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Challenges of Environmental Management in the Upper Pungwe River Basin, Zimbabwe

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ABSTRACT

This study examines the challenges faced in managing the environment in the upper Pungwe River basin (Chipinge). An investigation was conducted on how stakeholders interacted with environmental protection and water management agencies. The study employed a mixed-methods research approach. Both qualitative and quantitative methods were employed. The president of the Environmental Protection Commission received 17 questionnaires. Three water management specialists from PSCC and ZINWA were also interviewed while EMA, Mutasa RDC, and their District Administrators each received three extra questionnaires. Mann-Kendall statistics and regression analysis were employed to assess the Pungwe River's water quality, sediment load, and river flow in order to spot trends and forecast future water levels. A negative linear association between pH value and river sediment loading was observed. It was noted that improvements need to be made among stake-holders.

Keywords: Environmental Management, Upper Pungwe, River Basin, Zimbabwe

INTRODUCTION

Environmental issues have been on the focus of attention on a worldwide scale for several decades. Since the Rio de Janeiro 1992 United Nations Conference on Environment and Development (UNCED), world leaders have adopted a comprehensive and sustainable development plan for biodiversity protection (Berg, 2010). The world's largest industrialized nations decided to cut back on or cap greenhouse gas emissions through the Kyoto Protocol five years later (UN, 1998). There have already been a number of conferences and symposia arranged with a particular focus on environmental sustainability. Zimbabwe has also acknowledged the value of environmental management and sustainability for a very long time (Feresu, 2010). In addition to Agenda 21, an action plan developed during the UNCED in 1992, the nation is a signatory to more than 11 significant international environmental conventions (Nickerson, 1994). The Natural Resources Act, Mines and Minerals Act, Forest Act, and Water Act were among the laws that were already in place to address various environmental issues in the 1970s (Nickerson, 1994). The Environmental Management Act Chapter 20:27 (EMA Act Chapter 20:27), which was created in response to the necessity to manage the environment as a single entity, is an all-encompassing piece of legislation (Government of Zimbabwe, 2002.). The Natural Resources Act (Chapter 20:13), the Atmospheric Pollution Prevention Act (Chapter 20:03), the Hazardous Substances & Articles Act (Chapter 15:05), and the Noxious Weeds Act (Chapter 19:07) were all repealed in whole or in sections with the passage of the EMA Act (Chapter 20:27) (Government of Zimbabwe, 2002). In contrast, even though parts of the Water Act's provisions were transferred to function under the EMA Act, the Water Act

(Chapter 20:24) of 1998 was still in effect to supplement the EMA Act (Government of Zimbabwe, 1998a; Government of Zimbabwe, 2002).

The Environmental Management Agency was established as a result of the adoption of the EMA Act's in 2002 and its subsequent implementation on March 17, 2003, under Statutory Instrument 103 of 2003 (EMA, 2014). Although the EMA Act is a broad piece of legislation, it must be supplemented by other laws that do not clash with it or else it will take precedence (ZELA, 2003). As a result, the EMA Act grants it the power to oversee how various laws and policies are implemented by various governmental entities and parastatals. The majority of the mechanisms for stakeholder participation and conserving the environment in environmental management are provided by the Traditional Leaders and Rural District Councils Acts (RDCs), which specify the framework for environmental management committees and subcommittees at the ward level (Zimbabwean government, 1988; Zimbabwean government, 2000).

STUDY AREA

SAVE is one of the seven ZINWA Catchments in the nation that were created as a result of the late 1990s water sector reforms (Government of Zimbabwe, 2001). The Regional Water Authority (RWA) and the Department of Water Development (DWD) were combined into one organization, ZINWA, in 2000 as a result of the 1998 Water and ZINWA Acts (Makurira and Mugumo 2006). Save Catchment, which is located on Zimbabwe's eastern border, shares borders with the following four catchments: Mazowe, Manyame, Sanyati, as well as Runde (See Figure 1). Save, Budzi, and Pungwe are the three main rivers in the catchment that enters Mozambique.

