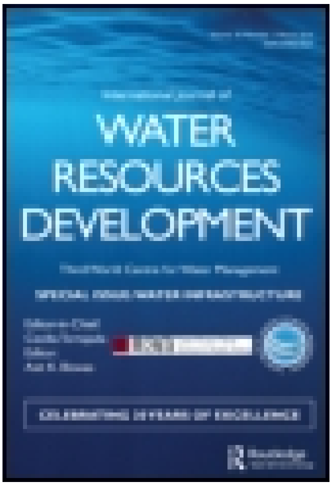

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The impacts of hydropower development on rural livelihood sustenance

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The impacts of hydropower development on rural livelihood sustenance

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The existing reservoirs on the River Tana (Kenya) were mainly constructed for hydropower generation, with inadequate consideration of the long-term impacts on downstream livelihoods. We investigated the impacts of the reservoirs on people's livelihoods downstream. The results showed a few positive impacts in the vicinity of the reservoirs and numerous negative impacts downstream (i.e. reduced flood-recess agriculture and floodplain pastoralism, and escalating resource-use conflicts). Inadequate stakeholders' consultation during reservoir development was also observed. We recommend a detailed basin-wide socioeconomic assessment for future reservoir developments and controlled flood release to simulate the natural flow regime, thereby restoring indigenous flood-based livelihoods while retaining sufficient reserves for power generation.

Keywords: River Tana; Kenya; communities' perception; hydropower development; impact assessment; floods

Introduction

River basins are the cradles of civilization and cultural heritage. Ancient and modern civilizations first developed in the vicinity of great rivers due to the role of rivers in the provision of food to support livelihoods, inputs for industries, and by providing opportunities for commerce and navigation. These roles are highly dependent on the river continuum, which is profoundly affected by river damming (Vannote, Minshall, Cummins, Sedell, & Cushing, 1980). River damming is increasing at unprecedented rates with millions of reservoirs having been constructed globally in the last century (Smith, 1971; WCD, 2000) to harness water for electricity generation, domestic or industrial use, food production, navigation, fisheries, and recreational as well as for flood control purposes (Graf, 2002; Snoussi et al., 2007).

The economic benefits of reservoirs have been assumed to outweigh their costs in the past, thus providing a rationale for the expansion of reservoirs around the world (Beck, Claassen, & Hundt, 2012; Liu & Speed, 2009). However, the impacts of reservoirs on rivers' ecological, geophysical and chemical processes, and related ecosystem services are high, and may include ecosystem and habitat degradation, obstruction of fish breeding and migrations routes (Dudgeon, 2003), loss of biodiversity and habitats (Pizzuto, 2002;

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Stave, Oba, Stenseth, & Nordal, 2005), increased nutrients and sediment retention (Bowonder, Ramana, & Rao, 1984; Vörösmarty et al., 2003), disruption of biogeochemical cycles (Dumont, Harrison, Kroeze, Bakker, & Seitzinger, 2005; Harrison et al., 2009); altered water quality and natural flooding of the wetlands and flood plains, and increased greenhouse gas emissions (Richey, Melack, Aufdenkampe, Ballester, & Hess, 2002; St. Louis, Kelly, Duchemin, Rudd, & Rosenberg, 2000).

The construction of reservoirs and the associated environmental and ecological impacts often lead to secondary effects on the livelihoods of the people dependent on the downstream natural resources and their ecosystem services. These impacts may include displacement of families, diminished living standards, deprivation of lifetime benefits (such as flood recess agricultural land, fisheries), and reduced food supplies, shelter, medicines, income, employment and cultural values (WCD, 2000; Wiejaczka, Piróg, Soja, & Serwa, 2014). Some of these adverse environmental, ecological and social impacts of river damming are often largely unanticipated or grossly underestimated during the design of most reservoirs (Duvail & Hamerlynck, 2003).

River damming may continue unabated in the developing countries despite their negative impacts on downstream ecosystems and community livelihoods. This is necessitated by the fact that more than 1.6 billion people are still without access to electricity, while 1.1 billion people are without access to a reliable water supply (United Nations Development Programme (UNDP), 2006). Moreover, water and electricity have been recognized as essential resources for promoting economic growth and enhancing community livelihood (Snoussi et al., 2007; Yüksel, 2009). The UNDP has also emphasized the importance of affordable energy in the developing world as a critical input for the realization of Millennium Development Goals by the year 2015 (UNDP, 2006). It is against this backdrop that African countries are promoting hydropower as one of the sustainable technologies (Bartle, 2002).

Kenya has a number of reservoirs. For instance, the River Tana already has a total of five hydropower reservoirs in the upper catchment with a number (Karura, Mutonga, Low Grand Falls, Usheni, Adamsons Falls, Kora and High Grand Falls) still planned downstream of the existing reservoirs (Snoussi et al., 2007). However, the existing Tana reservoirs were constructed without thorough environmental and social impact assessments (Odingo, 1979). Moreover, some past impact assessment studies focused primarily on areas in the vicinity of the reservoir while ignoring the fact that reservoirs may substantially modify riverine ecosystems hundreds of kilometres downstream.

Reservoir planners in Kenya have in the past failed to recognize the linkages between the environment and economic development leading to a number of negative socio-economic impacts. Similarly, the government has always assumed that economic, technological and social benefits derived from reservoir establishments are important for the development of the overall country and that spillover effects will eventually improve the livelihoods of the entire population, including those directly affected by the river damming.

There is, therefore, an important need to develop strategies that will minimize the negative socio-economic impacts of hydropower projects so that they can be implemented fairly and cautiously for the benefit of all stakeholders. This study intended to provide part of the information that will inform this process by exploring the socio-economic impacts of cascading reservoirs along the River Tana on the livelihoods sustenance of the downstream communities. Specifically, this study intended (1) to identify the socio-economic benefits or problems caused by River Tana damming, (2) to identify the mitigation measures perceived by the communities that may minimize adverse socio-economic impacts and enhance the beneficial impacts of reservoirs; and (3) to provide baseline data that may be used to assess the impacts of other proposed reservoirs.

