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THE SOCIO-ECOLOGICAL IMPACTS OF MUSHANDIKE DAM, MASVINGO, ZIMBABWE

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ABSTRACT

Demand and supply of water over space and time is being influenced by changes in land use, population growth, industrial development and construction of dams. In this study, we focus on Mushandike dam located in Mushandike Sanctuary, Zimbabwe, and evaluate the socio-ecological impacts associated with this dam. We gathered data through interviews with local farmers and agricultural extension officers. We also retrieved historical data on rainfall, water levels, fish harvest and irrigated agricultural production linked to Mushandike dam. Following Mushandike dam construction, several people were relocated and a resettlement scheme adjacent to Mushandike Sanctuary was established with water from the dam being used for irrigation. The relocation had positive impacts in the early years of the irrigated agricultural schemes as the standard of living for the families improved. However, the situation has recently changed as the farmers are now faced with water scarcity for crop irrigation. The irrigation scheme has failed to operate for over a year now due to competing demands on the water resource. This study attributes the main cause for the water level decline in Mushandike dam to the increasing losses of water as it flows from the dam and to the irrigation canals. Water scarcity has resulted in the reduction in crop production and decreased aquatic life in the dam. There is need therefore, to improve water management in Mushandike catchment to allow for sustainable conservation and development.

Keywords: dam, hydrology, irrigation, land use, sustainable development, water scarcity

INTRODUCTION

In arid to semiarid countries water may be the single most important limiting resource in sustainable development (De Bruine & Rukira, 1997). Water, the basic element of the life support system of the planet, is indispensable to sustain any form of life and virtually every human activity (Zbigniew, 1997). Sustainable water supply development implies the use of water in such a manner that no adverse effects are induced for people or ecosystems that have been dependent on the availability of natural water resources, and in a way that sufficient quantities of acceptable quality will be available to future generations (De Bruine & Rukira, 1997; Everard & Harper, 2002; Zbigniew, 1997). The global increase in construction of dams during the twentieth century and the associated negative impacts has brought attention to the need for project managers and financiers to adopt more sustainable practices in construction, operation, and eventual removal of dams (Beck, Claassen, & Hundt, 2012). Consequently, the World Commission on Dams (WCD) was established in 1998 to promote more sustainable approaches to dam development (Beck, et al., 2012).

There is increasing concern about the availability of water supplies in developing countries to provide clean drinking water and sanitation as well as providing for irrigation to enhance food security and wildlife conservation (Andre, 2012; Gozo, 2011; Inkoom & Nanguo, 2011; Rusinga, Murwendo, & Zinhiva, 2012). However, hydrological changes and unsustainable water use over space and time are and will continue to be an issue, induced by both climate change and anthropogenic factors related to land and water management (Chifamba, 2011; Cudennec, Leduc, & Koutsoyiannis, 2007; Postel, 2003). High demand of water has led to dwindling of water tables, shrinking and drying up of rivers and lakes (Cudennec, et al., 2007). Although the benefits of dam construction are numerous, particularly in the context of climate change and growing global demand for electricity, recent experience has shown that many dams have serious negative environmental, human, and political consequences (Baxter, 1977; Brown, Tullos, Tilt, Magee, & Wolf, 2009; Bunn & Arthington, 2002; March, Benstead, Pringle, & Scatena, 2003; Zisadza, Gandiwa, Van Der Westhuizen, Van Der Westhuizen, & Bodzo, 2010). According to Postel (2003) water modification and appropriation for human purposes is costing more than benefiting, meanwhile, creating irreversible damage on species and ecosystem services. Therefore, there is need to enhance our knowledge in order to allow scientists and natural resource managers to reliably predict and quantify biotic responses to changes in the collection, storage and discharge of water, at various scales from the local to the sub-continental (Bunn & Arthington, 2002).

This paper contributes to the existing knowledge on the socio-ecological challenges related to irrigated agricultural production and nature conservation around Mushandike dam in Masvingo, Zimbabwe. Information from this paper will be valuable in addressing potential conflicts likely to arise from increasing water scarcity, raise awareness on the interdependence between upstream and downstream land and water use by the various stakeholders, and negotiations related to water use, hence necessitating the need for continuous sharing of information and communication geared towards sustainable management of the water resource. We therefore, addressed the following two questions: 1) what could be the possible causes for the continued water level declines in Mushandike dam? 2) What is the impact of dwindling water resources on the ecological function of the aquatic ecosystems in Mushandike dam and downstream?