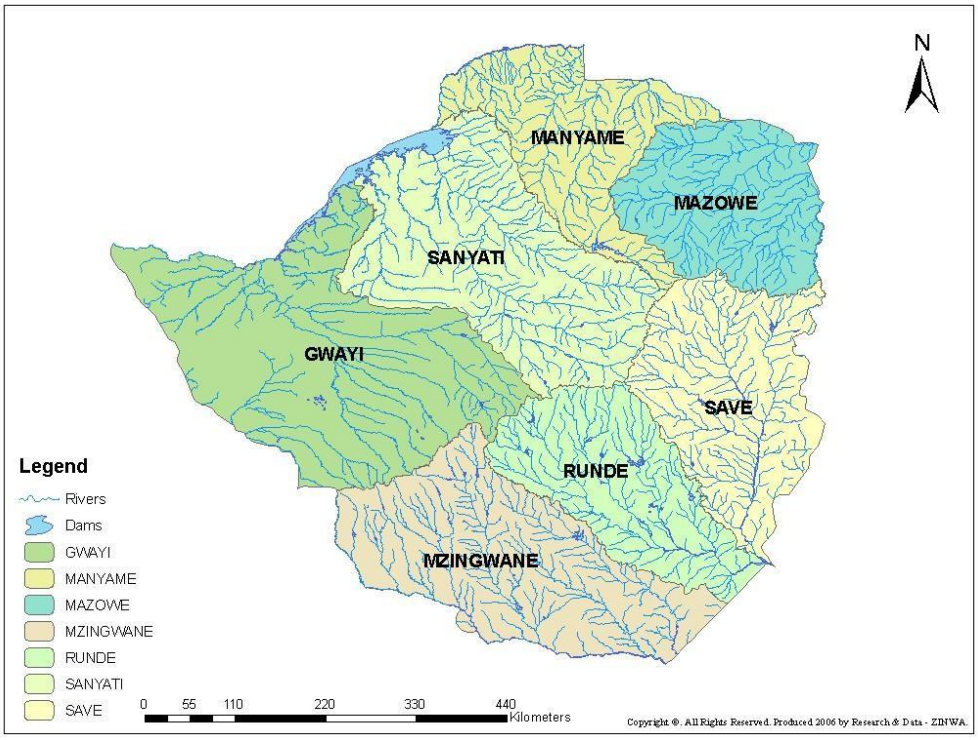

Figure 1: Zimbabwe's River Catchments
Source: ZINWA, 2006

Zimbabwe's Structures of Environmental Management

The Environment Management Agency is the main environmental and natural resource management agency in Zimbabwe. At the highest level, EMA reports on all environmental matters to the Environmental Management Commission and the Ministry of Environment,

Water and Climate (Government of Zimbabwe, 2002). The Environmental Management Act (Chapter 20, Section 27) is the most important environmental management law. There are three approaches to environmental management in Zimbabwe, which are: laws and regulations and their implementation; It encourages businesses and institutions to create markets and promote self regulation (Chidavaenzi et al., 2010). Under it are the Conservation Management Committees and the Conservation Unit, which are organizations under the Urban Councils and the Rural Councils. Urban and rural councils are therefore central to environmental management in Zimbabwe as they deal with drinking water, wastewater and solid waste (Figure 2). Water and wildlife management organizations such as ZINWA and the Parks and Wildlife Authority inform EMA when faced with environmental challenges (Chidavaenziet al., 2010).