Study approach and methods

Study area

The study was carried out in the River Tana basin, Kenya (Figure 1). The Tana is one of the most important natural resources and the longest river in Kenya, rising in the Aberdare

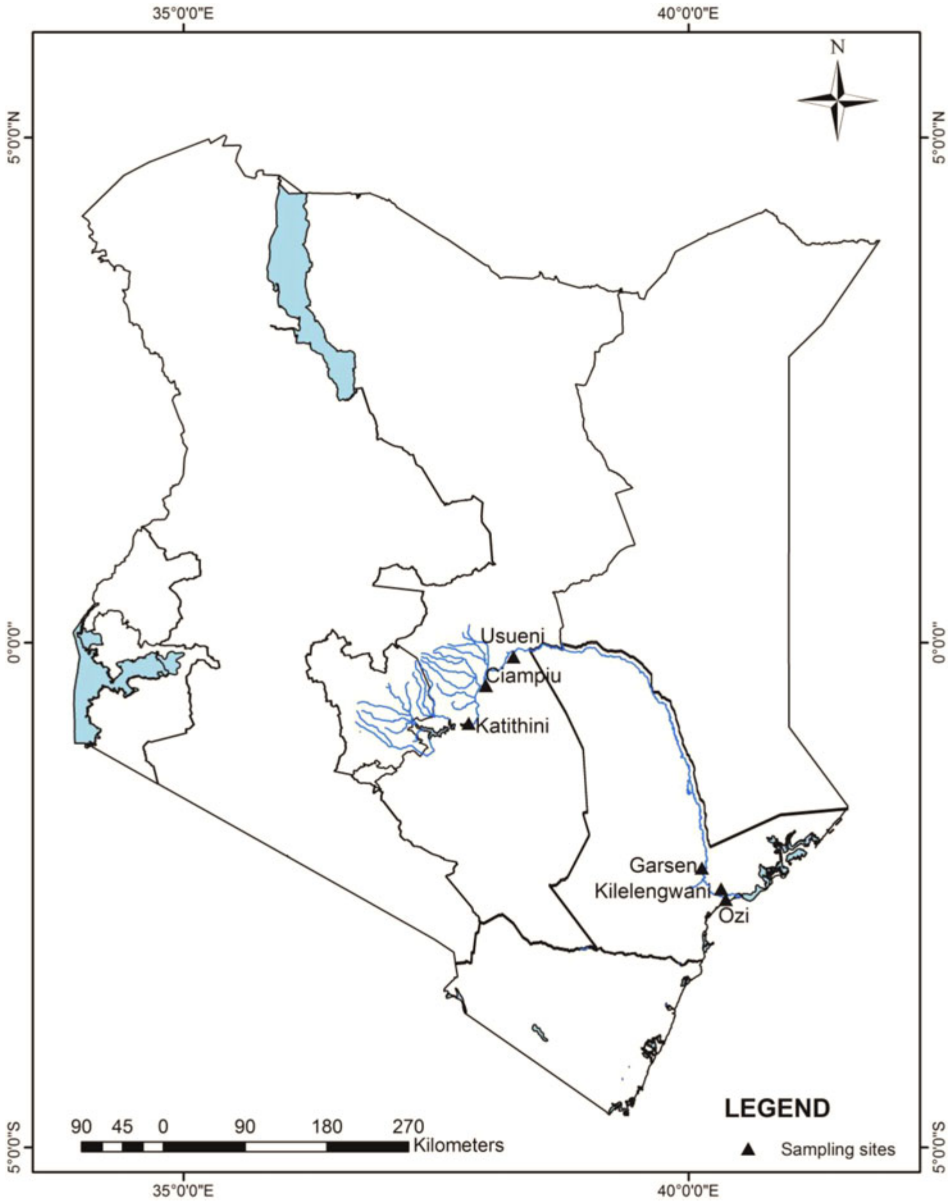

Figure 1. Study area showing the surveyed villages.

Table 1. Main characteristics of Tana River reservoirs.

Reservoir	Altitude (m)	Year commissioned	Capacity (× 106 m^3)	Surface area (km^2)	Original maximum depth (m)	Installed capacity (MW)
Masinga	1050	1981	1560	120	50	40
Kamburu	1010	1974	123	15	56	96
Gitaru	924	1978	20	3.1	30	225
Kindaruma	780	1968	16	2.5	24	72
Kiambere	700	1988	585	25	112	168

Source: Brown et al. (1996).

ranges and Mount Kenya of central Kenya and running through the arid and semi-arid lands in the eastern part of the country to enter the Indian Ocean through a fan-shaped delta (Saha, 1982). The river has been exploited for hydroelectric power generation and irrigation (Maingi & Marsh, 2001) through the Seven Forks Hydro Stations comprising the Masinga, Kamburu, Gitaru, Kindaruma and Kiambere reservoirs (Table 1). Water is released from one reservoir to the succeeding one in the cascade to provide adequate flow for hydroelectric power generation.

Study population sample

The target population was purposively selected from the upper and lower sections of the River Tana with the proposed Grand falls/Mutonga Hydro Power Project site acting as the demarcation line of the sections. The target population in the upper section consisted of households that lived in the proximity of the reservoirs and therefore experienced the direct impacts of damming, while the target population in the lower section consisted of households that experienced the impacts of altered flow regime downstream of the Tana due to damming. Based on the purposive sampling (a technique described by Patton, 1990, as a non-probability technique based on a researcher's judgement; Black, 2010; Nachmias & Nachmias, 2004a), the Upper Tana villages surveyed included Ciampiu in Mbeere district, Katithini village (Embu County), and Usueni in Mwingi district (Kitui County), whereas the Lower Tana villages were Bilissa, Centre 2 (Garsen), Kilelengwani and Ozi villages (Tana River County). Subjects of the study from these villages were chosen based on their homogeneous characteristics and experiences (e.g. gender, age and occupation). Information derived from the past studies aided in setting up the criteria for respondents' choice, which depended on benefits derived from the River Tana while at the same time taking into consideration the residents exposed to the perceived impacts from the damming of the Tana.

Katithini and Usueni villages are inhabited by the Akamba ethnic community, while Ciampiu is inhabited by the Mbeere ethnic community. The Kamba people were originally long-distance traders, although they are currently engaged in agriculture. The lower Tana villages surveyed are mainly inhabited by the Orma ethnic people (who practise semi-nomadic pastoralism) and the Pokomo (who are mainly farmers and fishermen). A total of 181 respondents were interviewed from households with different occupational backgrounds.

