *Diospyros greenwayi* and *Pavetta linearifolia* (Luke *et al.* 2005).

The flagship conservation species in the area are two endangered primates (Jong and Butynski, 2009): the Tana River Red C*olobus Procolobus rufomitratus rufomitratus* and the Tana Mangabey *Cercocebus galeritus* (estimated population size of about 1200 individuals). In 1976 an area of about 17,000 hectares of floodplain and adjacent terrace was gazetted as the Tana River Primate Reserve (TRPR), primarily to conserve these species.

Administratively the study area is situated in the Coast Province but a substantial proportion of the rangelands with which it strongly interacts through mobile livestock and pastoralists is in the North-eastern province, in particular the Ijara District. The floodplains and forests of the study area are in the former Tana River District (38,782 square kilometers, 232,488 inhabitants, average 6 inhabitants per square kilometer). This district was recently split into three separate districts:

- the southern Tana Delta District (of which the Garsen Division covers part of the study area)
- the central Tana River District (with most of the study area in the Wenje Division and a lot of the western rangelands in Galole Division)
- the northern Bura District.

Statistics are not yet available for the separate new districts so reference will be made continuously to the "Greater Tana River District", comprising the three new districts. The southeastern part of the study area is adjacent to the rangelands of the northern part of Lamu District. All these areas are highly

Lower Tana landscape with oxbow lake, forest, floodplain grassland and river branches

food insecure because of erratic rainfall. Arable land in the Tana River District is only three per cent of total surface area with the rest rangelands. Some 35204 hectares of land in the district has been equipped for irrigation but virtually all these large-scale highly centralized projects have not been operating properly for many decades and only 700 hectares was cultivated in 2009 (Ngumbi *et al*. 2009). In addition to conceptual, technical, and institutional deficiencies the main cause of failure is generally poor governance e.g. for the 100 million $US resettlement/ irrigation scheme in Bura (Ledec 1987, Maingi and Marsh 2006, Mwega 2008).

Both provinces, coastal and north-eastern, are characterised by very low indicators of human well-being with particular stresses caused by biodiversity loss and limitations on food production, water and fuel supply (Wong *et al*. 2005). Human Development Indices (HDI) in the area are among the lowest in Kenya. For example, within Coast Province the average HDI is 0.518, very close to the national average of 0.532, but the Tana River District ranks last with 0.307 (e.g. adult literacy rate is only 43 per cent, while the national average is 69 per cent). Similarly, Gender-related Development Index (GDI) is abysmally low with 0.378 compared to the 0.539 average for Coast Province and 0.627 nationally. The Human Poverty Index (HPI), which includes the percentage of underweight children, adult illiteracy, lack of access to safe drinking water, life expectancy (per cent not surviving after 40) and lack of access to medical care stands at 53.5, to be compared with the Coast Province HPI of 43 and the national 36.2 (UNDP 2006).

3. Climate and hydrology

Annual rainfall declines rapidly when moving inland from the coast, from an average of about 1000 millimetres (1050 millimetres at Malindi some 85 kilometres SSW of the river mouth at Kipini and 960 millimetres at Lamu some 75 kilometres NE of Kipini) to 520 millimetres at Garsen (45 kilometres inland) and 325 millimetres at Garissa (250 kilometres inland). There are two rainy seasons with the main rains between April and June (about 45 per cent of the annual rainfall at Garsen) and the "small rains" in November-December (about 25 per cent of annual rainfall). All other months have on average less than 50 millimetres of rainfall. The area is hot all year round with average monthly minimum temperature 22.6°C and average monthly absolute maximum temperature 34.1°C at Garsen (1976-1987). In such areas open water evaporation easily exceeds 2000 millimetres per year, more than 4 times annual rainfall. Though rainfall is obviously important for the development of the vegetation in the rangelands around the floodplains, the most important water supply for the floodplains themselves comes from the Tana River which is characterised by a double flood peak linked to the similar pattern of two distinct rainy seasons in the upper catchment. According to Maingi and Marsh (2002), the construction of the series of hydropower dams in the upper catchment has resulted in a decrease in the peak flow in May and an increase in the dry season flows from December to March (figure 3). The resulting reduction of flooded surface area, flood peak duration and meandering dynamics is likely to have negatively affected floodplain productivity and forest regeneration.

