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Ecological Restoration and Remediation of a Degraded Estuary: The Case of the Mvoti Estuary, KwaZulu-Natal, South Africa

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ABSTRACT This paper describes the current status of the Mvoti Estuary, outlines a plan for restoration, presents a set of strategies to redress the situation and proposes viable management initiatives. The latter include enforcing relevant environmental protection laws and building partnerships between the users and the authorities responsible for management; conserving a good health status; abating, controlling and monitoring pollution to improve water and sediment quality; re-introduction of indigenous instream and riparian vegetation and eliminating alien vegetation; measures for reducing the high sediment levels in the river and, improving water flow particularly during 'low-flow' periods.

INTRODUCTION

Estuaries are ecologically important systems (Buggy and Tobin 2008; Marcus et al. 2014) as they sustain and support a wide range of flora and fauna, and provide humans with a unique variety of services (Breen and McKenzie 2001). This places them amongst the most sensitive and productive ecosystems known, despite occupying a small percent of global waters (Glennie 2001). Estuaries are affected directly by actions and processes occurring within them and in close proximity of them (Breen and McKenzie 2001; Carlos et al. 2015). They are also affected by activities which do not occur within their bounds, for instance in their catchment hinterland and in the upper reaches of the river feeding them (Mason et al. 2014).

The degradation of South African estuaries had been identified as a cause for concern more than four decades ago (Brownlie 1988; Sukdeo et al. 2011). Without human intervention, damages to estuarine systems due to escalating population growth and development will most likely increase and eventually become irreparable. Fortunately, the value of estuaries has recently been recognized and efforts to rehabilitate and manage them have been made (Kerstin 2015; Singh et al. 2015). In doing so they may retain their valuable characteristics and continue to provide valuable services on which we depend (Danielle et al. 2010).

In South Africa (KwaZulu-Natal in particular), efforts have been made to rehabilitate the Siyaya and Sezela estuaries (Wiseman and Sowman 1992) and, proposals have been put forward for the rehabilitation of the Isipingo estuary (Kalicharran and Diab 1993). The Mvoti Estuary is one of the most severely degraded systems on the north coast of KwaZulu-Natal and despite numerous surveys on its health, and its importance as a bird sanctuary, no significant attempts have been made to restore or manage this estuary. This paper provides the first attempt at restoration and remediation in estuarine degradation, investigating management initiatives and devising a realistic set of strategies to redress the current situation.

Study Area

The Mvoti River drains into the Indian Ocean at 29°24' S; 31°20' E off the east coast of South Africa. The catchment occupies an area of approximately 3035 km² (DWAF 2004) and entirely within the province of KwaZulu-Natal (Creemers and Pott 2002). The 197 km long river begins in the midlands of KwaZulu-Natal and ends in the Mvoti Estuary, located approximately 90km north of the economically significant port city of Durban. The approximately 2km² estuary

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(Wepener 2007) is commonly regarded as a river mouth (Begg 1984) dominated by fluvial discharge (Sukdeo et al. 2010). As is typical of such systems there are no considerable tidal influences, and the system remains almost entirely comprised of freshwater (Sukdeo et al. 2011) except for marine water contributions from wave over wash during spring high tides. The Mvoti River falls within the Mvoti to Mzimkulu Water Management Area and under tertiary catchment U40 (DWAF 2004).

A sandbar approximately 1 km in length (Fig. 1) separates the estuary from the adjacent ocean, causing the river to deflect at the coast and open at a slightly southerly position (Wepener and MacKay 2002; Sukdeo et al. 2011). Wepener and MacKay (2002) note that the Mvoti mouth has been fairly stable, rarely closing since the mid 1990s. However, when necessary, the sandbar was Anthropogenically breached to prevent inundation of the adjoining sugarcane fields, or to prevent anoxic conditions of the estuary caused by excessive effluent disposal (MacKay et al. 2000a).