Data collection

This study involved collection of both secondary and primary data. A literature review was carried out to obtain relevant secondary data from scientific publications, official government documents and other grey literature. Primary data collection was carried out through observation and by administering key informants interviews and semi-structured questionnaires (see the Supplemental data online) to individuals in a number of villages according to Marshall and Rossman (2011). Kiswahili was used as the language of interview, and translations to and from local languages was performed by local guides where necessary.

Direct observation

Direct observation was used as a supplementary method to collect data to complement those obtained through the other methods. As observed by Adler and Adler (1994), direct observation provides a richer understanding of the subject-matter and may also be used to validate the information obtained through the semi-structured interviews.

Key-informant interviews

The key-informant interview technique was used as described by Bunce, Townsley, Pomeroy, and Pollnac (2000) to gather information from the opinion leaders in the study area. The snowball method (Goodman, 1961) was used to identify key informants who included the chief engineer of the Kenya Electricity Generating Company Ltd (KenGen), the project manager of the Tana and Athi Rivers Development Authority (TARDA), village chairmen, assistant chiefs and other people who held respected positions in society.

Semi-structured interview

This is a form of in-depth interviewing in which open-ended questions (see the Supplemental data online) were administered to the respondents according to Nachmias and Nachmias (2004b) and Mugenda and Mugenda (2003). The open-ended questionnaires had thematic areas such as socio-demographic aspects of the population, perceptions on the impacts of River Tana damming, and suggestions on mitigation measure to minimize the negative impacts.

Results

Demographic characteristics of the respondents

The 181 respondents interviewed in the survey comprised of farmers, pastoralists, hunters, gatherers and fishermen. The survey respondents were represented by 69% ($n = 124$) men and 31% women ($n = 57$). It was noted that the upper Tana catchment area was sparsely populated due to the rough terrain in the area compared with the lower Tana (Table 2).

Table 2. Summary of the sampled population.

$N = 181$	Catchment	Villages	Percentage of respondents
$N = 50$	Upper Tana	Katithini	14.9
		Ciampiu	4.4
		Usueni	8.3
$N = 131$	Lower Tana	Garsen	37.0
		Kilelengwani	13.8
		Ozi	21.5

A total of 84% of the respondents were married (with the number of wives ranging from one to four), while the rest of the respondents were single (7%), widowed (3%), separated (3%) or divorced (3%). The average household size was seven, with a minimum and maximum of two and 24 members, respectively. Breadwinners constituted 74% of those interviewed (64% men and 10% women). The ages of respondents ranged from 17 to over 84 years, with an average of 40 years. About 97% of the respondents owned homes, while the rest lived in rented houses.

A total of 60% of the respondents had no or little education (e.g. only madrassa or incomplete primary school), 28% had completed only primary school, while only 12% had attained complete secondary school and college training, as shown in Figure 2. Men were the majority of the literate population and were engaged in formal employment. Women were marginalized as they were mostly married off at an early age before completing schooling.

Socio-cultural characteristics

Garsen (Centre 2) and Ozi villages were mainly inhabited by the Pokomo. Pokomo culture is rich in folk tales, songs and dancing (*kitoko, maribe, miri* and *kuhinywa*). They engage in a number of celebrations, especially during bumper harvests, births, circumcisions and weddings. The communities in Kilelengwani village adhere to both Pokomo and Orma cultural practices. Cultural practices in the surveyed villages were reported by 32% of the respondents to have changed after River Tana damming. For instance, reduction in the use of traditional medicine (resulting from a decline of riverine forest and associated hunting

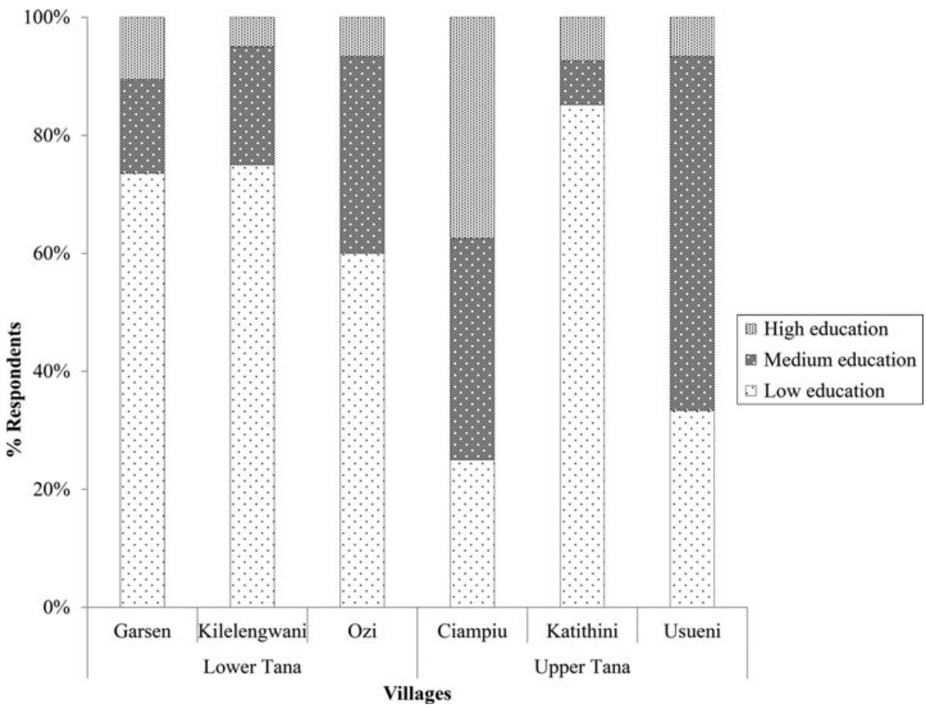

Figure 2. Education levels of the respondents in the various studied villages.

and gathering activities) and an overreliance on relief food (resulting from reduction in flood recess agriculture and floodplain pastoralism).