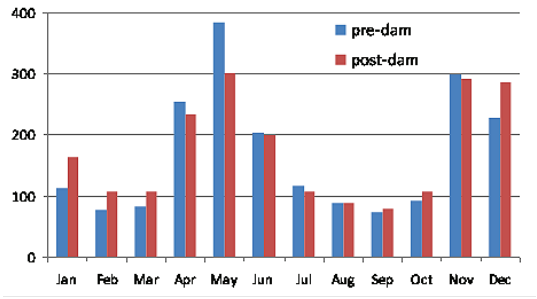

Figure 3. Average monthly discharge at Garissa in cumecs (cubic meters per second) in the pre-dam (1941-1979) and the post-dam (1982-1996) periods (adapted from Maingi and Marsh 2002)

4. Population and socio-cultural aspects of land use

The north-eastern coast of Kenya was, according to linguistic studies, originally the home of Khoisan-speaking hunter-gatherers, but all traces of their presence have disappeared. They were superseded about 4000 years ago by Eastern Cushitic speaking hunter-gatherer groups such as the Boni and about 2000 years ago by the Dahalo. The origin of the Watu, an Oromo speaking group originally confined to areas west of the Tana River, is unclear. Either they are local groups that took up Orma culture when the latter arrived in the seventeenth century or a group that migrated with them (Stiles 1981). A very small number of these hunter-gatherers still reside in the study area, usually in a separate small settlement of a few huts in association with other groups, traditionally with the Orma. Historically they played an important role as elephant hunters, providing ivory for export. They are now very marginalised.

The characteristic floodplain farming community are the Pokomo, a bantu-speaking group of sedentary farmers who have been present in the area for at least 6 centuries and who traditionally cultivate various levels of the floodplain with crops adapted to its particular flooding frequency, height and dura-

Small-scale fisheries in the floodplains, river branches and oxbow lakes of the Tana are an important source of animal protein and income for local communities

tion and groundwater level. Thus on the sandy levees they grow mango trees, banana, beans and vegetables, in slightly lower areas on mixed soils maize dominates and rice is cultivated on the black-cotton soils of the depressions in a system very similar to floodplain cultivation along the Rufiji River in Tanzania (Duvail and Hamerlynck 2007).

The surrounding rangelands have traditionally been exploited by Cushitic speaking semi-nomadic Orma (referred to as Galla in the nineteenth century literature) or nomadic (Wardei, Somali Galje'el clan) pastoralists that have arrived in successive waves. There is a tendency for them to become progressively more sedentary and take up some farming and even fishing. The milk herds stay around the permanent settlements all year round, exploiting the floodplains and the delta, and the "dry" herds move out to the rain-fed pasture in the surrounding rangelands.

Politically the Lower Tana was part of the Witu sultanate of Zanzibar and initially claimed by Germany as a protectorate but handed over to the British East African Protectorate in 1890 and thus, at independence in 1964, integrated into modern Kenya. However, the area has always felt distinct and physically isolated from the rest of the nation by the Tana River and floodplains. People still say they are going to "Kenya" when leaving the area. The area has also been characterised by decades of insecurity and low-grade armed conflict, initially linked to the so-called *shifta* wars of the 1960s but increasingly politicised using citizenship, ethnicity and religion as convenient banners for temporary alliances and divisions that can support calls for modern types of land ownership (in contrast to traditional use rights) or increase electoral clout (Kagwanja 2003).

5. Traditional natural resource management

As the Tana River flows through semi-arid lands its water is a highly precious commodity attracting different types of use. Historically, complementary and mutually beneficial resource exploitation strategies between the various user groups have always regulated rights of access to key resources, especially during the dry season. Elders of both Pokomo and Orma groups would jointly perform the required rituals after which the Orma could access water-points and floodplain pasture (Kagwanja 2003). In combination with low population density and sufficiently regular and extensive flooding these practices have allowed the different ecosystems to thrive and maintain the exceptional biodiversity. Thus nineteenth century explorers that travelled along the river described "an impenetrable jungle" and "beautifully foliaged trees covered with creepers fringed both banks of the river" (Gedge 1892, cited in Hughes 1984). Indeed, the forests, and especially the clay evergreen forest are considered a highly valuable resource even today (Luke *et al.* 2005). About a hundred plant species from the forests are commonly used by local people, especially for technology (43 species) and construction (34), traditional remedies (23) and food (15) and the main impact on forest structure is the use of large trees for canoes or beehives (Medley 1993), honey being particularly important to the Pokomo. Because of the shifting and meandering nature of the river and the forest use practices, the forest always has different stages of succession and is characterized by dynamic carbon storage (Glenday 2005). Though they need large trees, Red Colobus seem to prefer forest edges over mature forest (Mbora and Meikle 2004a) and the semi-terrestrial Tana Mangabey are well adapted to a landscape mosaic with alternating small fields, bush and forest at different stages of maturity.