During flood conditions the sandbar is naturally breached and the river enters the ocean in a more northerly position (Wepener and MacKay 2002). Such was the case during the floods experienced by KwaZulu-Natal in September 1987 (Badenhorst et al. 1989). During this particularly harsh flood, large areas of sugarcane adjacent to the lower Mvoti were destroyed as the entire valley flooded, and the river scoured through the sandbar and established a direct course to sea. Despite its relatively small size,

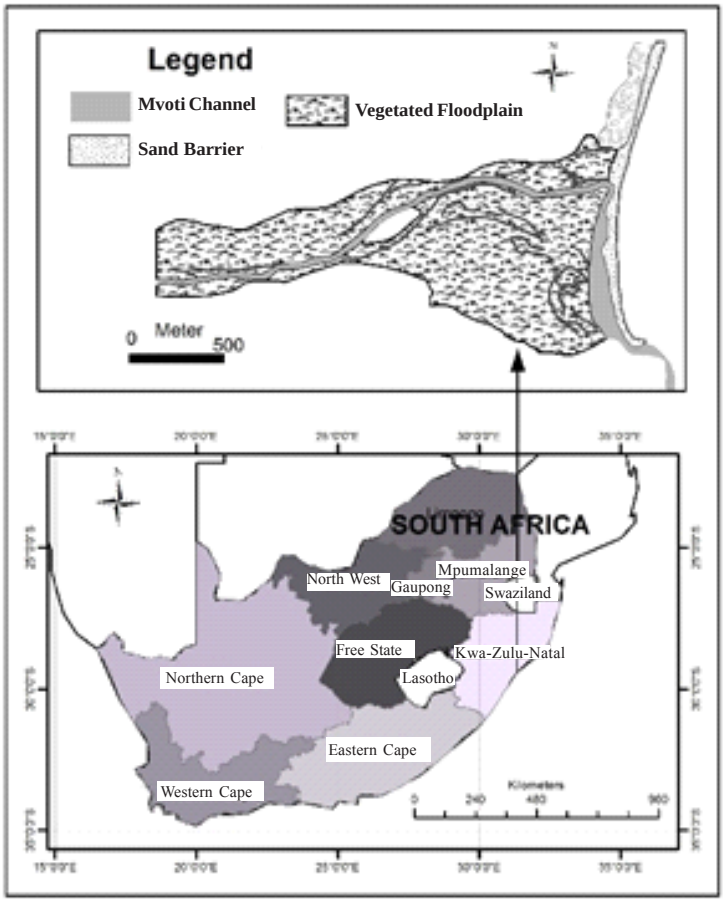

Fig. 1. Schematic representation of the Mvoti Estuary and is location on the South African coastline
Source: Authors

the Mvoti River supports a number of towns, villages, and both rural and informal settlements along its course.

According to Creemers and Pott (2002) in the middle and lower regions of the Mvoti, water supply for the local populace is almost solely dependent on this river. In addition, the Mvoti catchment is a crucial resource for agricultural practices throughout the catchment, and industrial activities in its lower reaches. In terms of commercial agriculture, forestry and sugarcane farming are the two most extensive practices within the catchment, occupying approximately 576 km² and 370 km² of the total catchment area respectively (Malherbe 2006). As these are both alien species to KwaZulu-Natal (Malherbe 2006) this can have serious implications for the catchment. The Glendale Distillery, Ushukela Sugar Mill and Sappi Stanger Paper Mill are responsible for the bulk of the industrial uses of the Mvoti water.

The Mvoti is described as a 'working river' as a result of the high utilization of the catchment and river. The river is severely degraded particularly in its lower reaches after its intersection with Stanger and onwards as it flows onto the coastal plain, with the current condition differing completely to the original (MacKay et al. 2000a).

The objectives of this study are to describe the past and present environmental concerns that have led to the progressive decline in the health status of the lower Mvoti system and to formulate recommendations for the effective restoration and management of the system.

METHODOLOGY

The Mvoti River and Estuary was seasonally assessed (summer and winter) at five sampling sites over a ten-year period. This included water quality and bed sediment analyses, at three riverine and two estuarine sites. Water quality analysis was done for diffused oxygen, conductivity, pH, total dissolved solids, ammonia, nitrates, chloride, potassium, calcium, and magnesium. In addition, sediment samples were analysed for a range of heavy metals. The results of these studies have been presented elsewhere but the potential impacts to the estuarine system are discussed here. Apart from primary data collection, a number of secondary sources of information, especially research publications, about the Mvoti system was referenced over the period. The collective knowledge of the Mvoti Estuary thus gained informs this paper.