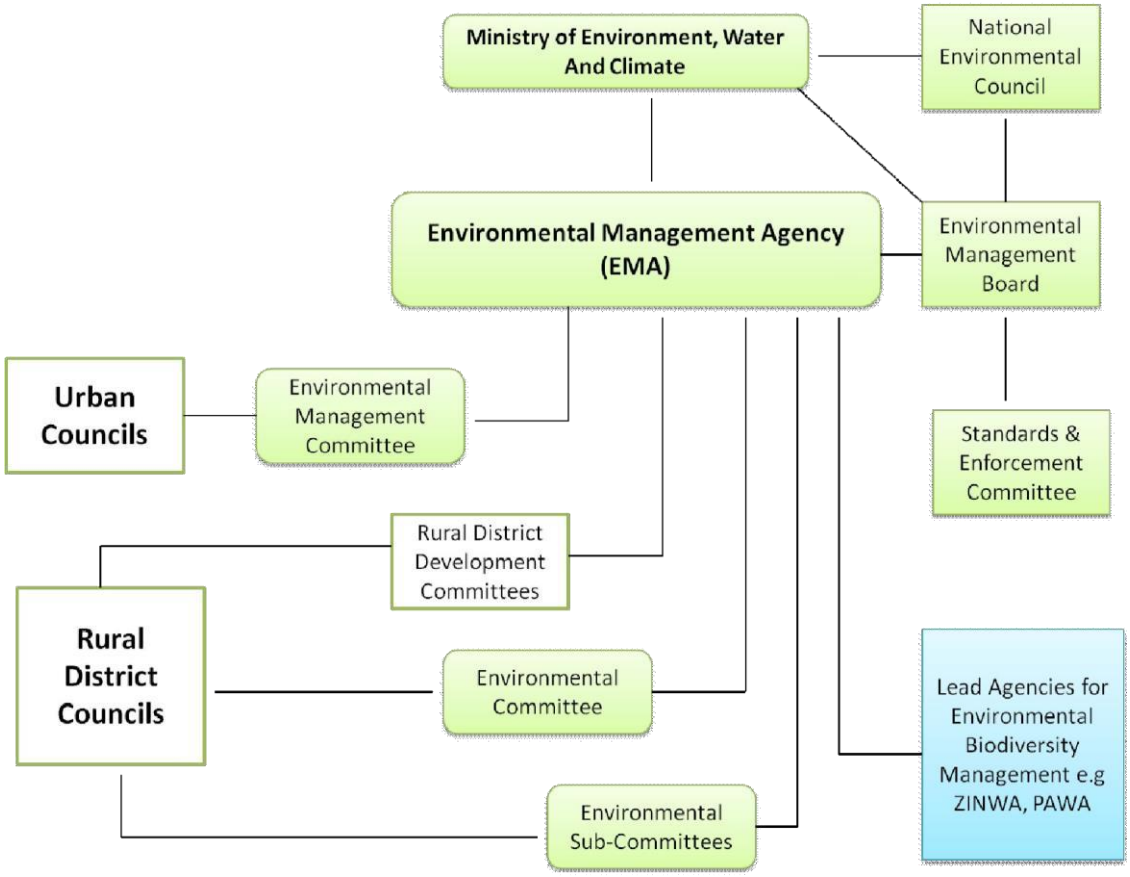

Figure 2. Environmental Management Structures in Zimbabwe
Source: Chidavaenzi et al., 2010

The Water Act of 1998 (section 20:24) governs the use of water resources in Zimbabwe. The Water Act supports the idea of integrated water management by offering a flexible framework for longterm planning and successful stakeholder engagement (Government of Zimbabwe, 2001). In Zimbabwe, water management starts at the sub-basin council level, which is the lowest applicable level (Government of Zimbabwe, 2001). Various stakeholders are represented on the Security

Council, including municipalities, commercial and municipal farmers, mining, and private lands (Government of Zimbabwe, 2000a). The catchment Council, the top water management organization at the river basin level, receives reports from the sub-catchment Council. All water management concerns in the watershed, including water licensing and watershed protection, are the responsibility of the Water Resources Commission (Government of Zimbabwe, 2000a). River Basin Commission Report: The Department of Water

Development (DWD), which is part of the Ministry of Environment, Water, and Climate, provides policy guidance on water management to the commission through its secretariat, ZINWA (Figure 2).

According to the Zimbabwean government (2001), ZINWA provides raw and purified water to local government, farmers, and industries. One of the important tasks in water management is played by organizations that offer secretariat services to basins of rivers and river basin councils (Government of Zimbabwe 1998a and 1998b). ZINWA collaborates with the Department of Water Development on its own. On a variety of topics, including hydrology, hydrogeology, water rates, and others, the authority provides advice to the minister and the reservoir (Government of Zimbabwe 1998a).

