

Full Length Research Paper

Approach to resolving pollution of river water associated with human activities in Tanzania

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Lack of coordination among sectors and institutions is among factors that results in ineffective management of natural resources in most basins in east Africa including Tanzania. In many cases, this has reported to be the most factor contributing natural resources degradation and conflicts between societies. This paper presents findings on different factors affecting the sustainability of the Mara River Basin (MRB) and proposes a management framework that will bring about sustainable resources use in the basin. The study was limited to the MRB part of Tanzania and multiple approaches were used in data collection. The MRB is experiencing a number of management problems including deforestation, land degradation and pollution of the river water associated with human activities. Institutional framework for natural resource management (NRM) is rather sectoral thus lacking integration and sometimes results into conflicting efforts to conserve natural resources. It is evident that some cultural attitudes including gender have positive impact on natural resources management such as the customary land tenure system. For sustainability of the MRB resources, a well coordination of natural resources and livelihoods projects, programs and stakeholders' participation is a key factor without neglecting cultural aspects. Furthermore, different policies need to be considered by linking them together to achieve sustainability.

Key words: Mara river basin, natural resources, sustainable, water resource management.

INTRODUCTION

The Mara River (MR) is an international river, shared between Kenya and Tanzania and the river is very potential in supporting community livelihoods in particular through agricultural production (Majule, 2008). Natural resources (including water, soils, forest, wildlife, macrophytes and others) in most river basins including the MR have been managed in unsustainable manner, thus leading to their depletion and degradation with negative impact to community livelihoods (Majule et al., 2009). Likewise in other basins, climate change and variability coupled with land use change in the basin affects agricultural production in a number of ways including declining crops and livestock production (Salinger, 1992; Frederic, 1997; Majule, 2008; Lema and Majule, 2009; Kangalawe and Lyimo, 2010). Main reasons for resource depletion have been mentioned to be due to population increase, high poverty incidences, lack of coordination in managing resources between sectors and also due to poor technology and lack of incentives (Kangalawe and Lyimo, 2010). Stakeholders in the basin are increasingly facing problems with poor water quality and

environmental degradation in particular soil erosion and compaction (Reij et al., 1996) leading to declining crop productivity and thus limiting efforts to achieving poverty alleviation, improving health and food security. In this case, economic development and protection goals of the natural resources are negatively affected and this requires an understating on both social and biophysical characteristics of the basin in order to formulate appropriate interventions (Salinger, 1992; Yanda et al., 2005; Kangalawe and Lyimo, 2010). Main issues include the loss of forest cover in the upper catchments and along rivers, unsustainable agricultural expansion and intensification (including small scale irrigation), population growth, poorly planned water abstraction, pollutions from mining, agriculture and inappropriate fishing methods. A review indicates that different projects have been initiated in the MRB to address socio-economic economic, cultural and environmental concerns. For example, the MRB Project was developed to serve as a catalytic agent for bringing various stakeholders within and outside the basin to the discussion table to exchange ideas and