RESULTS AND DISCUSSION

The estuarine degradation in the Mvoti can be attributed to impacts emanating principally from the agricultural and industrial sectors within the catchment. Specifically, the problems comprises of issues such as excessive sedimentation, agricultural and industrial pollution, disruption of wetlands, and, disruption of riverine riparian vegetation as discussed below.

Water Quality

The water quality entering the Mvoti Estuary has been recognized as a major problem for a considerable period of time. Begg (1978) described the condition of the estuary as 'grossly polluted', and now, almost four decades later, it is apparent that conditions have generally worsened. About forty years ago the major sources of pollution in the estuary were treated sewage effluent and sugar and paper mill effluents. These were discharged into the lower sections of the river from the town of Stanger. Currently, such effluent is still discharged on a large scale into the river.

Agricultural practices and domestic uses also contribute to the poor condition of the estuary. Over the years, a number of assessments (Malherbe 2006; Chili 2008; Mackay et al. 2000a) have affirmed the inferior quality of water entering the estuary, and its overall modified and degraded state (Wepener and MacKay 2002; Sukdeo et al. 2011).

Water quality analyses by the authors confirmed general deterioration of the estuary. Dissolved oxygen concentrations were consistently extremely low (decreasing to values as low as 0.71 mg/L within the estuary). On the other hand, concentrations of dissolved chemicals in the water consistently exceeded the target water quality ranges provided by the Department of Water Affairs and Forestry, DWAF (1996a, b). This was particularly true of ammonia levels (exceeding the target level of 7 mg/L for aquatic ecosystems. In the estuary itself concentrations of chloride and nitrate ions were always higher than the proposed water quality ranges of 0.2 μg/L and 0.5 mg/L respectively.

Water Abstraction and Siltation

The mean annual runoff of the Mvoti River is approximately 375 million m³/annum (Malherbe 2006). However, the lower Mvoti River near Stanger experiences large scale water abstraction for industrial, agricultural and domestic purposes. Considering that this area is only 5 km upstream of the estuary, such abstraction affects flow rates are detrimental to the natural functioning of the estuary.

The paper and sugar mills are the main water abstractors on the lower Mvoti (VonBratt 2007). To facilitate their water requirements, these industries have been largely responsible for modifications to the river channel and extensive water abstraction from the Mvoti. Furthermore, the Mvoti Estuary is subjected to extensive effluent discharge which underscores the vitally important role that river flow plays in dilution and flushing of pollutants. If the fluvial discharge is insufficient for effective flushing and dilution, there would be potentially serious impacts on the estuarine biota (MacKay et al. 2000a).

Extensive, continuous water abstraction can also lead to modification of the stream banks and alteration of the channels and consequently affects the hydrological, habitat and ecological integrity of the estuary (MacKay et al. 2000b; Malherbe 2006).

Over the recent past the Mvoti Estuary has experienced levels of sedimentation such that elevation of the bed level has occurred, resulting in a very limited tidal influence. Hence the estuary is predominantly river dominated and referred to as a perched estuary. VonBratt (2007) noted that the catchment geology of the Mvoti River is characterized by highly erodible soils which, combined with the high rainfall, runoff and anthropogenic activities have caused elevated sedimentation rates (VonBratt 2007). Figure 2 illustrates the impacts of sugarcane farming and sugar milling, on watercourses upon which they depend (adapted from Begg 1978).

Sediment Contamination

Research conducted on heavy metal contamination of estuarine sediment indicated by the