According to Terer *et al.* (2004) the floodplain wetlands and in particular the oxbow lakes (recession agriculture of sorghum and millet, fishing, reeds for roof thatch, fresh water, grazing) are also considered of high value, as is the Tana River itself (water for various uses including irrigation, transportation, sand for building and as a protective barrier against bandits). As can be seen from figure 4, the floodplains have a very important function also in the attenuation of flood peaks through the overspilling of the banks, storage on the floodplains and in the oxbow lakes, infiltration into soils raising the groundwater level, etc. thus protecting downstream areas from their destructive power.

Though hunting is illegal in Kenya the rich wildlife associated with this mosaic of different forest types, wetlands, rangelands and small-scale agriculture continues to provide animal protein. Elephants have

Table 1. Ecosystem services in the Lower Tana

Provisioning services	
Food	Recession agriculture, small-scale flood irrigation, mobile livestock keeping, capture fisheries, collection of wild plant and animal food products
Fiber	Timber for canoes and construction, beehives, roof thatch and weaving products from palms, wood fuel
Clay	Construction of mud houses, brick-baking, pottery, fertilization of soils
Genetic resources	Not studied, potentially some traditional crop varieties
Biochemicals, natural medicines and pharmaceuticals	Important role of forests for local medicinal products, honey and palm wine
Freshwater	Surface water for various uses and groundwater recharge (subsurface waters are in general saline)
Regulating services	
Air quality regulation	Dynamic forests in different life stages with efficient carbon fixation, barrier to wind erosion
Climate regulation	Evapotranspiration by forests, oxbow lakes, etc.
Water regulation	Reduction of flood peak between Garissa and Garsen (see figure 4)
Erosion regulation	Riverine forest slows bank erosion and stabilises meanders
Water purification and waste treatment	Absorption of nitrogen, reduction of sediment loads by deposition in the floodplains
Disease regulation	Not studied
Pest regulation	Not studied
Pollination	Not studied but most probably important
Natural hazard regulation	Resilient ecosystems continue to provide services during climate extremes
Cultural services	
Cultural diversity	Different livelihood strategies complement each other e.g. fertilisation of fields by livestock, provision of wild foods and milk in exchange for farming produce
Spritual and religious values	Not as strong as in the Mijikenda of the more southern coastal forests but there is a strong emotional affinity with the traditional landscapes
Knowledge systems	Elaborate traditional knowledge under threat (sedentary lifestyle, schools, wage jobs, outmigration to towns)
Educational values	Teaching of bush practice and traditional pharmacopeia
Inspiration	Many locals enjoy transect walks and being in the bush
Aesthetic value	Both traditional and modern
Social relations	Rituals by elders of various communities for access to resources
Sense of place	People who received land at Kipini in compensation have remained attached to their ancestral lands, return of livestock keepers to abandoned TDIP land (Wardei)
Cultural heritage values	The Pokomo claim they brought the Red Colobus with them from Central Africa
Recreation and ecotourism	Good potential but issues with the security situation, access, infrastructure and human capacity (language, training of local guides)
Supporting services: soil formation, photosynthesis, primary production, nutrient cycling and water cycling underlie all the other services and are usually not included to avoid double counting in ecosystem valuation	

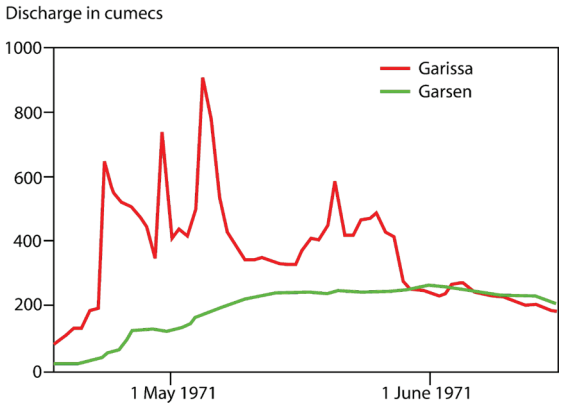

Figure 4. Flood peak attenuation by the floodplains between Garissa and Garsen: example of the 1971 flood peak (adapted from TARDA 1986)

virtually disappeared during the late 1980s, because of intensive poaching, but various ungulate species are still quite abundant in the area and human wildlife conflict, especially with buffalo, is a major complaint of the local communities when interacting with the Kenya Wildlife Service.

In summary, since time immemorial the area has provided a wide range of mostly flood-dependent ecosystem services to the different users (table 1). This dynamic equilibrium and the human well-being dependent on the services are increasingly threatened through a large number of indirect and direct drivers of change (figure 5).