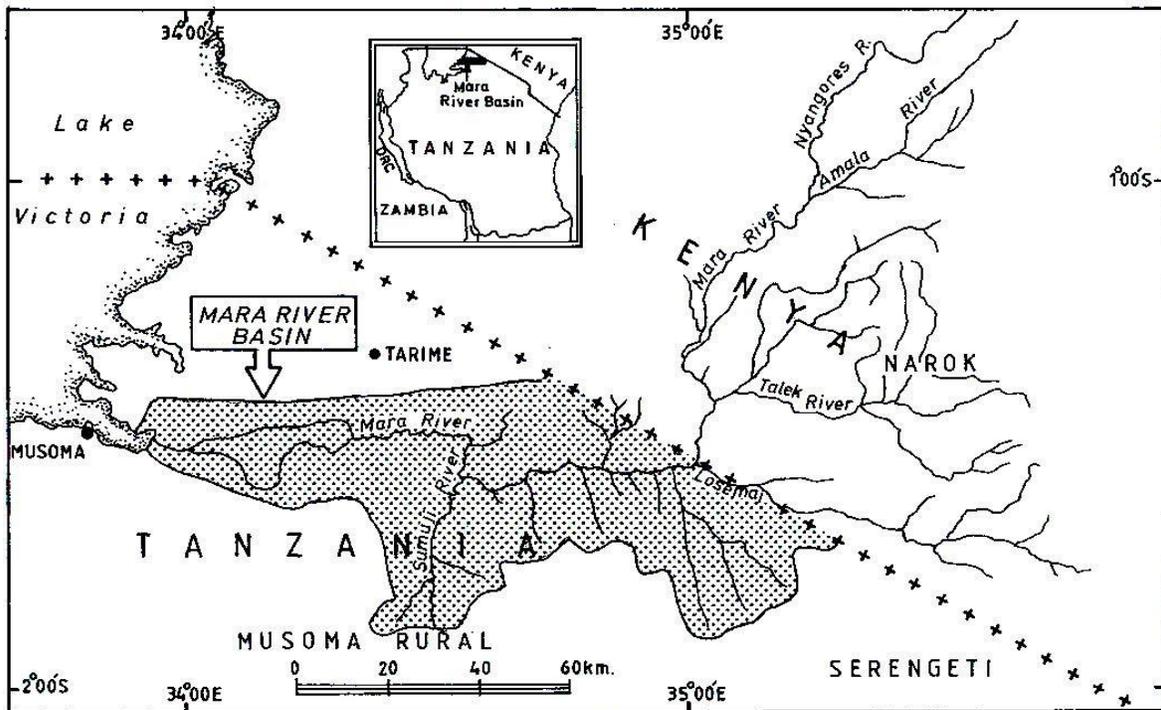


Figure 1. Location of Mara river basin (Source, IRA cartographic unit).

information for planning and implementing shared sustainable management and conservation initiatives. It has been realized that there is a growing need for generating baseline data prior implementing different development programs in order to make sure that development activities does not really compromise with natural ecosystems (Yanda et al., 2007; Majule and Kalonga, 2008; Majule et al., 2009). For sustainable management and development of re-sources of the MRB, there must be political commitments from the governments of Tanzania and Kenya and support stakeholders' dialogue to develop a shared vision, mission and objectives. This means that Tanzania and Kenya needs to develop a management framework that will supervise the implementation of social economic activities taking into account that what ever activity is implemented in the upstream part has no significant impacts socially and environmentally downstream. For example how do you manage agricultural production and livestock keeping in the upper catchment to minimize water pollution and siltation downstream? This requires a compromise between the two countries that share the basin. A baseline study on socio economic and cultural aspects on the MRB was therefore intended to provide different stakeholders and scientific community information that can be used in the planning of different development activities such as mining, expansion of irrigation, sustainable livestock keeping and other investments on wildlife management. MRB is endowed with a number of natural resources which are undergoing degradation due to

several factors. A coordinated planning in managing such resources was therefore revealed to be necessary and thus a need for such study. The paper presents facts about socio-economic, cultural and environmental concerns on the sustainability of the MRB and used such information to emphasize a need to developing a well coordinated framework for managing natural resources in a sustainable way (McDonald and Kay, 1988). This paper also provides a comprehensive analysis of best and poor practices that enhance sustainable planning of the management of the MRB natural resources in particular water. This paper also discusses and proposed the institutional framework for managing natural resources in a sustainable way in MRB and ascertained how socio-economic activities, cultural aspects contributes to resource management. The environmental implications associated with resource management and policy interventions that could be adopted in other basins have also been highlighted for policy implementation.

DESCRIPTION OF THE STUDY AREA

Geographical locations

The MR is an international river, shared between Kenya and Tanzania in East Africa. The size of the MRB is about 13,750 km², of which about 65% is located in Kenya and 35% in Tanzania. The basin is located in the northern part of the country and is shared with Kenya on the upper stream part (Figure 1). The Mara River drains

its water into Lake Victoria and the basin covers Musoma, Tarime and Serengeti districts in Tanzania.

Climate and soils

The Mara region is divided into three major climatic zones namely; i) the northern zone which falls within the MRB in highland area covering Tarime and part of Serengeti districts. This zone receives an average rainfall of between 1250 and 2000 mm per year and it has two rainy seasons; a short one from September to January, and a long rainy season from February to June. This zone favors the growth of different annual and permanent crops including beans, maize and coffee respectively; ii) the central zone which covers much of Musoma district and eastern parts of Serengeti districts. The zone receives between 900 and 1300 mm of rainfall per year and it favors the growth of different crops including rice, maize, sorghum and many others; iii) The last zone is lowland area which includes much part of the Bunda district that does not fall in the MRB.

The region's soils have been formed by weathering of granite rocks resulting into a wide range of soil types. Generally, soils vary from coarse and light to heavy and fine textured soil. Other soil inclusions include light sandy loams, grey clays particularly in the valley bottoms and in wetlands and black calcareous soils referred to as mbuga soils. The later are located in the lower part of the basin and are naturally very fertile supporting the growth of different crops.

Geology

According to De Pauw (1984), geologically the MRB is a flat sheet of dark grey basalt associated with Meta-volcanic rocks. The rocks belong to pre-cambrian age forming a base for the formation of younger rocks. Mara region has been classified into three portions on geological basis.

1. Northern highland: This occupies the whole of Tarime, parts of Serengeti and Musoma and it consists of granite granodiorite foliated gneisses and magnetite.
2. Southern highlands: This occupies the western parts of Serengeti and large parts of Bunda district. It consists of mainly volcanic rocks of alkaline nature
3. Central lowland: Mainly in Serengeti and parts of Bunda and Musoma. It is of Meta-volcanic nature having conglomerates. They also dominate in southern side of the Mara River.