MATERIALS AND METHODS

Study area

This study focusses on Mushandike dam which is located within Mushandike Sanctuary, Masvingo, Zimbabwe. Mushandike Sanctuary measures 129 km^2 in extent. The dam was constructed between 1980 and 1990. The construction of Mushandike dam in the early 1980's resulted in the relocation of over 400 families from their rural homes into nine villages which have since increased to 10. The dam lies in agro-ecological region IV with average annual rainfall of 650 mm. Among Zimbabwe's five ecological regions, regions IV and V are semi-arid and have erratic rainfall making these areas sensitive to changes in the hydrology. Water resource management assessments, at any scale, in such regions are crucial as uses of water keep increasing with population increase, rise in living standards, development of irrigated agriculture and rise in recreational activities (Postel, 2003).

Mushandike Sanctuary hosts numerous wildlife species some of which include water dependent species such as waterbuck (*Kobus ellipsiprymnus*) (Richardson-Kageler, 2003). The sanctuary's aquatic life includes fish and macro-invertebrates. Common fish species in Mushandike dam include: greenhead tilapia (*Oreochromis macrochir*), Mosambique tilapia (*Oreochromis mossambicus*), tilapia (*Tilapia rendali*), black bass (*Micropterus salmoides*), African sharp tooth catfish (*Clarias gariepinus*), *Serranochromis robustus* and *Labeo cylindricus*. Downstream, apart from humans, the water is used by livestock and for irrigation. The Mushandike dam catchment comprises three intermittent rivers which only contain water and flow during the rainy season (Fig. 1). Mushandike irrigation scheme adjacent to Mushandike Sanctuary has a 25 km open canal, which has concrete lining on 17 km and the rest is earth without any lining (Ndamba, Sakupwanya, Makadho, & Manamike, 1999). Individual agricultural plots at Mushandike irrigation scheme are 1.5 ha in extent.

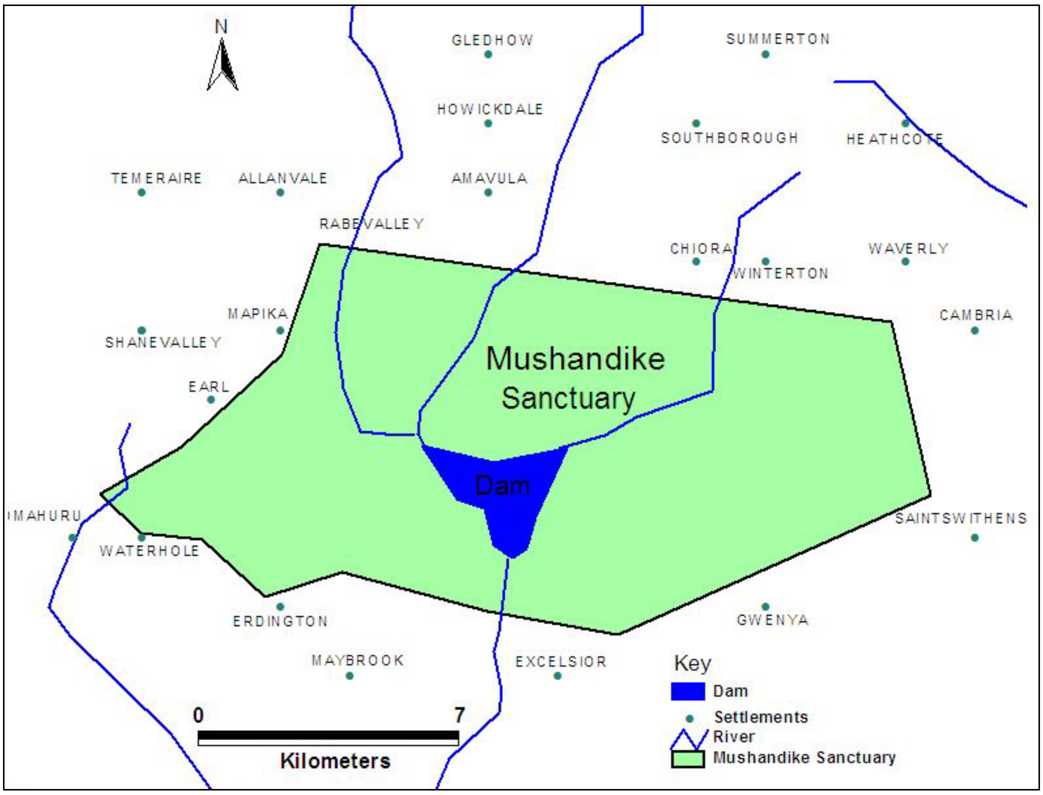

Figure 1. Location of Mushandike Dam in Mushandike Sanctuary, Zimbabwe. Source: This study