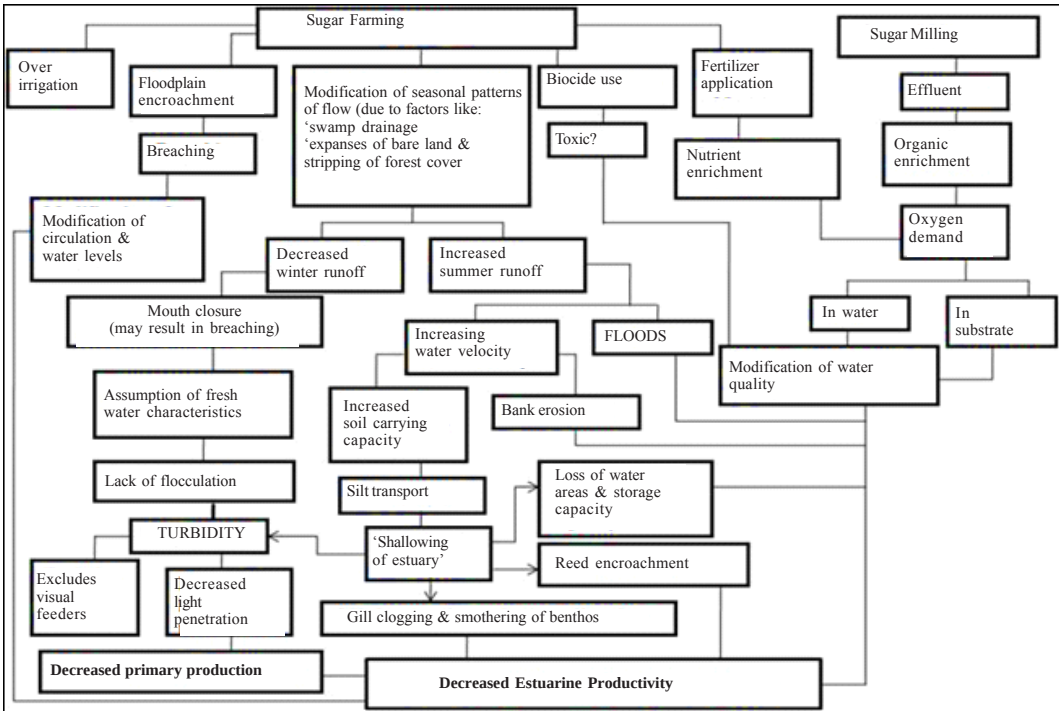

Fig. 2. Impacts of sugarcane farming and sugar milling on estuarine productivity
Source: Authors

authors were in the upper estuarine and riverine sections of the study area closest to where the Mvoti River experiences industrial discharge and utilization of the river for domestic purposes by informal settlements, had the highest concentrations of heavy metals present (Sukdeo et al. 2011). Accumulation of heavy metals in riverine and estuarine sediments is increasingly becoming a major cause for concern, as, apart from affecting benthic dwellers, these elements are often remobilised into the water column and accumulate in food webs with detrimental end-results (Sukdeo et al. 2012). Despite this presence of contaminants in the system, Sukdeo et al. (2012), found the sediments to be only low to moderately polluted due to the relative coarse sediment texture of the bed sediments and therefore further support the notion that the Mvoti sediments are potential sources of re-contamination into the system as opposed to contaminant sinks.

Habitat Integrity and Species Diversity

Habitat plays a crucial role in the survival of a species in an ecosystem, and any decrease in habitat sustainability or availability will result in a decrease in the diversity of species (DWAF 1999; Malherbe 2006). The Mvoti Estuary was known to support a variety of birdlife and has been frequented by many Red Data species such as the *Pelecanusonocrotalus, Ciconiaepiscopus*, and *Glareolapratincola*, some of which utilize the sandbar as a nesting area. However, over the years these numbers have decreased (MacKay et al. 2000a). Reduced river flow, poor water quality, and the predominantly sandy substrate have been cited as cause of the decrease of diversity in the system (MacKay et al. 2000a; Pillay et al. 2013).

Sand Mining

The increasing demand for infrastructure and housing in South Africa has made building sand an important resource in the industrial and construction sectors. Large scale removal of alluvial sand is associated with negative effects on rivers and estuaries and consequently negative impacts on local sectors such as tourism and fisheries (De Lange et al. 2009).

The hydrological and geomorphological functioning of river systems are directly impacted as a consequence of sand mining. Parameters affected include channel morphology, flow dynamics turbidity, sediment transport and deposition, discharge, temperature and aquatic chemistry (Pillay et al. 2013). Changes in these characteristics often cause follow-on changes to riparian and instream habitats, all of which may impact adversely on biota, both instream and in the riparian zone (Demetriades 2007). Pillay et al. (2013) and others have identified several impacts caused by sand mining operations. Table 1 summarizes some of these for the Mvoti River:

Alien Vegetation

Riparian vegetation is responsible for a number of ecological functions that assist in main-

Table 1: The activities and consequent impacts associated with sand mining on the lower