Topography and drainage

Mara Region lie between the low granite hills rising at about 100 m above the gently sloping foothills, which lead down to rather narrow flooded areas of Musoma point, and Makoko foothills (URT, 2003). Other parts of

the region are the areas in which plateau surface is broken up by long narrow hill ranges, which rise above rather flat low lands. There are several hills, which are within the region's area including the Ryamakongo hills, which rise up to 1259 m.s.l, Kibayo hills 1254 m.a.s.l, and Nyabisonga hills. Generally, the topography of the region is undulating to rolling with wide valleys and occasional steep sided hills and this allows for different livelihood systems to interact within and across ecological gradients (Majule et al., 2009). The MR is the only perennial river in the basin and it forms the major drainage pattern in the region with its tributaries flowing to Lake Victoria. Other streams flow to the lowlands forming flood plains which are potential for livestock grazing as they provides water and favors pasture growth for livestock grazing (Figure 2).

STUDY METHODOLOGY

This study used both secondary and primary data. Secondary data collection involved review of existing reports (unpublished, gray and published reports) from libraries and documentation centers in various institutions in Dar es Salaam and Mara Region. Some reports were also made available through Internet search. Secondary information were supplemented by primary data at district level whereby small meeting were made with District commissions, District Executive Directors, District Planning Officers, District Agricultural and Livestock Development Officers, District Natural Resource Officers and Community Development officers for Musoma, Tarime and Serengeti Districts.

In this case a total of 18 stakeholders were consulted in total for all three Districts. Since the study had to be conducted in a limited period of time, the Participatory Rural Appraisal was employed where by a checklist with few key questions was used to collect required information. The method's cornerstone was interactive learning, knowledge sharing and assurance of high local people's participation.

The Participatory Research Approach methods were applied to quickly generate additional information through transects walk (Chambers, 1992; Kangalawe et al., 2005; Majule and Mwalyosi, 2005). The interviews with leaders at district level took place in an informal way where only some of the questions were predetermined and the rest arose during the interview.

The study also involved visiting of some specific areas for physical observation on how natural resources are being managed and implications on the ecosystem. Such areas include a number of hotspot areas such as a gold mine at Nyamongo, farmlands and selected forestry patches in the MR flood plain and villages situated nearby. In the village a total of 15 community members attended at focus group discussion including a Village Executive Officer (VEO) and a village chair person. On the other hand, at the Nyamongo mining, a total of 5 people were involved in the discussion including company manager, an administrative officer, 2 geologists and a waste management expert. The information collected consolidated this paper about MRB. Due to the scope of this study, data collection was limited to Tanzania part of the MRB.

RESULTS AND DISCUSSION

Socio-economic characteristics

The findings reported under this section are purely based



Figure 2. Part of the Degraded Simoni Riverline Forest in Ikongo Area (Photo by Majule, 2008).

on review and consultations made between a researcher and district leaders and few other stakeholders consulted at community level.

Administrative issues

It is estimated that about 65% of the MRB is in the Kenyan side and 35% in the Tanzanian side. In Tanzania, the basin falls under Mara administrative Region which is divided into four districts namely Musoma, Tarime, Bunda and Serengeti. Bunda is the only district which does not fall in the MRB. The MRB has a total of 16 divisions, 97 wards and 336 villages by the time of this study.

According to the consultations made, currently there is no coordination in the planning and management of common resources found in the MRB. For example, planned activities on water resource use by abstracting water from the MR for hydropower development on the Kenya side is likely to have large impacts on the ecology of the Mara river and consequently on Lake Victoria. This or any other development initiatives in the upper part that will entail water use from MR are also likely to have implications on community livelihoods downstream. Under such a situation a cross border integrated planning on resources use and management is very important for sustainability of the MRB ecosystem and community livelihoods. The proposed Amala Weir Water Diversion Project and the shelved Ewaso_Ngiro Hydropower project will significantly reduce water quantity and

completely drying of the Mara River under severe drought. Implications of this development on the Kenyan side would have severely affected the Serengeti ecosystem and the livelihood of the people on the Tanzanian side.

Other initiatives that can be seen as opportunities include the involvement of East African Community and the Nile Basin Initiative (NBI) in particular the Mara River Basin Project under NBI. Moreover, there is Lake Victoria Basin Water Office at the national level that deals with management of water resources in the basin part of Tanzania. Figure 4 proposed a best implementation framework for sustainability of natural resources in the basin.

Although there are policy frameworks governing integrated approach in managing natural resources in the basin, it is evident that in practice there is lack of coordination in planning and management of natural resources in the MRB. A common practice is that each of the three districts is fully mandated in the planning and management of various natural resources found in their respective territories. It is often the case that most of the ecological units are cross border resources and are managed differently and management plans therefore do not complement each other. For examples, the river itself and pockets of forests located in Ikongo area are shared by more than one district but managed using different approaches. Under such situation, it has been found that lack of integrated approach in natural resource management among the three districts has contributed to the on going degradation of natural resources in the basin

ecosystems. Typical examples of problems observed to be associated with lack of integration in resource management include;

1. The Serengeti District council is currently implementing a strict by-law, which restricts large scale charcoal burning while the neighboring districts of Tarime and Musoma are not implementing such by-law. As a result, charcoal business is mushrooming in the Tarime and Musoma Districts leading to further forestry degradation.
2. The remaining part of the Simoni Riverline forest at Ikongo area (Figure 2) is only found on the Serengeti side while on the Tarime district side has been completely cleared and converted into grazing and cultivation.