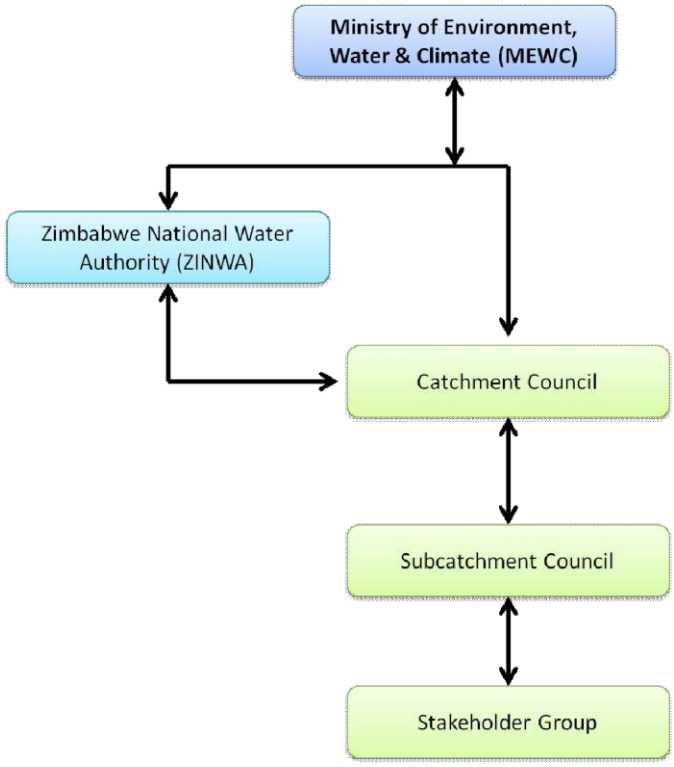

Figure 3: Water Management Structures in Zimbabwe
Source: Government of Zimbabwe, 1998a

RESEARCH METHODOLOGY

In order to manage water resources sustainably, the study aims to identify environmental management challenges in the upper Pungwe River basin. Data that were both qualitative and quantitative were thus gathered. Data about rivers and the amount of river silt they carry were gathered from ZINWA, which is in charge of gathering and storing this information. Since Mutasa District in Manicaland Province contains the Zimbabwean portion of the research region, the Pungwe River Basin, data on water quality were gathered there. The Pungwe Watershed Board also provided a report on the environmental difficulties they encountered. Additional information and data were gathered from ZINWA, EMA, PSCC, Mutasa RDC authorities, and local environmental management committees via questionnaires and self-administered interviews. To find eligible respondents, a purposive sample and stratification combination was applied. By looking over pertinent laws and regulations, the functions and duties of water and management of the environment organizations in watersheds were determined. Tables and figures were used to organize the qualitative data that was gathered through questionnaires and interviews by topic. Descriptive statistics were then used to

interpret the data. In order to define and forecast patterns in quantitative data, such as the amount of sediment and water quality, Mann-Kendall tests and regression analyses were also used.

LITERATURE REVIEW

Environmental Management and Integrated Water Resources Management Interface

Integrated water resources management is defined as, "…a process which promotes the coordinated development and management of water, land and related resources, in-order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP-TAC, 2000: 22). The 4r principles, which were developed during the 1992 International Conference on Water and Environment in Dublin, are the foundation of integrated water resources management;

- "Fresh water is a limited and fragile resource necessary to sustain life, development and the environment.
- Water development and management must be based on a collaborative approach involving users, planners and decision makers at all levels.
- Women play a central role in water supply, management and protection.
- Water for all competitive uses has economic value and must be recognized as an economic asset" (Xie, 2006: 5).

As a result, integrated water management could not be discussed apart of environmental management, according to Manzungu (2002). The formulation and implementation of watershed conservation plans under the EMA Act are one of the primary water management responsibilities of the Catchment Council, according to the Government of Zimbabwe (2000). The quantity and quality of both land and water in the Pungwe River basin have been substantially diminished as a result of watershed degradation (Chifamba, 2011). The provision of adequate and safe water for social and economic activity supports sustainable advancement and environmental management.

The current literature makes it abundantly evident that problems with environmental management result from natural management systems. This requires environmental management agencies to recognize the link between the environment and water so that integrated approaches can be adopted or strengthened where necessary.

Challenges of Current Environmental Management Approaches

According to Murwira and Tevera (2010), management and planning strategies have historically been developed by different entities inside and outside of government with a focus on certain natural resources. With a change in emphasis, Zimbabwe has implemented a policy for environmental impact assessment for the use of natural resources and moved toward an ecosystem approach that incorporates all environmental systems (Government of Zimbabwe, 2001). The historical idea that water and the environment are in conflict is rejected by the ecosystem approach. The local environment is considered to be "...an unfortunate but inevitable accident of development" (Coates et al., 2013: 31).