Energy sources and social amenities

Results indicate that 96% of the respondents had no access to electricity (Figure 3). The main energy source for cooking was wood fuel (52%) and paraffin (38%) with hydroelectric power contributing only 1%. Locals in Garsen (Bilissa) and Kilelengwani villages depended on wood fuel as the main source of energy for both cooking and lighting. Firewood is collected from the forests, along the riverbank or freely obtained from the communal land. A few locals in these villages use paraffin for lighting purposes even though it is not easily affordable.

Ciampiu, Katithini and Usueni villages use firewood and charcoal for cooking and kerosene for lighting. A few respondents used solar energy for lighting purposes. Garsen's (Centre 2 village) proximity to Garsen town gives it an advantage of electricity supply for lighting purposes, though some respondents use paraffin. Firewood and charcoal are mainly used for cooking purposes. There is no electricity in Ozi village, though a few people use solar energy to operate their electric appliances and lighting. Kerosene is the most preferred source of lighting, while firewood is the most used source of energy for cooking purposes.

Prior to the damming of the River Tana, the main source of domestic water was identified to be the Tana itself (82%), while other sources included wells, oxbow lakes and

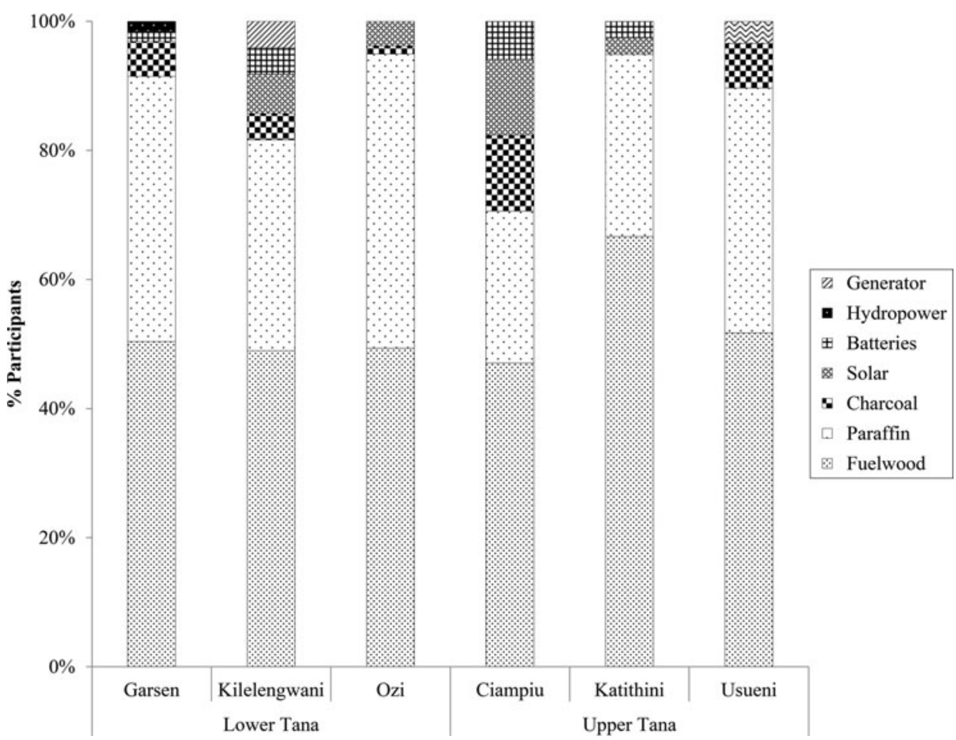

Figure 3. Energy/fuel sources in the surveyed villages.

water vendors. Access to clean drinking water was still identified as a challenge by 83% of respondents.

Respondents also affirmed that they have access to social amenities like schools (47%), hospitals/dispensaries (28%), mosques (9%), churches (8%), markets (4%) and administrative posts, i.e. the General Service Unit, chiefs or police camps (4%).

Infrastructure

In this paper we have defined infrastructure to cover only road networks. Bilissa village is accessed via an ungraded road network. The locals mainly travel on foot to various destinations. In contrast, Garsen (Centre 2) is served with a tarmac road since the village is close to the main town centre. Proximity to the town has contributed to growth of the village, which is well served with piped water and a waste collection system. Ozi village, on the other hand, is accessed via unsurfaced road networks to the banks of the Tana at Kipini, from where people cross the river using canoes. The Kilelengwani area has ungraded roads that are prone to frequent erosion and are impassable during the rainy season. Katithini village has well-maintained roads serviced by KenGen.

Livelihood activities

People in the surveyed villages were mainly self-employed (93%), with only 7% involved in formal employment. Farming (81%) and fishing (7%) were the main sources of livelihood among the self-employed category (Figure 4).

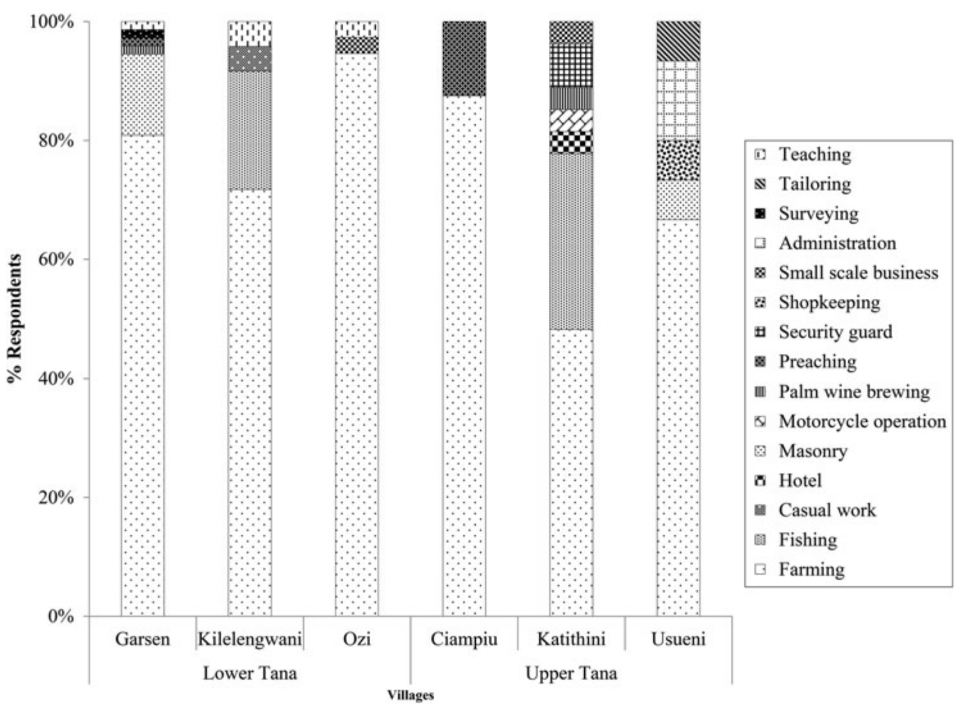

Figure 4. Ooccupation of the respondents in the surveyed villages.