Integrated planning must be extended to lower administrative units such as wards and villages. For example, more than one village located in the Kisaka ward shares the Ikongo forest within Serengeti district. Apparently, it is Buchanchari and Nyansurumunti villages in only that have taken strong initiatives to conserve resources in the MRB. The strategy used includes prohibit tree cutting for various uses, use of forest for recreation purposes, and set of a fine of \$10 (Tshs 10,000) for offenders violating these by laws.

Ethnicity, cultural characteristics

In the MRB, there is diversity of ethnicity that is associated with different cultural attitudes with various impacts on natural resource management. The dominant ethnic groups in the MRB are Wakurya, Wajaluo and Wajita (URT, 2003). In Tarime and Serengeti districts, the dominant ethnic group is Wakurya. They occupy the major fertile land in the districts mainly in highlands. Wajaluo are also found in parts of Tarime district. Wajita are dominant in Musoma district and other small tribes such as Wazanaki, Wasuba, Waikizu, Waisenyee, Waikoma, Wangoreme, Wakwaya, Waluli and Washashi also characterize the region's ethnicity picture.

Wakurya is a native tribe and has maintained its culture over decades and this has strong impact on management of land resources. For example, this study revealed that land is owned by clans thus it is difficult for the village government to plan on how land can be used. On the other hand, such land tenure system seems to be effective in that they the owners have security over land resources and they can therefore manage it appropriately. In such a situation it is hard to find deforestation taking place by outsiders. They have regulations and rules on how land resources can be managed. This practice should be seen as an opportunity in natural resources management perspectives.

On the other hand, the clan system has large impact on population size in Tarime district. This is because clans are confined in defined geographical areas, densely

populated and thus restricting movement of people from one area to another area occupied by a different clan. The only interaction (outlet) is through marriages. Under circumstance that the population in a clan is large enough, resource degradation is likely to occur. In this regard, people are forced to move to the neighboring districts such as Serengeti searching for agricultural land and pastureland. This is a threat to MRB management.

Culturally, most ethnic groups in the Mara Region are agro-pastoralists and they value the number of livestock as a sign of wealth and a symbol of status in the society. As a result, large herds of livestock particularly cattle are found in the basin. The survival of livestock depends largely on Mara River resources particularly water and pasture. Excessive livestock keeping is a threat to the basin ecosystem.

In terms of gender, there is also a significant division of labor and resource ownership based on gender. For example most of the land is owned by male while female undertake most of the farming and household activities including for example firewood collection. It was also noted that most of the fishing, miming, hunting and charcoal business, livestock keeping are done by young and middle aged male. Male are in most cases the head of households but there also very few females who head households (less than 5%) and there are those who tends to own another female to work for them through "*Nyumba nyitu*" arrangements.

Within the basin there are pockets of forests on water sources, which are used as sacred sites. Such cultural believe environmentally friendly because water and forest resources are protected. Such areas may also be of biodiversity importance similarly to what has been reported elsewhere (Yanda et al., 2005; Kangalawe et al., 2005; Majule and Mwalyosi, 2005).

Population characteristics

The 2002 Census report provides population data of Mara region (URT, 2003). The region had a total population of 1,368,602 people of which 715,153 were females and 653,449 males (Table 1). Average household size is 5.5 members and the annual average population growth 1988-2002 was 2.5% (URT, 2003). The 1988 population census placed Mara as the seventh most densely populated region after Dar es Salaam, Mwanza, Kilimanjaro, Mtwara and Kagera at 43.7 persons per square kilometer. However when we exclude the Serengeti National Park area, the population density of Mara region increases to 76 people per square km making Mara region the fourth most populated region in mainland Tanzania. Due to high population density, competition for land between cultivators and herdsmen is escalating and deforestation marches on at an alarming rate (URT, 2003). Competition for land resources eventually contribute to land degradation and consequently

Table 1. Population structure at district level in the MRB.

District	Total populations				Growth rates		
	1967	1978	1988	2002	1967/78	1978/88	1988/2002
Musoma	196,625	263,129	316,632	330,953	2.7	1.8	2.4
Tarime	188,536	253,010	333,888	492,798	2.7	2.8	2.8
Serengeti	158,984	207,688	111,710	176,609	2.4	7.5	3.3

Source: URT (2003).

Table 2. Major livestock distribution in the Mara river basin.

Type of livestock	District		
	Musoma	Serengeti	Tarime
Cattle	272,635	199,533	307,694
Goats	90,606	307,694	150,300
Sheep	40,257	150,300	69,265
Donkey	1,698	432	2,738

Source: URT (2003).

change the catchment's hydrology such as infiltration characteristics which brings about soils and river bank erosion which was observed during field visit during this study (Table 4) .