Broad stakeholder involvement in natural resource conservation is now recognized locally and nationally (Motimore et al., 2008). Many river basin organizations (RBOs) recognize that ecosystem access is essential for sustainable watershed management (Roy et al., 2011). In the Indonesian province of Papua, stakeholders are calling for and institutional and legal reforms to allow decentralization of forests and strict control over local communities (Kayoi et al., 2008). Transboundary ecosystems in Nigeria operate with environmental management agencies that go down to the village/district level and communicate seamlessly between levels (Sherferd, 2008), but landscaping, agricultural extension services, forestry, etc.

nationally in Asia and Africa in general. The sectoral representation of the various ministries dealing with their issues is not consulted even if they are management units with an ecosystem approach (Sherferd, 2008). Destructive activities such as hill and riverbed development can weaken soils and contribute significantly to sedimentation, ultimately leading to reduced capacity or silting of dams and rivers (Mutepfa et al., 2010). Because it encourages the integration of governmental agencies and organizations involved in water and environmental management, the Government of Zimbabwe (2001) argues for the implementation of an Integrated Catchment Management (ICM) approach to the management of water and natural resources.

Manzungu (2002: 166) defines Integrated Catchment Management (ICM) as "…an integrated natural resource management system consisting of the interconnected elements of land and water in a watershed managed on an ecological and economic basis ". The integrated management of water resources and the environment proposed by Somura et al. (2008) is essential for the sustainable use of natural resources in all river basins. There is general agreement among experts that greater environmental management collaboration is needed between environmental protection agencies and water agencies on issues affecting water. In order to better the management of natural resources, the Government of Zimbabwe supports the merger of the Sub-Committee on Natural Resources' duties with those of the Sub-Committee (Government of Zimbabwe, 2001). Therefore, in order to manage the environment sustainably, all stakeholders involved in rural development—including government agencies, NGOs, political parties, churches, and communities—need to work together (Naome et al., 2012). Environmental monitoring should be used as a strategy for rural development because it has a significant impact on the conservation of watersheds and can help stop further degradation of the environment (Chifamba, 2011).

FINDINGS AND ANALYSIS

Environmental committees are made up of participants in the Upper Pungwe River Basin's environmental management. 12 of the 17 District Environmental Committees are properly constituted and are so operating. Since the start of the year, the other five committees were not functioning, so no responses from these departments have been obtained.

Table 1: Aggregated respondents' gender

Male	Female	Total
6	6	12

Source: survey results

Six men and six women responded to the survey. As a result, there were equal numbers of men and women serving as chairs of the basin's environmental management committees (see Table 1).

As the chairman were between the ages of 25 and 50, the committees were led by both young and senior people. Six of the committee heads had served on the environmental boards for no longer than two years, while the other five had done so for between two and five years (see Figure 4). As seen in Figure 4, one chairman served for more than five years. As a result, the committees include both young people and those with background in Pungwe River Basin environmental management. Even while young people and women were equally represented on the committees and included in their frameworks, this study was constrained in that it did not look at considering the importance of these special interest groups.