Mvoti River	
Observed activities	*Resultant impact*
Sand mining operations in very close proximity to each other	Large scale morphological changes; dramatic changes to hydrological functioning; habitat destruction
Individual operations constructing separate access route(s) from the main road down to the river bank.	Enhanced erosion rates, and the negative effects of heavy vehicles and machinery on the floodplain.
Clearing of large areas of riparian vegetation around these operations	Loss of bank stabilization; complete destruction of habitats and the fluvial environment
Wide scale disturbance and removal of large areas of unconsolidated sediments; increased downstream transport of fine-grained material	Adverse effects on the estuary including: sedimentation, changes in sediment composition, disturbance of benthic communities, and, a direct decrease of estuarine habitat integrity and productivity. These also impact negatively on estuarine community especially fish.
Selective removal of particular grades of sediment	Increased downstream transport of discarded fine sediment which leads to increased potential for heavy metal sequestration in estuarine sediments,

taining a healthy ecosystem (Malherbe 2006). These include retaining channel form, bank stabilization, erosion control and providing a habitat for biota.

Along the lower Mvoti River the riparian zone is almost entirely modified (MacKay et al. 2000a) where places are completely cleared for agriculture, usually sugarcane, and with the prevalence of subsistence agriculture in rural areas. The invasion of the riparian zone by alien vegetation species also poses a problem. Areas of natural vegetation does exist and are usually dominated by either *Phragmites. sp,* reeds or exotic species. Alien plants species commonly invade disturbed areas as the new condition of the area enables these plants to establish (Von-Bratt 2007). Hence, the disturbed riparian zone of the lower Mvoti River is an ideal habitat for alien vegetation invasion.

Restoration and Management of the Mvoti Estuary

Van Niekerk (2007) identified 16 international conventions, 10 white papers, 40 national acts and, provincial and local by-laws which govern estuarine management. In the South African scenario, there is often confusion surrounding government and local institutions that are responsible for estuarine management.

The Department of Environmental Affairs and Tourism is largely responsible for environmental management in South Africa, and *via* Marine and Coastal Management, they play a major role in the management of riverine and estuarine biodiversity, and consequently estuarine management (Van Niekerk 2007). The Department of Water and Sanitation (previously The Department of Water Affairs and Forestry) is responsible for all water bodies in South Africa including estuaries. They are also responsible for the management of water quantity and quality in estuaries and executing the National Water Act, Act 36 of 1998, which requires the formation of Catchment Management Authorities (CMAs) to control upstream activities and actions that negatively affect estuaries. Finally, local municipal authorities are responsible for the estuaries falling within their jurisdictions. The local authority responsible for the Mvoti Estuary is the KwaDukuza Local Municipality.

However, the current state of the estuary indicates that there is a lack of enforcement of policies and legislation designed to protect such water resources. There is also a lack of action taken against perpetrators who have exploited the resource. This was particularly noticed during a pilot survey of the study area, where local authorities had erected signs warning the public against fishing and swimming in the estuary, as inferior water quality posed a health hazard. However, no known attempts have been made to improve any aspect of the system, and it remains in a poor condition.

The ultimate goal of rehabilitation of the Mvoti estuarine system is to restore the value of the system by improving the overall environmental health of the system and its riparian zone. Currently, access to the lower estuary is restricted. Admission to the northern banks can only be gain via a trail from Blythedale Beach, about 1km away, and the southern banks fall under private property owned by Jex Estate. Hence, the lower estuary is seldom under large scale recreational use, and, restoring it for recreational purposes is not a main priority. However, should this be later considered as an option, then recreational activities should ideally be nature-based and should not degrade the estuary in any way (Kalicharran and Diab 1993; Sukdeo et al. 2011).

To achieve this goal, it is necessary for the causes of degradation, as opposed to its effects be addressed (Kalicharran and Diab 1993). For the purpose of this study, the main environmental problems identified in the Mvoti Estuary are poor water quality, sedimentation, invasion of alien plants, and, loss of habitat integrity and species diversity. Reduced water flow rates are also a concern.

It is recommended that an estuarine management committee be formulated to oversee the implementation of rehabilitation strategies and management of the estuary. Short term goals following the formulation of a committee would be to identify the current environmental problems that have led to the degradation of the estuary, and determine suitable remediation strategies for the systems. The committee should include relevant national government departments, para-statals and non-government organizations.

With respect to the problems faced by the Mvoti, the Department of Water and Sanitation and the Department of Environmental Affairs and Tourism have major roles to play in remedi-

ating water quality, and, controlling water abstraction and alien plant eradication. The Department of Mineral and Energy Affairs has a huge role to play in controlling sand mining.