Farming is the main economic activity in Garsen villages, although some individuals are also involved in selling building poles, charcoal, farm produce, fish, honey, local brew and groceries. Residents in Ozi village are mainly farmers who grow rice, bananas, mangoes, coconut and also rear livestock besides fishing in the Tana and Indian Ocean. Locals in Ciampiu and Usueni villages are predominantly farmers. Fishing was mainly practised in Kilelengwani and Katithini villages.

A total of 61% of the respondents had not changed their occupations after the river damming, while 39% had opted for other activities primarily as a result of the decline in income from their former occupations and the need for livelihood diversification (e.g. 46% of former hunters and gatherers have since changed to alternative livelihoods following the reduction of riverine forest occasioned by the damming of the Tana).

Land tenure

A total of 80% of the land in the studied villages was communally owned with only 18% public land. Land in Ciampiu and Usueni villages was fully owned by the community, whereas 92% of the land in Katithini village was government owned and residents are squatters on the land. Although 81% of the respondents confirmed that they were not directly affected by the limitation to access government land for grazing or farming, about 14% claimed that restrictions were imposed especially in accessing water for farming.

Perceived impacts of River Tana damming

Most of the respondents (85%) asserted that damming of the River Tana had directly or indirectly affected some aspects of their livelihood. A total of 56% of the respondents observed that flooding occasioned by unexpected release of water from the reservoirs (during reservoir management operations) with related loss of crops was the greatest negative impact of damming. The other impacts of damming were reported as the emergence of human–wildlife conflicts (hippo and crocodile attacks leading to crop destruction and loss of life) and the emergence of an informal settlement due to inappropriate relocation plans. The emergence of an informal settlement was site specific, e.g. the occurrence of squatters in Katithini village (where locals live in the Kiambere reservoir buffer zone due to the availability of water for both domestic use and fishing even though the area is a prohibited for human settlement), as shown in Figure 5.

A total of 75% of the respondents had not experienced any positive impact of river damming, whereas fishing (13%), employment (6%), farming (5%) and transportation (1%) were identified as some of the benefits arising from the damming of the Tana. The outstanding positive impacts included: supply of water for domestic use (32%), farming (31%) and fishing (30%). In addition, the reservoirs provided employment (5%) and power generation (2%).

Mitigation measures

A number of mitigation measures were proposed by the respondents (Figure 6 and Table 3). Some of the respondents (15%) expressed a need to control unexpected water released by the reservoirs during maintenance. It also emerged that 74% of the respondents were not aware of any plans to increase the number of reservoirs along the Tana despite the fact that the Kenyan government recently received funding from the government of China to construct Grand Falls reservoirs (Makena, 2013). Even though feasibility and impact

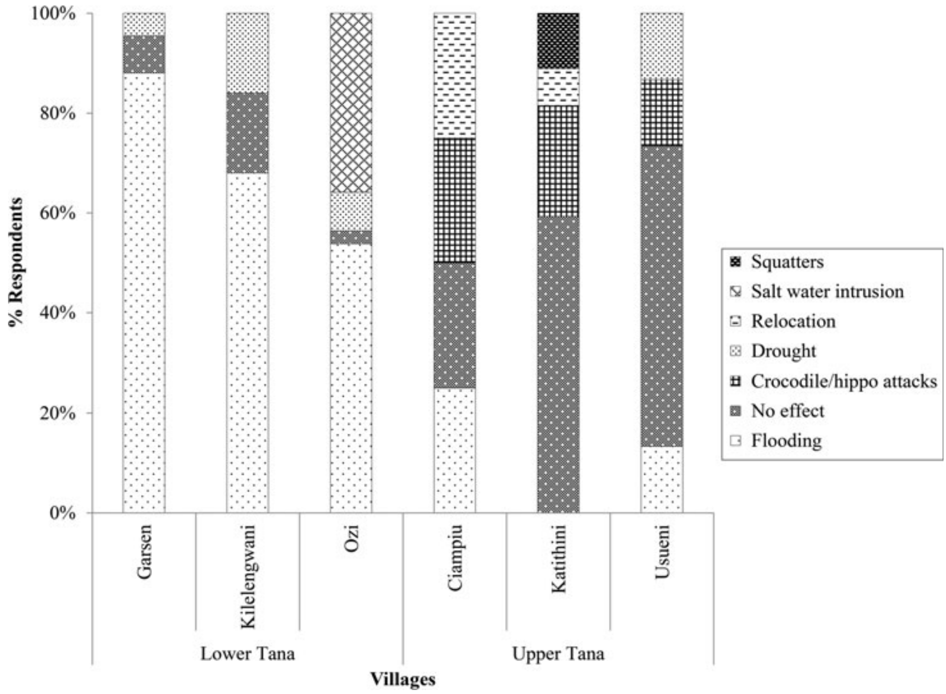

Figure 5. Communities' perceived negative impacts of River Tana damming.