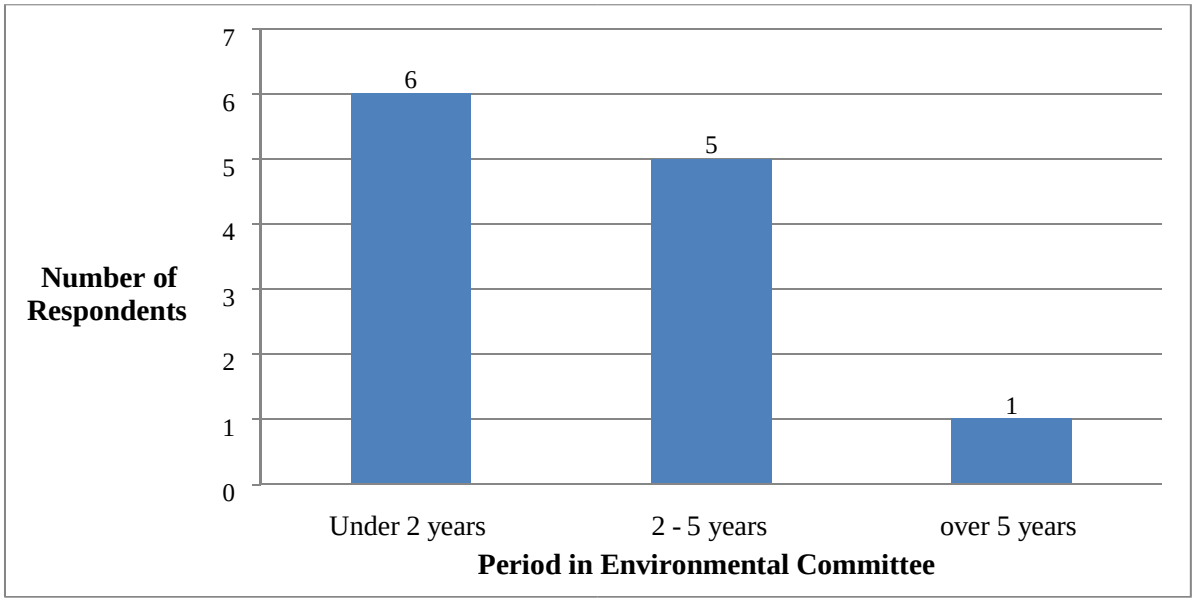

Figure 4: Environmental Committee Experience of Respondents
Source: Survey results

Institutions for Environmental Management in the Pungwe River Basin

Environmental management specialists from the Manicaland Province EMA, Mutasa District Administrator, and Mutasa Rural District Council self-administered three surveys. All responders turned in their surveys. All of the male respondents from the 3 upper Pungwe River environmental management institutes had a minimum of ten years of experience in the field.

Pungwe River Basin Water Management Agencies

Interviews were conducted with three specialists in integrated water management from ZINWA, Save Catchment, and Pungwe Sub-catchment Council. All of the respondents from the utility water management institutions, including both new and seasoned workers, were men. The PSCC outreach representative and river inspector both had more than ten years of experience, although the hydrologist had only been with the company for four years.

Institutional Interactions for Environmental Management

Stakeholder involvement in environmental management encouraged by district environmental management committees

The chairpersons stated that they were chosen to lead the environmental management groups by the organizations or stakeholders that were relevant to them. On local environmental management committees, 90% of the chairs said they represent a special interest organization. Local government officials, traditional chiefs, government agencies, as well as communities or villages in the districts, were among the parties said to have sent representatives. Two responders, however, chose not to respond to the query. The majority of the heads of environmental management committees concurred that their members were chosen or elected by their stakeholders.

District environmental management committees' responsibilities

According to the respondents, the districts' environmental management committees are in charge of a variety of tasks. The management of the environment and natural resources is the responsibility of the committees, according to eleven of the twelve chairpersons who responded. The 11 leaders made it very clear what the community environmental management committees were there for: environmental advocacy, policy development and action planning, natural resource protection, and general environmental management.

Environmental management institutional roles and responsibilities in the Pungwe River Basin

The goal of EMA was to reduce pollution and land degradation in order to guarantee sustainable management of the Pungwe River Basin. The community has benefited from the work of Mutasa RDC, which has also issued licences for "sustainable" mining and educated the locals on river basin management. According to the District Administrator's Office of the Ministry of Local Government, the department's duties included organizing, overseeing, assessing, regulating, and counseling institutions with everyone else on initiatives and operations in the basin.

The Pungwe Sub-catchment Council has played a key role in the catchment area's management of the environment and water resources. In its everyday activity, the PSCC coordinated with the EMA, Mutasa DRC, Mutasa DA, ZINWA, AREX, and other government ministries or agencies.

Without going via a government department, the PSCC would be able to settle any difficulties with the appropriate department or agency and completely enforce the laws against illicit water abstraction. The PSCC also emphasized that it ran public awareness campaigns before using the law's provisions. In order to achieve sustainability, the PSCC supports stakeholders in the integrated management of water resources.

The PSCC collaborated with the same organizations as ZINWA and the Save Catchment Council did. To ensure that the aforementioned environmental issues were addressed, they also collaborated with the Ministry of Lands, AREX, EMA,, and other governmental organizations, albeit at the provincial level.