6. Threats to ecosystem functioning and human well-being

6.1 Indirect drivers of change

Rural Kenya continues to have a highly dynamic demography with on a total fertility of on average 5.2 children/woman (in comparison to 3.1 in urban areas) and, though still declining the predicted transition to lower fertility seems to be slowing (Opiyo 2003). In 1966 the "Greater Tana River District" had 42,700 inhabitants but this figure may be less reliable than later surveys and would therefore overestimate growth rates. In 1979 the population was 92,000, growing to 181,000 in 1999 and 232,500 in 2005, or an annual population growth rate of 3.6 per cent (to be compared with the national average of 2.6 per cent).

6.2 Direct drivers of change

Land use change, i.e. the conversion of communal land to either nature protection (e.g. the Tana River Primate Reserve) or large-scale irrigation (e.g. the Tana Delta Irrigation Project) in combination with the demographics but without great advances in technology or economic processes, e.g. poor market access (the road between Garsen and Garissa is not tarmac and often impassable during rains) has increased the pressure on the natural resources while floodplain productivity declined in the face of reduced flooding (Maingi & Marsh 2002). The net result has been continued conversion of forest to agricultural land and a decline of the quality of the remaining forest habitat.

On the basis of a 1982 feasibility study funded by the Netherlands, the Tana and Athi Rivers Development Authority (TARDA) envisaged the development of a total of 16,800 hectares of irrigated land in both the Lower Tana floodplains and the delta, called the Tana Delta Irrigation Project (TDIP). However, an Environmental Impact Assessment (Ecosystems Ltd. 1985) highlighted numerous negative environmental impacts and pointed to serious flaws in the design and economic analysis of the project. The Netherlands therefore stopped all funding for project implementation (Hirji and Ortolano 1991). However TARDA refused to acknowledge the findings of the EIA and proceeded to obtain 6 million Yen (approximately 50 million American dollars) funding from the Overseas Economic Cooperation Fund (OECF) through the Japan Bank for International Cooperation (JBIC) and, in 1988, a first polder of about 2000 hectares was created between the water abstraction point on the Tana River at Sailoni and the Garsen-Witu road (see figure 2). With increased understanding in the international donor community that participatory processes were key to successful project implementation (Chambers 1994) one may wonder why a highly centralised top-down approach was again used for TDIP. The project was implemented as an estate system where TARDA was in charge of infrastructure, production, marketing and sales, administration, operations and maintenance. Thus TDIP did the ploughing, harrowing, sowing, harvesting, provision and distribution of seeds, fertiliser and chemicals etc. while a small number of locals were employed as casual workers for weeding, bird and wildlife scaring, sluicegate management and surveillance. Though infrastructure was only completed in 1997, production started in 1993 and was about 2.5 metric tonnes of polished rice per hectare, much lower than projected 6.5 tonnes and without a significant impact on rice production within Kenya (JBIC 2001). After mechanical harvesting by TARDA, the local communities benefited mostly from collecting the leftover rice grains in the fields (Lebrun *et al.* in press). The construction of the embankment and the exclusion of a large area of floodplain from flooding caused an increase of the water level upstream which destroyed the perennial crops of traditional farms. The embankment, in combination with the shift of

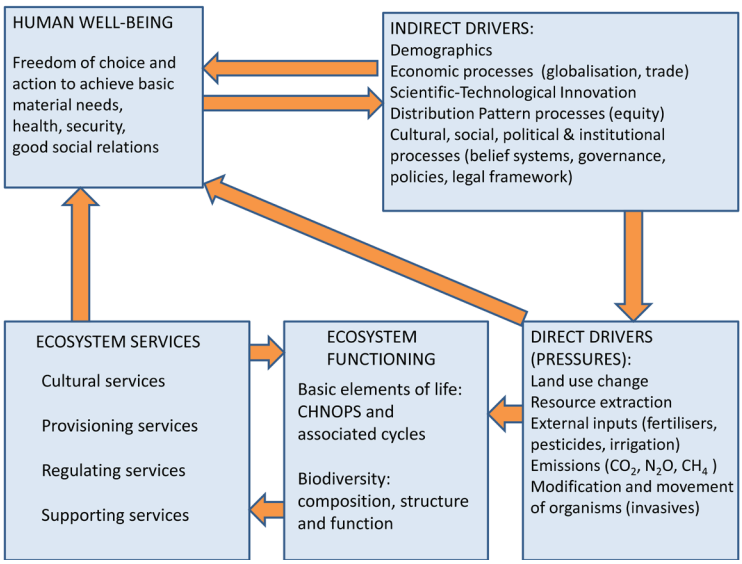

Figure 5. Conceptual framework of the interlinkages between biodiversity, ecosystem services, human well-being and the drivers of change (adapted from the Millennium Ecosystem Assessment 2005)

the dominant flow from the eastern to the western channel, reduced flooding of the forests and lakes to the east of the TDIP between Sailoni and Lango la Simba. The irrigation scheme collapsed totally during the 1997-1998 El Niño floods and human well-being in the area is extremely low with a very high percentage of vulnerable people (Luke *et al.* 2005).