Major economic activities

Major economic activities in the Mara region and particularly the MRB are agriculture, livestock production, fishing, mining and business and trade. Mara region communities rely on livestock production and ownership predominantly cattle, goats and sheep to fulfill social as well as economic needs. Livestock sector is the second most important contributor to the region's economy. It is estimated that 51% of total agricultural households in Mara region keep cattle and the size of herd per household ranges from 50 to 1000 cattle. Animals represent a bank stock, to be purchased when there is good harvest and sold during distress times in order to buy food. Cattle and donkeys are widely used for transportation of crops and other domestic goods and for ploughing. However, over the past decade, the occurrence of erratic rains and livestock distress, sales have tremendously reduced the quantity of livestock in Mara region to the extent that very few households now own cattle. Cattle ownership is more widespread in the midlands agro- pastoral communities. Table 2 shows livestock population in the three districts.

Most of the livestock kept in the area is grazed in the MRB, particularly in the flood plain during the dry season due to water and pasture availability and grazed in the uplands during the rainy season. There is no proper land allocated for grazing which is one of the major setbacks

in pasture and water management in the basin.

In Tanzania the agricultural sector contributed 48% of the countries Gross Domestic Product (GDP) and about 65% of the total foreign exchange earnings in 2000 (URT, 2000). Food crops grown in the region include: cassava, maize, sorghum, finger millet, paddy, sweet potatoes and beans. Production trend of food crops is shown in Table 3. Cash crops grown in the basin include: cotton, coffee, sunflower, tobacco and groundnuts. Production trend of cash crops is shown in Table 3 fluctuating yields are probably due to the fluctuation of weather conditions in the region.

Average individual annual income (per Capita GDP) in Mara region had improved from US\$ 142 in 1995 to US\$ 226 in 2000. Irrigated farming in Mara region is not common although it is feasible considering the existence of Lake Victoria and Mara River. Currently, individual households, growing mainly vegetables, do irrigated farming on a very small scale. Fishing provides employment for people along the lakeshore generating good incomes and sustains the fish trade within and outside the country. However, fishing contributes little to the region's economy compared to crop production and livestock keeping. Trade and industry do not have much significant importance to the region's economy. There is no reliable status on the catch volume and income generated from fishing in the river. Most of the available information refers to the catch volume from the lake. This is because fishing in the river is not considered to contribute significantly to the economy of the region.

Mining research conducted in the region has revealed that the region is rich in minerals, mainly gold, kaolin, limestone and gemstones. Currently, both artisanal and

Table 3. Production of major food crops in Mara region.

Crop/year	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	Year average
Cotton	21852	22846	5580	3003	22433	19095	17559
Coffee	1651	2011	2009	4077	2344	36	2585
Tobacco	65	75	600	190	N.A	N.A	233
Sunflower	40	149	68	18	240	100	134
Groundnuts	1450	154	848	512	1738	490	960
Total	25058	25235	9105	7800	26755	19721	21471

Source: URT (2003).

large-scale miners are operating in Mara region (Buhemba in Musoma and Nyamongo in Tarime districts). Artisanal mining is operated in areas around the large-scale mining at a small scale and is operated illegally. Large-scale mining operations are conducted by Afrika Mashariki Co. Ltd in Nyamongo and Meremeta Co. Ltd in Buhemba. Data on incomes generated by private companies from gold were not made accessible. The only available data is of early 1990s when gold was purchased by the Bank of Tanzania from small-scale miners.

Existing institutional framework for managing natural resources

It should be pointed out that MRB is shared between Tanzania and Kenya; hence an effective management approach should consider the entire basin. Management of the Tanzanian part of the basin will not be effective because it is the lower end of the river system, since mismanagement on the Kenyan side will have pronounced effect on the Tanzanian side. Similarly, the Tanzanian part of the basin should also be managed in an integrated manner.

The current local government reform has given district councils full mandates to plan and implement various development activities including management of natural resources. Figure 3 illustrates the existing institutional framework at district level. The existing framework has both strength and weaknesses. Major strength includes the coordinated ability the structure has in that all the sectoral directives from various ministries converge into District Executive Director's (DED) office. Various technical personnel representing key sectors support the DED thus ensuring integrated approach in the planning process.

The existing institutional framework (Figure 3) is intended to facilitate effective planning and implementation of various activities on the ground by ensuring that there is both top down and bottom up communication. However, lack of extension officers for some key sectors at the grass-root level is one of the limitations associated with this framework. For example, there is no extension staff on water resources, land and other natural

resources at the village level. There are some management efforts in place such as Serengeti National Park though it covers only a segment of the basin. Lake Victoria Environment Management Project is another regional management initiative. However, this management initiative is project oriented in that its activities will be implemented within a given time frame.