At a local level, the KwaDukuza Municipality has jurisdiction over the estuary and an active role to play in the estuary's remediation and management.

Other users of the river, namely local communities, the SAPPI and Ushukela mills and the Glendale Distillery, together with affected parties like the owners of Jex Estate play a vital role in rehabilitating the river and ensuring it is efficiently managed. Academic institutions should be involved by assisting with research and offering scientific recommendations or proposals. The rehabilitation of the estuary, once initiated, also requires, efficient management which needs to be an ongoing, and constantly monitored process in order to achieve completion and success.

Water Quality

The main pollutants in the Mvoti Estuary are industrial effluents released from the upstream industries and large scale milling operations, formal and informal settlements and, agricultural effluents. Prevention of further decline in water quality of the estuary requires compliance with existing legislation and enforcing legal action against perpetrators who are responsible for this decline (Wiseman and Sowman 1992; Kalicharran and Diab 1993). Brownlie (1988) suggested the development of management agreements between local municipalities and industries responsible for using the estuary would help reduce impacts. If the levels of pollutants exceed limits set by the Department of Water Affairs and Forestry, legal action should be initiated against the perpetrators (Wiseman and Sowman 1992; Kalicharran and Diab 1993) and the polluter-pays principle should be applied. A strict monitoring and compliance programme needs to be instituted to ensure that remediation can succeed.

In the past, artificial breaching has been practiced in the Mvoti Estuary to prevent inundation of the adjacent sugarcane fields. This practice would possibly flush out the estuary. However, according to Allanson and Baird (1999) this is not a viable option, as in the long term, it only makes the original problem more complex. Artificial breaching may lead to excessive accumulation of marine sediments in the estuary, and may also disrupt estuarine habitats.

Biologically, introducing more indigenous vegetation to the riparian zone can assist in the improvement of water quality by acting as a sink for nutrients and sediments (Lowrance et al. 1984). The presence of these plants along the banks of the river play a role in controlling nutrients and sediments derived from agricultural practices and runoff from the catchment, from entering the river channel. This might be especially viable for the Mvoti as much of the catchment is under agriculture. The presence of agriculture in the lower regions is so extensive that cultivation has replaced all riparian vegetation.

Establishing in-stream plant communities will aid in improving the river water quality as some macrophytes are capable of extracting nutrients such as nitrogen and phosphorous from both the water and sediment in the system (Clarke 2002). Aside from improving water chemistry, the physical structure of these plants offer resistance to the flow of water and its sediment load (Clarke 2002).

The Mvoti Estuary is a relatively shallow system (Begg 1984), and therefore vegetation such as reeds and sedges will be more suitable for the system as opposed to submerged plants which require deeper waters (Whitfield and Bate 2007). Reed beds can also be used to reduce any excessive bacterial levels (Kalicharran and Diab 1993).

The Mvoti vlei is a natural wetland present on the upper reaches of the river that aids the improvement of water quality. Artificial wetlands created in the lower reaches should be considered as these can be beneficial by acting as filters and decreasing the nutrient load of the river.

Reducing Sedimentation

Sand mining operations on the lower river are extensive to the extent that individual boundaries between the operations cannot be identified. To control and prevent sedimentation in the estuary, the issues of sand mining and riparian zone disturbance needs to be addressed.

There is an urgent need for responsible authorities to control sand mining, and to conduct a survey of current sand mining activities along the river, so that all illegal and uncontrolled operations can be identified and stopped. A comprehensive survey of the sand resources along

the Mvoti is essential for enabling informed decisions on the part of the Department of Mineral and Energy Affairs in issuing sand mining permits for the area in question. In addition, the quota for each permit should be limited, so that the river banks and the river bed have sufficient time to rehabilitate in terms of gravel and alluvial material accumulation. This can avoid drastic impacts on the morphology of the stream, and improve its potential as a habitat.

Re-vegetation of the riparian area with indigenous plants is recommended, as this decreases the time necessary for natural restoration and prevents erosion. This is also beneficial in that invasions by alien species, which thrive in disturbed conditions, can be controlled. Alternatively, the Department of Mineral and Energy Affairs can identify and provide access to an alternative, suitable source of sand material for extraction. The presently high levels of sediment can be reduced by the implementation of sediment traps. King et al. (2003) suggested that such traps should be located in accessible areas where the sediment can be removed by machinery.