Protecting the watershed and ensuring effective management and utilization of water resources were the responsibilities of ZINWA in river basin environmental management. Monitoring water flows, authorizing water use, distributing water fairly, and keeping an eye on floods and droughts are all parts of managing and using water.

Serious environmental challenges within the Pungwe River watershed

The most prevalent environmental issues in the basin that environmental management specialists agreed upon were listed as:

- Deforestation
- Climate Change
- Mining activities
- Stream bank cultivation
- Siltation
- Eutrophication
- Water pollution
- Lack of awareness
- Inadequate institutional frameworks

Since stream bank agriculture caused significant rates of eutrophication, water pollution, erosion, and sedimentation, it was determined that it was the primary cause of the other environmental issues. People tend to cultivate quite close to streams despite the prescribed shortest distance of 30 meters as specified by Statutory Instrument 7 of 2007 because of the river basin's rugged and hilly terrain and the area's large population (Government of Zimbabwe, 2007). The main factor contributing to the degradation of water resources was identified as anthropogenic land use practices. This has been demonstrated by the fact that there is a lack of land, the necessity to cultivate nearer to the water source, and the quest of communities in the river basin for fertile soils. The upper Pungwe River basin has experienced significant deforestation due to human activities such as logging, agricultural expansion and firewood collection. This has led to soil erosion, reduced water quality and loss of biodiversity. The upper basin of the Pungwe River is rich in minerals, which has led to mining in the area.

However, mining activities can have significant environmental impacts such as soil erosion, water pollution and biodiversity loss. Consequences of climate change, such as droughts, floods, and changes in precipitation patterns. These changes can have significant impacts on the environment and the communities that depend on it for their livelihoods. Moreover there is a lack of awareness among the local communities about the importance of environmental conservation and sustainable resource management. This has led to unsustainable practices that contribute to environmental degradation. The existing institutional frameworks for environmental management in the upper Pungwe River basin are inadequate. There is a need for better collaboration and coordination between different stakeholders, including government agencies, NGOs, and local communities, to address the environmental challenges in the area.

Institutional procedures for resolving the basin's environmental challenges

According to experts from water management organizations, alluvial gold mining and riverside farming in particular are to blame for the contamination and silting of the Nyamukwarara and main Pungwe rivers. Since not much was done to deter people from engaging in these degraded activities, it was claimed that community poverty and an apparent lack of other livelihoods were the main causes of these detrimental practices. Water shortages and falling river discharges have been attributed to climate change and the opening up of more area for agriculture. With the PSCC recording an average of 12 disputes a year, or one conflict per month, water constraints have led to another water conflict issue. Usually, the relevant government department or agency in charge of the resource took care of these matters. Together with stakeholders and development partners like the Pungwe program, these include PSCC, ZINWA EMA and traditional leaders. The majority of these environmental issues are reflected in river retreat and course alterations (see Figure 5). ZINWA uses measuring stations to monitor water flow at key locations, and these stations also give data on water flow patterns. A general rise in disputes over water may also be a sign of the situation of water shortage getting worse. Two outreach officers from the PSCC were stationed there and scouted the main Pungwe River and its subsidiary rivers while keeping an eye on water levels.

Figure 5: At the F24 Hydrological Station, gauge plates became clogged
Source: Field surveys

According to the EMA, environmental observers are scouring the basin for indicators of environmental deterioration. The EMA's Water Quality Section routinely sampled the catchment's ambient water quality at authorized monitoring sites. ZINWA amd EMA should

work together to tackle all water-related environmental concerns through the PSCC, in the opinion of the Environment Agency.

The EMA, Traditional Leaders, ZINWA, Conservation Officials, Law Enforcement, Mutasa RDC, Forestry Commission, Property, PSCC, Department of Agriculture and Extension Services, and Department of Irrigation have all expressed concerns to Mutasa DA about the environment. All of the water and environmental management organizations reported to the department since the district manager was in charge of every department of the government in the watershed. All environmental issues have been addressed by the District Administrator, who serves as the district's head of local government, in collaboration with other stakeholders, particularly local traditional leaders and pertinent government agencies. Therefore, it fell to the district administrator to mobilize all government agencies, parastatals, and other interested parties and to motivate them to take initiative and perform their duties as required by law.