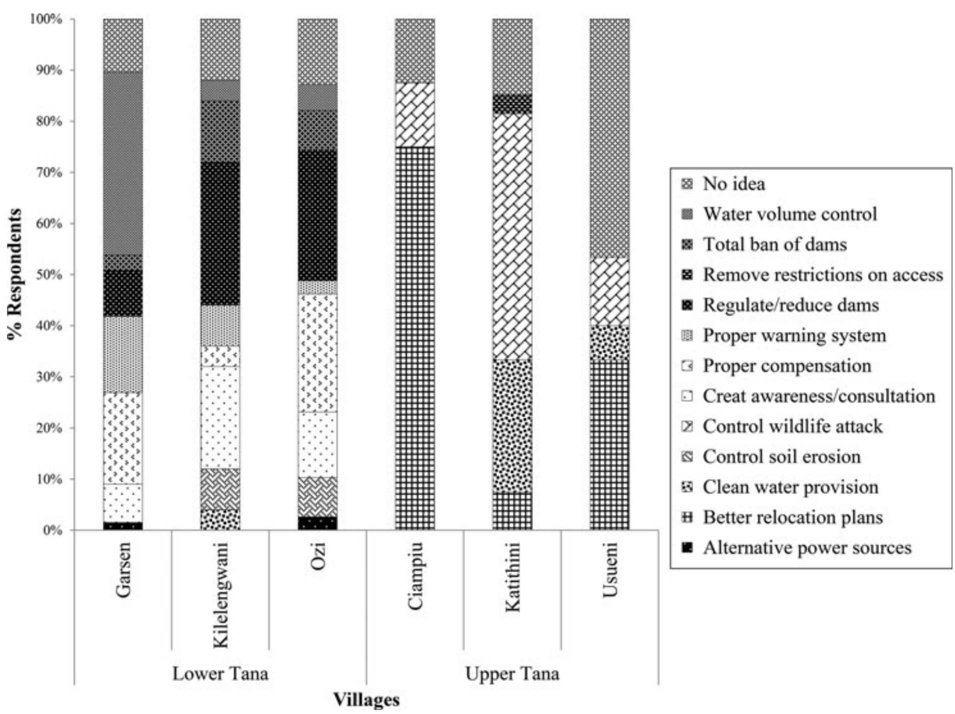

Figure 6. Mitigation measures for the negative impacts of River Tana damming as proposed by the respondents.

Table 3. Summary of the emerging issues and mitigation measures as proposed by the communities.

Emerging issues	Suggested mitigation measures
Unexpected flooding	Development of flood-risk warning systems to alert people downstream before opening reservoirs' flood gates
	Have definite dates when the flood release for reservoir management purposes will be released
	Reduce the construction of reservoirs by venturing in alternative source of electricity production
	Put up dykes to control excess water
Human–animal conflict	Drilling of wells or supply of piped water to homesteads to reduce the risks of attack by crocodiles or hippos
Saltwater intrusion	Regulate the number of reservoirs upstream to ensure minimum flow
Resource-use conflicts	Reduce the construction of reservoirs upstream to restore the flow of water downstream
	Encourage intermarriages between warring communities
	Allow equal access of resources among the community
	Involve all community representatives in decision-making

assessment studies have been carried out (Japan International Corporation Agency, 1997), it was noted that only 7% were aware that Grand Falls had secured funding and construction was expected to commence, while 19% of the respondents were aware of the intended increase of the number of reservoirs along the Tana but were not aware that Grand Falls will be one of them. The majority of respondent (94%) asserted that there had been no adequate consultation with local communities regarding the construction of any additional reservoir on the Tana.

Future approvals of reservoir developments in the River Tana by the National Environment Management Authority (NEMA) were objected to by 53% of respondents (particularly those in the lower Tana). Reasons cited included a fear of an unexpected flood release downstream during reservoir maintenance, lack of accrued benefits from the reservoirs, saltwater intrusion into the farm fallows during dry seasons (due to reduced freshwater-to-seawater ratios), increased drying of floodplain agricultural land (due to the retention of more water in the reservoirs), poor relocation plans, inadequate compensation, lack of/or inadequate stakeholder consultation, increased erosion downstream, and increased water abstraction (Figure 5).

Discussion

Impacts of damming the River Tana on flood recess agriculture and floodplain pastoralism

Farming (mainly of rice) in Ozi and Kilelengwani villages (Figure 4) is mainly carried out in the floodplains which offer favourable conditions for flood recess agriculture due to the presence of rich alluvial deposits and natural irrigation through flooding. In Kilelengwani, floodplain fallows are used for cultivation of rice, while in Ozi, farmers depend on the coerciveness of the spring tide to push river water into the irrigation channels of rice paddies. The Tana flooded its banks biannually (March–May and October–December) prior to damming. However, the damming of the Tana has altered the river's natural flow, thus reducing the frequency, extent, and duration of floodplain inundation and its related productivity (Retief, 2007). For instance, increased salt intrusion observed in Ozi village results in unfavourable farmland for rice farming (Figure 5).

Whereas the number could be higher at present, Emmerton (2003) estimated that about 115,000 households practised flood recession and riverbank agriculture along the Tana, thus providing the only source of land in the region that can be utilized for agriculture. It was evident from this study that further damming of the river may eliminate floodplain agriculture just as previously prognosticated by Quan (1994) and Retief (2007).

The Orma ethnic people depend entirely on floodplain pastoralism (characterized by seasonal migration from the hinterland to the floodplains during the dry season) for their livelihood. However, River Tana damming is forcing pastoralists to settle in the diminishing floodplains, resulting into social disorder, and civil and ethnic conflict between pastoralists and agriculturalists (arising from increasing competition for the dwindling floodplain resources).

Impacts of damming the River Tana on human health

In this study, River Tana damming impacted negatively on communities through unexpected flooding and related disease outbreaks (Figure 5), as similarly reported for the lower Tana by Retief (2007). The reservoirs serve as breeding grounds for bacteria, mosquitoes and snails, which cause illnesses such as cholera, malaria and schistosomiasis. Reservoirs and associated diseases outbreak have similarly been reported in Cote d'Ivoire where a significant increase (from 14% to 53% and from 0% to 73%) in the prevalence of schistosomiasis was documented after the construction of Lake Kossou and Lake Taabo, respectively (N'Goran, Diabate, Utzinger, & Sellin, 1997), while Clarke (1991) noted an increase (from 3% to 37%) in the incidence of schistosomiasis infection among children under the age of 16 years in Lake Volta.

Local communities naturally develop partial and protective immunity to communicable infections (e.g. upper respiratory tract infections, diarrhoea, intestinal worms, urinary tract infection and gonorrhoea) while under moderate exposure conditions (Japan International Corporation Agency and Nippon Koei, 1995; Ministry of Health Kenya, 1996). However, River Tana damming has reduced this immunity due to extreme exposures (e.g. the emergence of informal settlement in Katithini with the associated lack of infrastructure, poverty, crowding and poor hygiene) leading to high disease prevalence. Other health-related social impacts of damming include malnutrition (due to a change in livelihood sustenance activities), stress, drowning, injuries from hippo and crocodile attacks, and general loss of well-being.