Minimizing Water Abstraction

Lake Merthley is the only major impoundment on the Mvoti River. However, uncontrolled abstractions for irrigation of croplands, private and domestic users place considerable strain on the estuarine reserve. Therefore, the seemingly only suitable option for any improvement in water flow to occur, is water abstraction at a controlled rate. It is vital that a data base of all users of the water resources be compiled and that limits for abstraction be levied taking into consideration factors of availability and need. Alternatively, diversion of water from another river may be considered.

Sediment Remediation

Reducing the pollution load entering the Mvoti system will drastically reduce the amount of contaminants present in its sediments. To address problems with polluted sediments, one of two routes must be considered, namely removal or non-removal. Non-removal techniques occur in situ, or on site, and include the remediation of sediments via capping, containing or treatment (USEPA 2006). As the Mvoti system already experiences extensive siltation, and continually poor water quality, capping and containing would probably not be viable options. Treatment comprises of three options, namely chemical, biological and immobilisation. Remediation via immobilisation treatment might be the most feasible non-removal technique to apply in this area, as it is already suspected that there is a continuous sediment-water cyclic exchange of contaminants in this system (Sukdeo et al. 2012). In terms of removal techniques, environmental dredging, which involves the removal of contaminated sediments can be considered. However, this is a more costly option, as it requires further treatment, often non-removal capping and chemical treatment (USEPA 2006), when dredged sediments are relocated.

Eradicating Alien Vegetation

The development of an alien vegetation eradication programme would be beneficial in the removal of alien vegetation species from the riparian zone. This requires man power, is time consuming and requires the removal of these plants upstream to prevent reinvasion (Wiseman and Sowman 1992). Enlisting the assistance of local communities in these programmes may prove to be beneficial.

Assistance may involve educating community members on identification and removal methods of alien species in the region, in return for a fee or services they may require from local authorities. These programmes need to be ongoing and constantly monitored for them to be successful.

Such a strategy already implemented in South Africa is the 'Working for Water' programme, which sets out to eradicate both alien invasive plants, and unemployment. The Department of Environmental Affairs and Tourism, the Department of Water Affairs and Forestry and the Department of Agriculture were the governmental departments involved in this mission (USEPA 2006). River banks and riparian zones that have been cleared either via disturbance or alien removal can be rehabilitated by reintroducing suitable indigenous vegetation.

Improving Habitat Integrity

To address the loss of habitats and instream integrity, the pollution problem in the river needs