Data collection and analysis

Field visits and interviews were conducted with 20 local farmers, 15 fisherman and two agricultural extension officers in Mushandike area in October 2012. Discussions focussed on water use efficiency (Howell, 2001), patterns and causes of water level changes in the dam and possible dam impacts on agriculture and nature conservation. Records of rainfall patterns and crop production were obtained from Department of Agricultural Research, Technical and Extension services (AGRITEX). Fish catch data were retrieved from Mushandike Sanctuary research archives. The data included fish species, counts and weights. Moreover, data on historical and recent water levels in Mushandike dam were collected from Zimbabwe National Water Authority (ZIMWA). Data were analysed using descriptive and qualitative approaches.

RESULTS AND DISCUSSION

Causes of water level decline in Mushandike dam

Farmers were concerned with the rainfall they have been receiving in the recent past (mean = 598 mm for the period 2007–2011; Fig. 2), which they regarded as relatively low. However, the received rainfall between 2007 and 2011 is only about 50 mm below the long-term annual rainfall for the Masvingo region suggesting rainfall was somewhat within the range of variation for the region. Based on local knowledge, Mushandike dam recently only spilled twice in 1999 and 2001. Farmers pointed some of the existing water loss points as outlined in Table 1. Similarly, Ndamba et al. (1999) estimated the water loss to be about 42% of the total flow from Mushandike dam. In addition, climate change was raised as a possible factor that could have contributed to the slight reduced rainfall hence leading to lower water levels in the dam in the recent past (Fig. 3). However, climate change effects are difficult to identify since the impacts are long term and difficult to single out (Gandiwa & Zisadza, 2010).