Therefore, the priority accorded to the development of one ecosystem service, the provisioning of food, mainly for the benefit of a parastatal organisation rife with governance issues, has led to the loss of a large number of services that benefited directly to the local communities. In addition, the loss of the land in the TDIP polder, where the traditional users are considered squatters on their ancestral lands (court cases challenging this are still pending), has increased the pressure on the remaining flooded forests to the West of the TDIP while the forests and lakes to the East no longer receive significant flooding and have seen their productivity decline steeply. Forest cover has declined by 37 per cent in the area with a concomitant reduction in the quality of the remaining patches (Luke *et al.* 2005). Resource extraction has therefore clearly exceeded regeneration capacity. In addition *Prosopis juliflora*, which was introduced at the Bura irrigation scheme, is rapidly spreading in the abandoned TDIP area and the rest of the Lower Tana, further reducing the carrying capacity of the rangelands.

Similarly the World Bank/ Global Environment Fund investment of 6.7 million American dollars in the Tana River Primate Reserve between 1996 and 2001 has not succeeded in arresting the decline in forest cover though the loss (29 per cent over 21 years) was slightly less pronounced inside than outside (38 per cent) of the reserve (Moinde-Fockler *et al.* 2007). In theory, people that abandoned their fields in the TRPR would be compensated by land in the forests east of Kipini. However, most people who have accepted the compensation and have deforested land in the Kipini area seem to continue to also exploit their plots within the TRPR. The final evaluation of the intervention (World Bank 2005) qualifies the outcome as unsatisfactory, the sustainability as unlikely, the institutional development impact as modest and judges that both bank and borrower performances were unsatisfactory. One of the reasons evoked is that the project focussed too narrowly on the conservation of the two primate species.

One of the lasting impacts of both projects seems to have been the creation of deep resentment in the local communities against development/conservation projects and their implementing agencies i.e. TARDA and KWS.

7. Prospects

In collaboration with development partners, the Kenyan Government is currently investing massively in the rehabilitation of the food provisioning service of the irrigation schemes along the Tana River. From the above it is clear that the top-down sectoral approach used so far, both in agricultural development and nature protection projects, has shown its limits and that a fundamental change towards a more holistic and participatory approach, that looks at a much wider set of ecosystem services both at the river basin scale and at the local level, and that analyses their links to human-well being with particular emphasis on vulnerable groups, is required. A proposal for the rehabilitation of the biodiversity-rich forests in and around the TDIP has been formulated (Luke *et al.* 2005) but has so far received neither funding nor much support from civil society. Investing in the rehabilitation of environmental infrastructure, i.e. the forest, wetland, rangeland and agricultural landscape mosaics of the Lower Tana will improve the resilience of the ecosystems and this will secure the livelihoods of the local communities in the face of climate change and other threats. There is no reason why the rehabilitation of the irrigation schemes

should not go hand in hand with investment in environmental infrastructure. In fact, through managed flood releases, part of the irrigation water could usefully re-establish flooding of forests and wetlands to simulate the traditional multi-user multi-functional landscape as was done e.g. in the Deltaic floodpains of the Senegal River (Hamerlynck and Duvail 2003). Such interventions would need to be based on solid knowledge, including re-investing in hydro-meteorological assessment and monitoring. On the basis of these updated findings it may be necessary, at the river basin scale, to re-evaluate the management of the hydropower dams with appropriately timed managed flood releases that should perhaps strengthen the short rains-associated floods that, from an ecological perspective, seem to be better timed for productivity. The production kick-started through that early flooding phase in November and December can more easily be sustained during the more reliable long rains. Large long rains-associated flood releases may not be required (nor possible in the case of declining rainfall in the catchment) every year but, in order to ensure adequate forest regeneration and maintain wetland ecosystem functioning, may have to be practiced every three years. Local knowledge may guide these early flood-release experiments and lessons can be learned from them in a participatory manner.

It would be beneficial to all if, in both the design and implementation of the interventions, an ecosystem approach could be used which, from the outset, involves all stakeholders and follows a coherent stepwise implementation along the lines proposed by Borrini-Feyerabend *et al.* (2004).

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