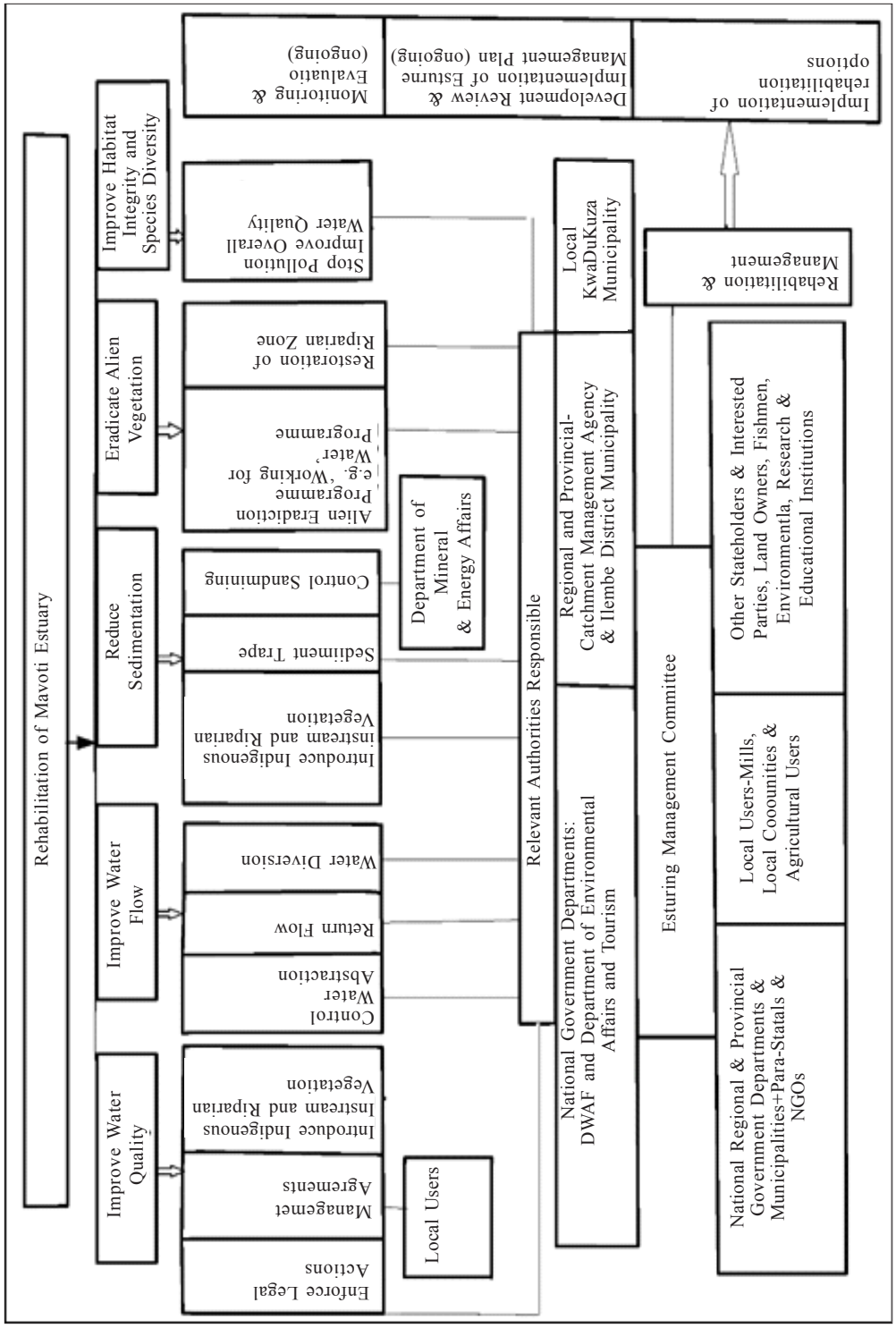

Fig. 3. The proposed rehabilitation and management plan for the lower Mvoti River and Estuary
Source: Authors

to be addressed. Biodiversity can only improve with an improvement in water quality. A decrease in siltation of the river would be beneficial to benthic communities and macro fauna less tolerant to turbidity and these may be able to re-establish themselves. A decrease in pollutants in the river will allow re-establishment and flourishing of less tolerant macro fauna. Environmental education will play an important role in influencing the attitude of users of the river to the environment (Kalicharran and Diab 1993). This would apply equally to industries using the resource as well as to domestic users of the Mvoti, a majority of who hail from informal settlements and rural areas.

CONCLUSION

The causes of degradation in the lower Mvoti River and estuarine system, and suitable potential restoration strategies have been identified. It has been established that the primary cause of environmental degradation within the lower Mvoti River and estuary is the inferior quality of the water entering the system. Sedimentation within the estuary is also a major problem, coupled with low water flow rates caused by over-abstraction of water by industries upstream, and alien plant invasions along the riparian zone. All these factors contribute to the current loss of habitat integrity and species diversity experienced by the system. There is a lack of enforcement of the laws protecting this water resource by the relevant authorities, and a lack of action against the perpetrators abusing the resource. These are the issues which have been considered in this study for the restoration of the lower Mvoti River and estuary system. Until an attempt is made to improve the current condition of the system, and effective management strategies are in place, together with monitoring and compliance initiatives the system will continue to move toward a more in a severely degraded state than its present condition.

RECOMMENDATIONS

Previous studies of the Mvoti system, in particular of the estuary have put forward several recommendations intended to improve the overall water quality, hydrological functioning and health of estuarine environment. However, the current water quality data demonstrates that the Mavoti River and Estuary is still chemically and microbiologically poor. This study proposes that the water quality management plan as presented in Figure 3 is implemented. It is of utmost importance that there is co-operation amongst all institutional role players namely; national, provincial and local government as well as the nongovernmental organizations. Furthermore, local communities must be mobilized and included as part of any management plan. Regulatory requirements must also be incorporated when implementing proper land use planning and management for future developments. This must also be coupled with rigorous enforcement and prosecution of any transgressions of environmental legislation.

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