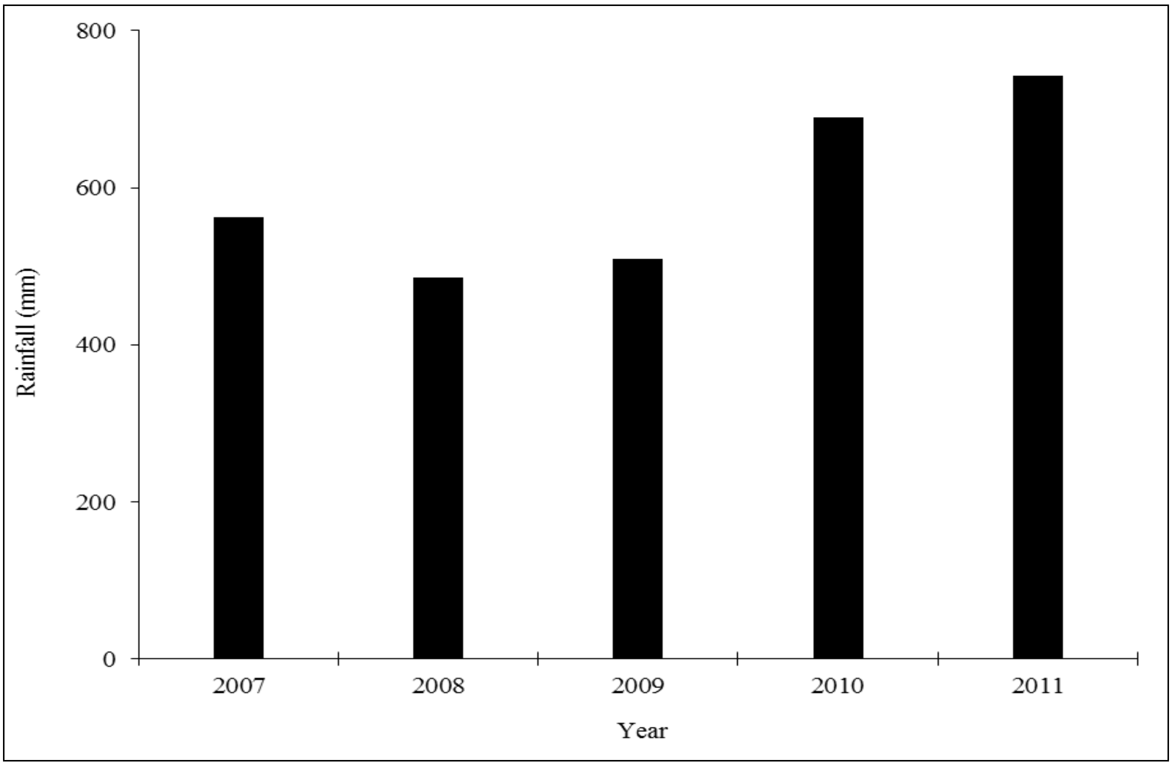

Figure 2. Rainfall received between 2007 and 2011 in Mushandike catchment, Zimbabwe. Source: AGRITEX, Masvingo

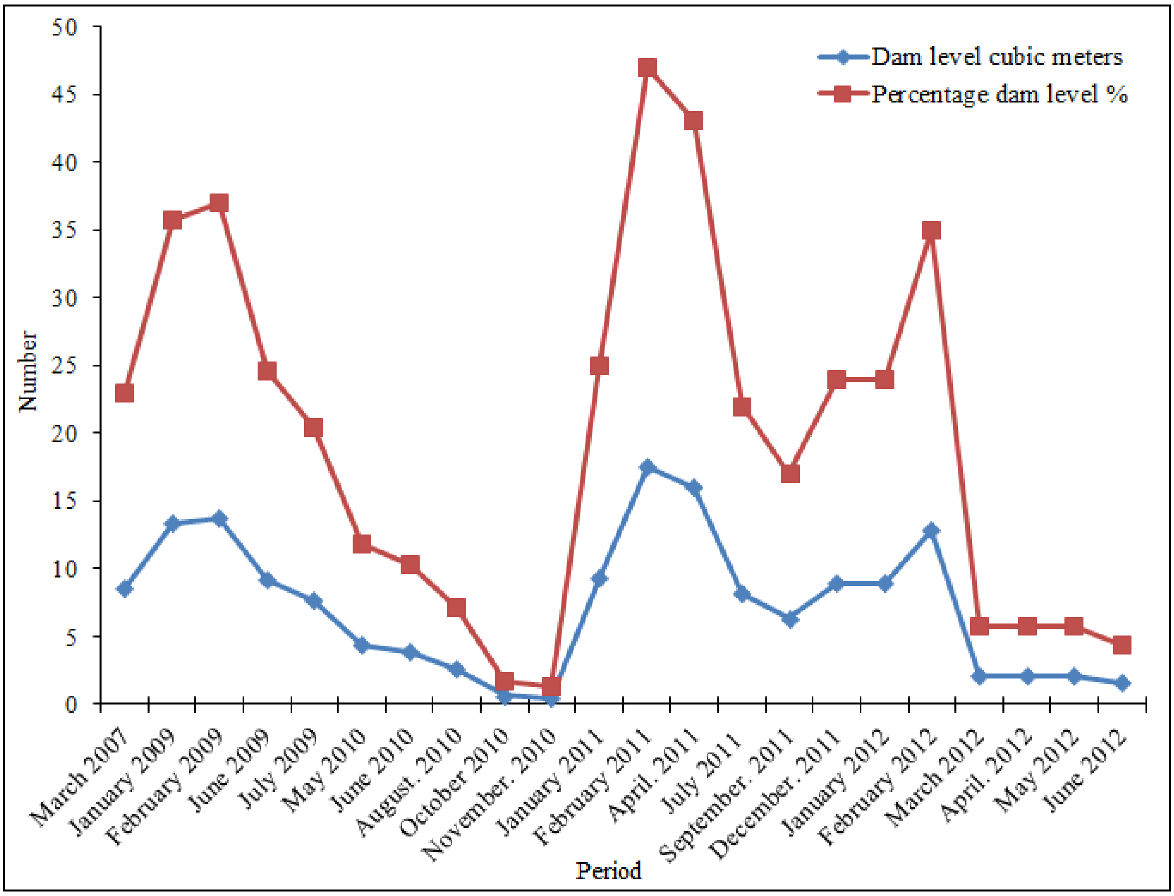

Figure 3. Trends in water levels in Mushandike dam, Zimbabwe, between 2007 and 2012. Source: ZINWA, Masvingo

Table 1. Summary of the perceived causes of water loss in Mushandike dam, Zimbabwe