A summary of key issues affecting resource management in the MRB

This study has revealed that most of socio-economic activities (Table 4) undertaken in the area have a large impact on MRB ecosystem. The study identified a number of natural resources management practices undertaken within the MRB. In general, human activities have been identified through consultations to have significant implications on natural resource sustainability and productivity as indicated in Table 4. This cause effects relation enabled a researcher to propose appropriate interventions which can also be applied elsewhere with similar conditions.

Community involvement in resource conservation and management

The land tenure system of Kurya ethnic group provides a good footing for community involvement in natural resources conservation and management. The clan regulates management of land resources. In this regard, these ethnic groups need to be facilitated by advocating for appropriate management approaches. It should also be pointed out that the initiative taken to ban charcoal making in the district is a lesson to learn and can be applied to all the districts. However, a caution is that such decisions should be effective only if alternative source of energy is given. Also, the initiative of Buchanchari Village to conserve the forest at Ikongo area is a testimony that if the villagers are coordinated they can come up with effective management plan for their own resources.

There are several initiatives taken by district authorities that aim at resource conservation and management. For

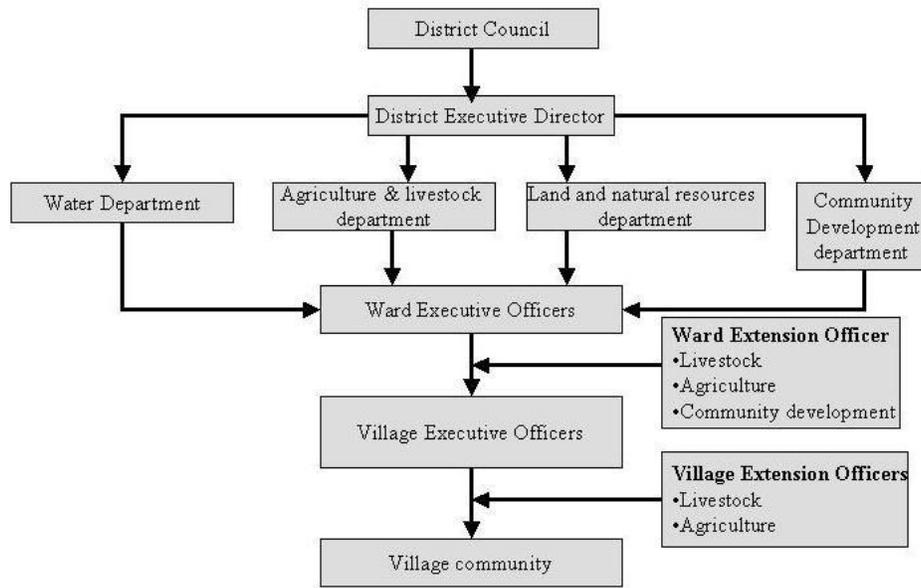


Figure 3. Institutional framework for managing natural resources at district level.

Table 4. Key Issues that need solution for sustainable MRB management and development.

Practices	Responsible actors in addressing the problem	Established impacts/threats	Proposed interventions
-Excessive water abstraction from the MRB river	-Mining companies -Crop irrigators -Livestock keepers	-Water disposal mechanisms is questionable -Water pollution	-Develop Integrated Water Resource Management (IWRM) plans -Abide to water allocation schemes - Conservation of water sources
-Deforestation along Mara river	-Local communities, Local governments, NGOs, CBO, Forest Departments	-This is a threat to environment in particular soil erosion, loss of carbon and global warming, loss of species and diversity	-Provide education to the communities on tree conservation -Introduce tree planting schemes - Encourage agroforestry practices
-Cultivation and grazing along the river bank	-Local communities, River - Basin Offices, Agricultural - Research institutions, Local Governments (DALDOs)	-Enhancing river bank erosion and river siltation	-Develop village land use plans -Undertake research on appropriate practices -Develop by laws on river bank use
-Illegal fishing practices -Use of chemicals -Fishing in breeding points	-Fisheries and Livestock Departments, Fish traders, local communities, NGOs, CBO	-Raises great concern to human health and water quality -Destroy breeding sites	-Establish by laws on illegal fishing -Education on better fishing practices
-Poor agronomic practices	Local communities	-Threats to the land and river siltation, soil fertility loss	-Train communities on better agronomic practices
-Illegal wildlife hunting in forestry patches (Ikongo Local communities, hunters area) and Game reserves		-Threats to both large (buffaloes) and small mammals	-Introduce alternative sources of income -Training in wildlife resource management -Involve communities in managing wildlife

Table 4. Contd.