Impacts of damming the River Tana on communities' basic rights and livelihood resilience

Most communities living along the Tana rely heavily on the river and riverine natural resources ecosystem services such as fishing, timber, honey, fruit, thatching materials and medicines to sustain their livelihoods. These communities have limited alternative livelihood options (evident from 60% of respondents having no or incomplete basic education; Figure 2) making them vulnerable to changes in the status of the natural resources.

Fishing supported the livelihoods of a number of respondents, particularly in Kilelengwani and Katithini villages. Nippon Koei Co. (1998) similarly reported that the River Tana, delta and estuary areas support a livelihood for over 50,000 fishermen in 1996. The fisheries in these areas have been dwindling down (Dadzie & Odero, 1987) and this has been putting many livelihoods that depend on the resource at risk. Whereas it could be argued that the reservoirs would provide a larger water body that would in turn increase the general fishery productivity of dammed rivers, studies elsewhere by Baran, Jantunen, and Chong (2007) and Marmula (2001) have shown that there is usually low productivity in the reservoir compared with riverine fisheries.

Similarly, the reduction in the frequency of the natural flooding of the Tana's banks has resulted in arid conditions downstream (Figure 5). Reduced flooding has thus led to a decline in arable land, increased costs of production (e.g. irrigation), and the consequent reduction in farming returns and change in land-use patterns (e.g. the Pokomo are slowly shifting to rain-fed agriculture by growing crops such as maize and green grams). River damming has also caused a shift in farming strategies to various forms of irrigation farming (with their related higher levels of inputs), exposing local communities to material vulnerability from economic trends and shocks such as changes in input prices.

The reduced downstream flow (due to Tana damming) has also led to a reduction in forest and grassland cover and the associated biodiversity (Maingi & Marsh, 2002). The reduction in biodiversity may have led to the observed shift from hunting and gathering to agricultural activities in the lower Tana.

Gitaru reservoir spillway releases water on a public road during spillway release, hence the need for longer alternative roads in accessing various destinations. Generally, this has a social disintegration impact as well as loss of valuable man-hours which could have otherwise been used on various economic activities.

Prior to Tana damming, communities accessed the river for bathing, swimming and fishing and obtained water for domestic use without major risks from drowning and attack by wild animals. Recently, there have been increased cases of drowning and attack by hippos and crocodiles in the reservoirs (Figure 5). Change to this has led to human injuries and deaths and other economic losses (from spoilt boats and fishing nets as well as the destruction of farms that are situated on the banks of the reservoirs).

Impacts of damming the River Tana on communities culture and cultural heritage

The indigenous people in Kenya have tried to remain loyal to their cultural practices. For instance, the Orma and Pokomo in Bilissa, Centre 2, Kilelengwani and Ozi villages strongly adhere to their culture as reported in this study. Changes initiated by Tana damming have resulted in massive famine downstream and this is slowly changing the culture of the local communities from self-reliance to overreliance on government relief food. For instance, 23% of household food sources were reported to be from government relief in 2007 (Kenya Red Cross Society, 2007). Other social cultures like the Pokomo traditional culture of ceremonies and feasting during times of surplus harvest are also slowly eroding since there are rarely any good harvests to celebrate following Tana damming.

Cattle are a social representation of wealth and status among the Orma, with most of their economic and cultural activities centred on livestock rearing (Leauthaud et al., 2013). The impact of declining riverine pastures (occasioned by a reduction of the flood plain area) has resulted in increasing exploitative pressure on the little remaining grazing land and water points which are shared by both farmers and pastoralists. Despite the agreements between groups on recognized access corridors for livestock to the river's watering points, disputes are becoming common, thus straining socio-cultural relations which have traditionally been mutually beneficial (such as the trading of milk for farm produce) and replacing them with increased resource conflicts, tension and the rampart ethnic clashes witnessed in the lower Tana villages. Frequent tribal clashes have also forced a number of villages, e.g. Bilissa, Ozi and Kilelengwani, to change their way of living by dwelling mainly in temporary houses since the communities no longer see the worth of investing in permanent houses which are destroyed whenever clashes occur.

Impacts of damming the River Tana on the marginalized and vulnerable groups

The observed inadequate education and lack of land ownership attests to the poverty status of the surveyed communities (Figures 2 and 5). A very high illiteracy rate of 48% and high proportion (72%) of Tana River County inhabitants has been reported to be living below the poverty line (i.e. earning less than US$1 per day) (Government of Kenya, 2005), thus confirming the vulnerability of these communities. The high illiteracy and poverty status observed in this study substantiate the observations of the World Bank (2012) that reservoir projects generally affect the poorest and most vulnerable sections of society, despite the fact that they are among those excluded from sharing the benefits, e.g. 95% had no access to electricity (Figure 3). Furthermore, these vulnerable groups are excluded from the reservoirs' development decision-making process (Figure 6), even though they were among the most affected by such economic ventures.

Apart from being marginalized, women were found to have an intimate relationship with water. For instance, they carry out all domestic jobs, farming and, in addition, built houses in Garissa, which all require water because they have mud walls. However, the resettlement to areas that are usually far away from water sources further makes the already marginalized women to shoulder the ordeal of the displacement far more intensely since they travel for longer distance to fetch water for domestic use. Lahiri-Dutt and Ahmad (2012) similarly argued that differences in gender roles account for the differential impacts of large infrastructural and developmental projects on women and men, while Bui and Schreinemachers (2011) noted a general reduction in net capital and natural capital for those resettled following water abstraction projects.

Impacts of damming the River Tana on flood control

Generally, flood protection is a known important service offered by the reservoirs, allowing communities downstream to live comfortably along any river without fear of volatile floods (Yüksel, 2009). However, 43% of the respondents in this study mentioned flooding as one of the negative impacts of reservoirs (Figure 5). The communities' perception that reservoirs may be responsible for flooding may have emanated from the fact that the Tana reservoirs' storage capacities are only effective in controlling small floods (which occur during the normal annual rains) and not the large floods (especially during heavy rains, for instance the El Niño rains) leading to flooding of former floodplains that are already converted to human settlements or agricultural land. It is this failed protection and the increased vulnerability to larger floods that the local communities may be referring to as a negative impact of damming. Pelling (2003) also reported that some households make a trade-off between vulnerability and poverty, accepting greater vulnerability in order to fend for their families. The false security provided by reservoirs against flooding has been reported to cause extensive losses of life and property in comparison with when flood control structures (reservoirs) were not in place (Lebel, Garden, & Imamura, 2005) due to their total unpreparedness for such calamities.