Point of water loss	**Cause of water loss**
Canals (from dam to fields)	Water loss from seepage along the canals due to cracks and blockages
Increased water extraction	Water extraction from increasing human settlements adjacent to the dam
Siltation	Siltation of the catchment rivers due to upstream agricultural activities

Source: Fieldwork, October 2012

Local farmers and AGRITEX officers pointed out that the Mushandike irrigation scheme was originally planned for 417 families during dam construction. Since 1985, when the irrigation scheme was first established, water from the dam has been used to irrigate crops such as cotton (*Gossypium* spp.), wheat (*Triticum* compactum), sugar beans (*Phaseolus lunatus*), soyabeans (*Glycine max*), paprika (*Capsicum annuum* var. *angulosum mill*) and maize (*Zea mays*) (see Fig. 4 for example). Particularly, tomatoes (*Solanum lycopersicum*) and cabbages (*Brassica oleracea* var. *Capitata*) have been mainly grown. However, due socio-political dynamics in Zimbabwe over the years, more people have been reportedly settling in the scheme leading to an increase in the number of families. This increase in families and expansion in water use resulted in increased water demand hence negatively affecting the water resources in the study area.

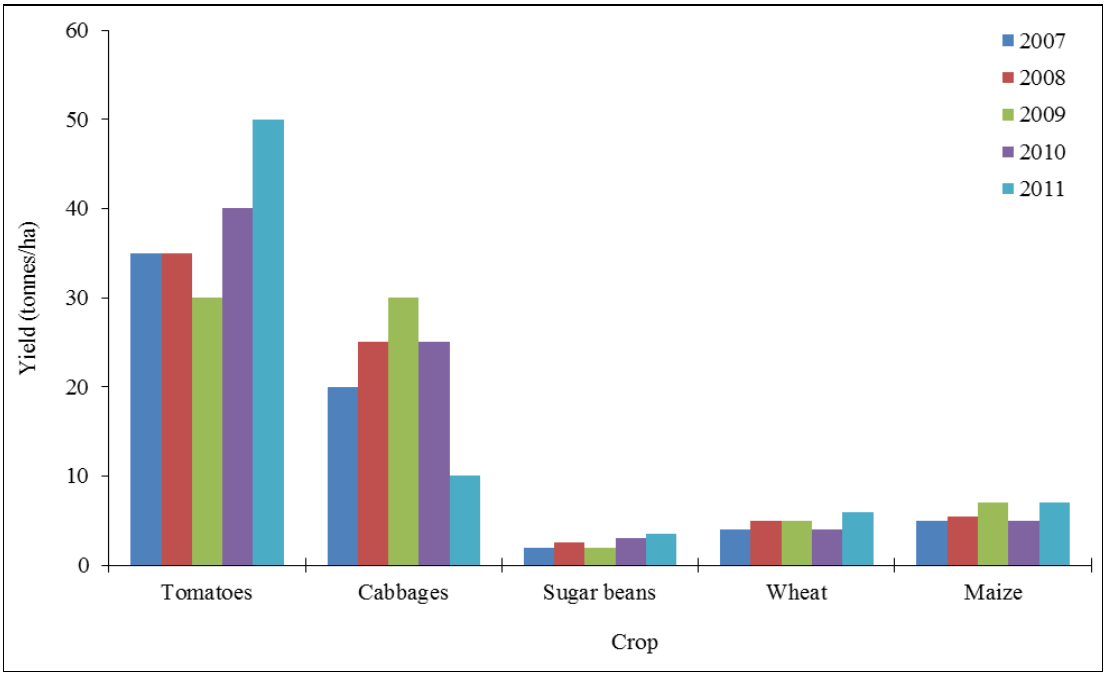

Figure 4. Crop production pattern and trends in Mushandike irrigation scheme, Zimbabwe, between 2007 and 2011. Source: AGRITEX, Masvingo

We gathered that over the past years no expansion have been made to the original canals, thus the water supply has remained the same despite the fact that the number of beneficiaries has been increasing. At full capacity the dam was expected to irrigate the originally planned fields for at least three seasons. However, this expectation has never been realized partly because Mushandike dam has not spilled in the past five years as highlighted during the interviews with the local farmers. The challenges of water scarcity have been exacerbated to an extent that the irrigation operations stopped functioning in September 2011. There is currently no water for irrigation with the water left in the dam being primarily kept for sustaining the aquatic life in the dam and wildlife within Mushandike Sanctuary (Fig. 5). According to the fish catch data for the period 2008- 2011 (Figs. 6 and 7), the fish show a reduction in both abundance and weight, with only the exception of *C. gariepinus* fish weight which appear to be increasing, thus likely showing the deterioration of the water quality in the dam. The general reduction in fish number and weight may be a result of loss of habitat for breeding and feeding normally found in the shallow water as previously reported (Qadir, Boers, Schubert, Ghafoor, & Murtaza, 2003; Rosenstock, Ballard, & Devos Jr, 1999).