-Un controlled fire	-Local communities (hunters, cultivators, livestock keepers)	-Loss of species of ecological significance and loss of soil fertility	-Education on impacts of fire -Establish by laws on fire
-Small scale gold mining particularly in Mara	Local communities	-Threats to water quality, land degradation (development of bad lands)	-Control small scale mining activities by providing appropriate guidelines and technologies

Source: Fieldwork and consultations with stakeholders.

example, a number of bunds to trap water in the sub-catchments for irrigation are being constructed in all the districts through funding from the central government. This effort is a result of the Mara Farmers Initiative Project (MaraFIP) concluded in 2002 (URT, 2003) and it aimed at enhancing food production, particularly rice as food and cash crop using the available water resource. Similarly, a number of watering points for livestock and dips are being developed in the various districts. Also, more watering points and dips are planned for future development. Such efforts aim at promoting livestock production, as it is the major activity in the basin. Furthermore, appropriate distribution of livestock watering points and dips is necessary to ensure even distribution of livestock, thus reducing effects of degradation in concentration areas due to trampling and overgrazing. Furthermore, village governments in Tarime and Serengeti districts are implementing Wildlife Management Areas (WMA) on pilot basis. This is seen to be a sustainable way of managing resources in parts of the MRB. The economic gains from such program support development activities and needs to be sustained.

Management of water resources in the MRB

There are three major sources of water in the MRB. These include water from the river Mara, water harvested in micro catchments draining into the main river water systems and borehole systems. Water from the main river systems is used for mining activities in Africa Mashariki Gold Mine whereby water license permit allowable abstraction rate of 4200 m³/day, and current average daily usage is about 3200 m³/day. Out of that, nearly 60% is recycled into the production system. This is the only large water abstraction activity in the basin. Other uses of water from the river include livestock and wildlife, domestic use and small-scale irrigation. All these activities use small amount of water. Water collected in micro-catchments is used for irrigation (Mara bands), livestock and domestic use. For example, in Serengeti alone there are 2 dams (Iseresere and Nyamandicha) constructed by MaraFIP and about 27 Chaco dams constructed by different stakeholders.

The responsibility of water resource management

currently rests under the power of the DED (Figure 3). However, the relevant technical personnel will do technical undertakings. For example, agricultural experts are involved if water is to be used for irrigation while livestock experts are involved if water is collected in dams for livestock drinking.

One of the major problems is lack of technology to abstract significant amounts of water for various uses. For example, watering cans, small furrow canals and small powered water pumps are used to draw water from the river. Presently, local communities do not realize water quality to be a problem. However, there is a growing concern from the regional and districts authorities that water is being polluted from different sources mainly gold mining and fishing by using illegal chemicals. With regards to the gold mining, the effectiveness of the waste disposal dam has not yet been monitored. What is more worrying is the artisan type of mining involving the use of mercury in gold extraction since the process is undertaken in streams draining into the main river system.

Impacts of socio-economic activities on the hydrology and other resources of MRB

A link between major economic activities and hydrology in the MRB is that the landscape characteristics determine the hydrology of the river system. On the other hand, socio economic activities can modify natural landscape characteristics and thus altering the river hydrology. For example, land degraded due to intensive crop cultivation and overgrazing enhances surface run off, less water infiltration, accelerates evaporation in a way reported by Scwab et al. (1993). In such a situation the river experiences less flow during the dry season, deforestation of river-line forest encourages riverbank erosion, desiccation of the wetlands, which are important habitats for flora and fauna, and wetland degradation also reduces buffering and water storage capacity of the wetlands. Wetland degradation due to poor farming practices has also been reported by Majule and Mwalyosi (2005) in the Rufiji River Basin. The impact of socio-economic activities on the basin hydrology as pointed out above is presently visible in the area. For example, high

Table 5. Pair wise ranking of different impacts on hydrology and natural resources due to human activities.

Number	Impacts identified	Total score	Rank (Position)
1	Deforestation and degradation of forest	8	1
2	Drying of wetlands and other water sources	6	2
3	Declining of soil fertility	5	3
4	Siltation of the Mara River	3	4
5	Pollution of the Mara due to chemicals	2	5
6	Soil erosion	2	5
7	Conversion to bad land due to mining	1	6
8	Soil compaction	1	6

Source: Field pair wise ranking (2008).

concentration along the river system has contributed to the degradation of immediate catchment areas through overgrazing and trampling. Such practices could lead to severe degradation if measures to control livestock movement are not taken. A study conducted by Yanda et al. (2005) in the Bahi basin revealed a need for controlling livestock numbers to meet the carrying capacity in wetlands and this also apply in the management of MB resources. Furthermore, livestock water drinking directly to the river system is causing riverbank soil erosion. Cultivation very close to the riverbank was also found to be common thus enhancing riverbank erosion. On the other hand, the ongoing bush fires and deforestation (for charcoal, fuel wood and building materials) reduces vegetation cover thus impacting the river system hydrology as pointed out above.

A focus group discussion using pair wise ranking approach at Ikongo village provided information on how different socio economic activities have negatively affected the hydrology and other resources in the basin. The analysis (Table 5) revealed 8 major impacts on hydrology and natural resources of the MRB that is associated with social economic activities. Deforestation and forest degradation scored the highest and this was followed by drying of wetlands and declining of soil fertility. Siltation of MR scored fourth and this was described to be associated with removal of vegetation cover in particular deforestation and cultivation near river banks. Siltation is common in most great rivers and has also been reported by Majule and Mwalyosi (2005).