In contrast to the negative view of floods by many people, the communities downstream recognize floodwater as essential for many reasons, e.g. floodplain agriculture and pastoralism. For instance, much water is usually retained in the Tana reservoir during the dry season, making their lands suffer: (1) exsiccation due to lack of adequate water to irrigate the crops, (2) saltwater intrusion in the farms leading to crop failure, and (3) increased accumulation of ocean sand on the riverbanks (in Ozi), thus preventing any form of cultivation. The communities thus expressed concern over control of the natural flooding since they have adapted their lifestyle and patterns of land use to take advantage of the natural flooding. Terer, Ndiritu, and Gichuki (2004) similarly reported that the communities in the lower Tana perceived normal floods as a blessing by supplying fresh water and fertilizing both pasture and agricultural land.

Reservoir management, e.g. flood release, has also affected the cycle of farming downstream. For instance, Bilissa and Centre 2 villages depend on the Tana to irrigate their land for a period of three months (before the water recedes), giving farmers a chance to grow their crops and an additional three months for the crops to mature for harvesting before the beginning of the second floods. This natural cycle was convenient for farming practice; however, the cycle has been altered by flood management following Tana damming. In addition to the elimination of natural floods, the reservoirs release unexpected floods causing poor crop yields due to the excessive water supply during untimely periods of the farming cycle. These unexpected floods also lead to loss of both life and property downstream. Retief (2007) similarly reported that reservoirs released floods at strange times such as in the middle of the dry season when they are considered to be unexpected and are destructive.

Positive impacts of River Tana damming

Despite the widely reported negative impacts of river damming, reservoirs may also provide some positive benefits (Doyle, Stanley, Luebke, & Harbor, 2000). For instance, River Tana reservoirs generate 40–64% of Kenya's national electricity demand (Knoop, Sambalino, & Steenbergen, 2012) even though only 2% of respondents identified electricity as a positive impact of Tana damming. The other reservoir-related activities provide employment for 6% of the local communities (particularly from the Upper Tana) who were either formerly employed as construction workers or are currently employed by KenGen. However, employment of the local communities was largely availed during reservoir construction, and the target population for employment switched (after commissioning) to skilled workers, thus locking out the majority of locals with inappropriate skills.

River Tana damming has also provided incentives for the development of businesses enterprises in the vicinity of the reservoir, as observed in Katithini village. Even though this market reduced substantially upon completion of the construction of power generation stations, the residents can still sell their produce to KenGen staff. An expanded market for local produce has similarly been reported elsewhere by Canter (1985).

Other opportunities offered by Tana damming include fishing in Kamburu, Masinga and Kiambere, and ecotourism activities in Masinga. The importance of reservoirs has similarly been reported in Volta Lake (which is a major source of protein in Ghana), with the fishing industry rated as one of the most significant benefits of the reservoir to the Ghanaian economy (Adams, 1992). A similar scenario was reported in Zimbabwean Kariba, Mutirikwe, Manyame, Chivero, Mazvikadei and Mayfair reservoirs which are used for fishing, and recreational and tourist purposes (Chenje, Sola, & Paleczny, 1998). Even though not yet well established in the Tana reservoirs, recreation and tourism may also be enhanced, thereby creating employment and income.

It is important to note that all the positive impacts of the reservoirs are restricted to areas in the vicinity of the reservoirs, while downstream communities rarely experience such impacts.

Conclusions and recommendations

The communities in the lower Tana reported that most small floods were retained in the reservoirs, thus affecting the environment and livelihoods downstream which depend on these floods. Furthermore, the reservoirs have been releasing unexpected flood waters during routine operations which seriously affect farming downstream. Both electricity and livelihoods are important. There is, therefore, a need for a more integrated river basin development that takes into account environmental concerns and community livelihoods, while generating the needed electricity as proposed in the soft landing concept suggested by Falkenmark and Molden (2008). This soft landing can be achieved in the Tana basin through managed flood release from the reservoirs (during the pre-agreed periods of the year) to simulate key aspects of the natural flow regime. This will inundate the floodplains, thus rehabilitating indigenous flood-based farming systems whilst retaining sufficient reserves for power generation. Such a scheme of managed flood release is well elaborated by the Japan International Corporation Agency (1997) for the planned Grand Falls reservoir.

The culture of accountability, transparency and inclusiveness should be adopted in future damming plans to allow the ideas of affected stakeholders to be incorporated in decision-making through a consultative process. Recognition of the right to free, prior and informed consent for local communities should be the basic principle in such consultations.

The results of this study suggest that values of downstream ecosystems and livelihoods were not adequately considered in the design of the existing reservoirs, despite the fact that they experience a disproportionate share of the impacts. We therefore recommend the integration of ecosystem services into future cost–benefit analysis. This will provide conceptual linkages between environmental conditions and human well-being, thus promoting both conservation and development as elaborated by Brauman, Daily, Duarte, and Mooney (2007).

We noticed that unlike most of the other reservoirs in the world, Tana reservoirs are underutilized with the main focus being power generation. We recommend that a feasibility study be carried out on the possibility of utilizing the reservoirs for cage aquaculture and water-based ecotourism. This will diversify livelihood options and aid in dealing with malnutrition and poverty problems in this region. The development of water-based ecotourism has the potential of acting as a catalyst for economic growth along the River Tana reservoir by changing the perception of viewing the numerous hippos, crocodiles and other wild animals in the areas as a source of death to income generators.

River Tana reservoirs can offer important opportunities for poverty alleviation and sustainable development if diversification of livelihoods (beyond their traditional role in providing electricity) could be explored. Adequate stakeholder consultations that propose a trade-off between reservoir development and the traditional uses of the river and the associated floodplains will ensure that maximum benefits are derived from future reservoir development projects.

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