Figure 5. Water level in Mushandike dam, Zimbabwe, October 2012. Source: Fieldwork

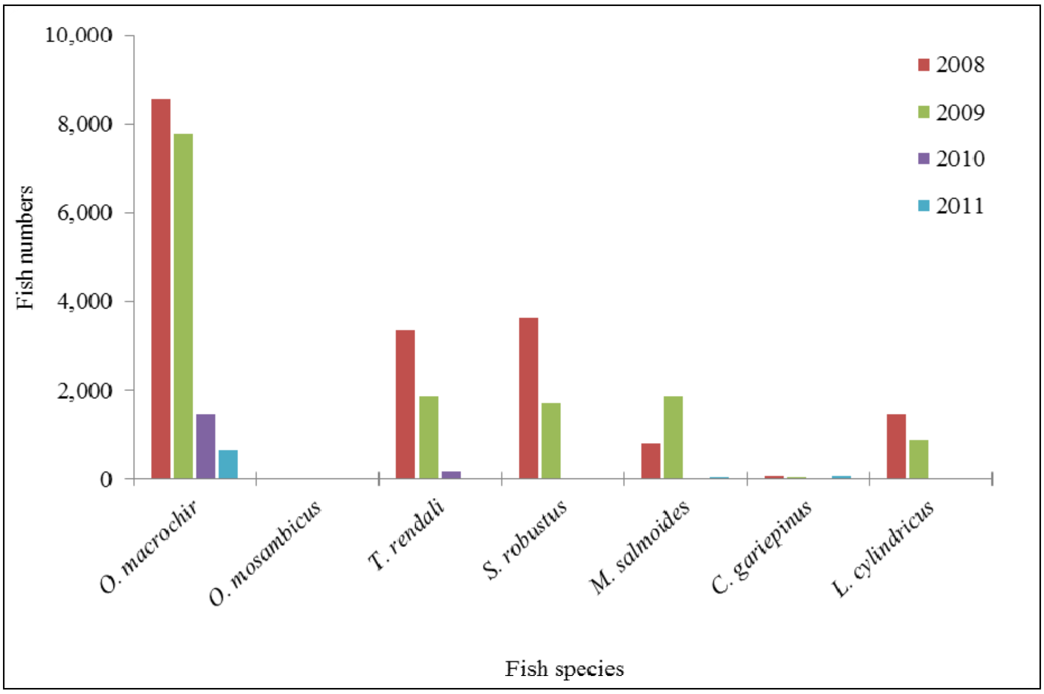

Figure 6. Trends of fish abundance in Mushandike Dam, Zimbabwe, between 2008 and 2011. Source: ZPWMA, Masvingo