Other impacts reported were pollution of MR water due use of agricultural chemicals in particularly fertilizers and chemicals for fishing as well as use of chemicals by both small and large scale miners. Interventions in addressing such problems should be part of the management issues for MRB indicated in Figure 4.

Proposed framework for sustainable natural resources management in the MRB

To ensure that water resource is properly managed at

basin level, the government of Tanzania has developed a structure on which river basins under the ministry of water has a mandate of managing water resources effectively (Figure 4).

The foundation for the implementation of the new guidelines in the water sector in Tanzania is the Water Sector Development Plan (WSDP) (URT, 2007) and its implementation manual in its updated version of 2007. In this case, the development of the program for the three elements of the sector is explicitly considered. The framework shown in Figure 4 is also applicable in the MRB and this also need to be applied to the upper catchment areas in Kenya part but should not compromise with the existing structure.

Policy implications on MRB management

Environmental conservation has to be analyzed in the context of the relevant policies governing management of natural resources and sustainable livelihoods. Table 5 presents a summary of key policy issues in terms of opportunities and constrains that need to be taken on board in addressing legal aspects to the planning for conservation of MRB.

Conclusions

Agriculture and livestock keeping are the major socio-economic activities in the basin. It is these activities that have adverse impact on the ecosystem. MRB is experiencing a number of natural resource management problems including deforestation, land degradation and pollution of the river water due to mining and illegal fishing using poison. The management approaches seem to be sectoral, thus lacking integration. Local community involvement in natural resources management is also not properly co-coordinated and therefore less effective and conflicting. It is evident that some cultural attitudes have positive impact on natural resources management such as the customary land tenure system in the Kurya

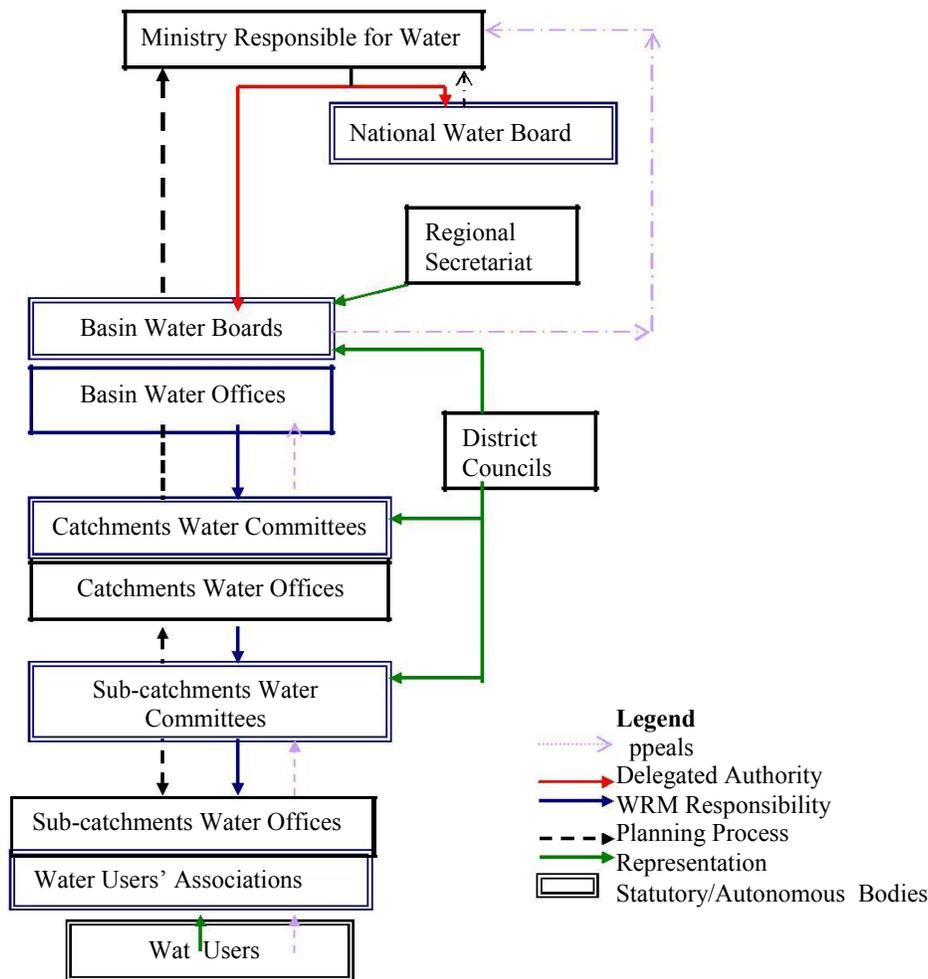


Figure 4. Relationship between Different Institutions in Water Resource Management in Tanzania (Source URT, 2007).

community. Despite of promising efforts both in terms of policies and strategies for managing natural resource in the MRB, knowledge sharing across basins is still needed to manage shared resources in particular water effectively. Other factors including climate change impacts, vulnerabilities and adaptation strategies needs to be considered and then integrated into the basin management framework.

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