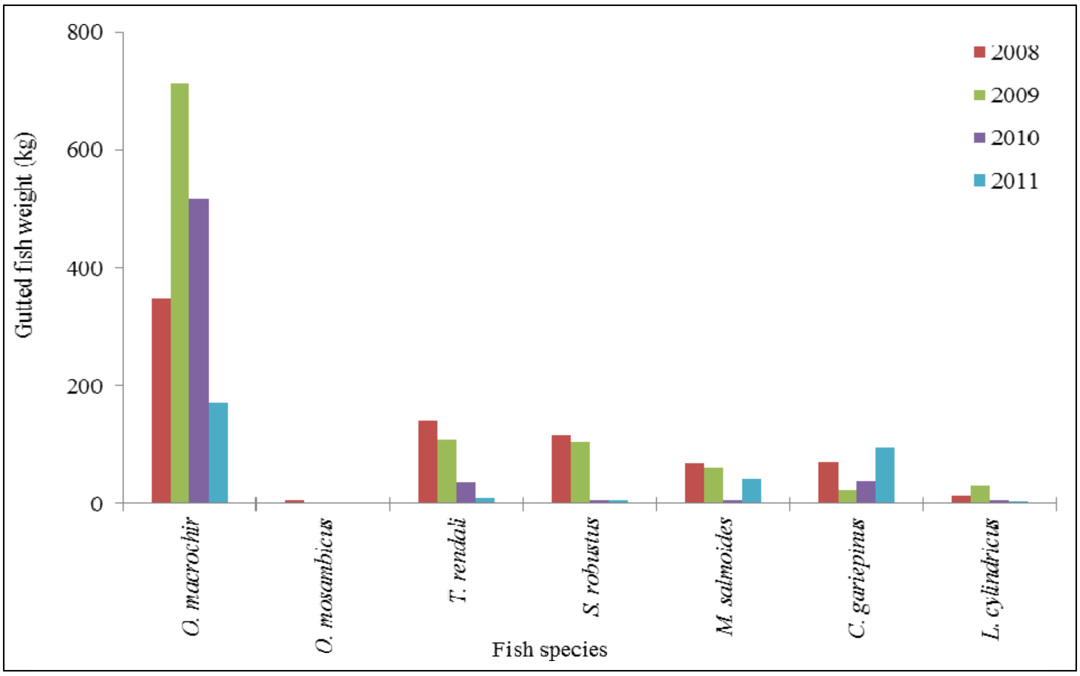

Figure 7. Trends of fish weight in Mushandike Dam, Zimbabwe, for the period 2008–2011. Source: ZPWMA, Masvingo

From the interviews, it emerged that socio-economically the farmers improved their standard of living from farming in Mushandike irrigation scheme as they were able to buy cattle, send their children to school and clothe their families. In addition, when Mushandike irrigation scheme was fully operational it was a source of employment for many people. Dam construction and associated socio-economic activities have been also reported to improve the livelihoods of the local communities in some areas (Mudzengi, 2012). However, due to the low production as a result of reduced water levels in the dam, some people have left the scheme in search for greener pastures. As observed in other studies (Baxter, 1977; Bunn & Arthington, 2002; Manyanhaire, Svotwa, Sango, & Munasirei, 2007; March, et al., 2003), the Mushandike irrigation scheme has had both positive and negative impacts since its establishment. It should be noted that the challenges being faced at Mushandike irrigation scheme were also exacerbated by the experienced economic decline in Zimbabwe between 2000 and 2008 (Zvikomborero & Chigora, 2010).

Impacts of dwindling water resource on the aquatic ecosystems in Mushandike dam and downstream

Damming disrupts migrations of most macro-fauna (e.g., fish, shrimps and snails) that have diadromous life cycles (March, et al., 2003). Such species have adults living and breeding in rivers and streams, with larvae drifting downstream to salt water where they metamorphose to post-larvae and then migrate upstream to freshwater. Therefore, maintaining river flow is a major determinant of the physical habitat in streams, consequently, a major determinant of biotic composition and life history evolution (Bunn & Arthington, 2002). Fish fauna richness seems to increase with habitat complexity since fish exhibit habitat preferences. Therefore, limited habitat due to reduced flow also affects the growth, reproduction and survival of native fishes in the study area (see Figs. 6 and 7). These changes in water resources and resultant wildlife dynamics have negative implications on fishing and wildlife viewing opportunities (Gandiwa, 2011), in our case, Mushandike Sanctuary.

CONCLUSIONS

It has been reported that water shortage is, therefore, likely to be the most dominant water problem in the forthcoming century, jeopardizing sustainable development (Zbigniew, 1997). Sustainable development requires an integrated approach and a holistic perspective, in which a structure of inter-linked components is taken into account. This structure contains not only hydrological or water resources components but also a number of other components, such as environmental, economic, demographic, socio-cultural and institutional subsystems (Zbigniew, 1997). Our findings suggest that the main cause for dwindling water levels in Mushandike dam is the water loss during extraction to irrigate the fields since some of the canals are currently not being regularly maintained. The continued loss of water from Mushandike dam has led to the reduction in the irrigated crop production, hence negatively, affecting the local people livelihoods, and also the disappearance of aquatic life, and to some extent terrestrial animals, within Mushandike Sanctuary. Future studies should examine the effects of other human activities such as gold panning and deforestation on the water resources in the study area. We end by suggesting that adaptation strategies such as strengthening and improving indigenous land and water management practices, use of decision support tools, such as seasonal weather forecast data, growing drought resistant crops, and development of irrigation infrastructure (Chifamba, 2011; Maguvu & Mutengu, 2008; Mutekwa, 2009) should be developed and/or implemented in Mushandike catchment area.

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