Effectiveness of the catchment's institutions and mechanisms for managing water and the environment

The Pungwe River's three primary environmental management organizations, EMA, Mutasa DA and Mutasa RDC, asserted that their organizations were highly successful in combating river pollution and siltation. The environmental issues associated with water difficulties would be addressed by these institutions' environmental awareness initiatives and the enforcement of laws.

As a venue for stakeholders to bring up their environmental issues to various ministries and government agencies, environmental management structures, according to experts from water management institutions, are very effective. Additionally, they claimed that these organizations made it possible for interest groups to report environmental problems, despite the fact that environmental management organizations at the time did nothing to solve the problems highlighted. They desired that all of these issues be handled by one entity. Among the water management specialists we spoke, "Having water management that includes monitoring and level allocation in one organization and then monitoring water quality in another does not appear to be very effective in promoting sustainable water management" (interviewee).

Involvement in the administration of institutions managing water and environmental resources to address water-related environmental issues

A variety of environmental management parties must be involved in order to address any concerns discovered due to the fragmented nature of environmental regulation in Zimbabwe. The chairs of seven out of twelve neighborhood environmental management committees (58%) said they had consulted with every environmental and water management organization in the watershed. Institutions for environmental management employ more presidents than those for water management. EMA and Mutasa RDC were both hired by ten chairpersons, while ZINWA and PSCC were chosen by 9 and 7 presidents, respectively. According to the findings, there was an excessive amount of interaction between the EMA and Mutasa RDC, followed by the ZINWA and the PSCC. At lower levels of the environmental management hierarchy, institutional commitment to improved environmental management is therefore less prominent.

Just 2 out of 9 chairs of neighborhood environmental committees informed water management organizations about water issues. 78% of the presidents who responded to the question stated that they were discussing the issue in their committees or referring it to organizations in charge of managing the environment and land, such as AREX, Mutasa RDC, EMA and the Forestry Commission. The Pungwe River Basin's abundance of water and environmental management institutions, which results in overlaps and gaps in the application of environmental regulations and water, may be the cause of stakeholders' inconsistent treatment of water concerns. This might also be the result of a lack of clarity or comprehension

on the part of the institutions involved regarding the obligations and functions of other river basin institutions. ZINWA stated that they and Mutasa RDC were still in communication. The Pungwe Sub-catchment Council, for which the ZINWA organization provided the secretariat, included Mutasa RDC as a member. They engaged in conversation during the council's plenary sessions, which were conducted in the basin, for this reason. The influence of environmental management on the water was then brought up and discussed. In addition to Mutasa RDC, according to PSCC, EMA was also involved in issues as they occurred and was obediently required to attend all PSCC full board sessions as auxiliaries. Institutions involved in water management and environmental management appeared to be working together continuously. In order to boost water and environmental management in the river basin, water management organizations believed that there was much that needed to be done in terms of cooperation.

PSCC and ZINWA are crucial in tackling water-related environmental challenges, according to Mutasa RDC. In general, respondents agreed on how environmental issues in the catchment area related to water are being dealt with. According to Mutasa RDC, they are implementing the SI 7 provision of 2007 and undertaking awareness efforts through meetings to stop the depletion of water resources. The EMA claimed to have employed this technique. ZINWA and PSCC were the catchment water management organizations that would be contacted or involved.

Pungwe River Water Quality Trend

The information on water quality covered the years January 2003 through March 2013. However, pH results had more data coverage than turbidity did. For the years 2007 through 2009, there were no data available. Following the passage of the EMA Act (20:27) and the establishment of the Environmental Management Agency in 2007, during this time ZINWA's water quality monitoring responsibilities were transferred to EMA (EMA, 2014).

The pH readings were typically lower than seven and hence acidic between the years 2003 and early 2006. This can be a result of destructive farming methods used in the watershed. pH levels continuously rose above seven from 2012 to late 2013, however trend analysis was confounded by missing data during 2007 and 2009. From 2005 to 2013, turbidity levels varied between 12.1 and 0.09. From 2.15 in 2003 to 12.1 in 2005, turbidity rose. The Pungwe River's turbidity thereafter started to decline, reaching a low of 0.09 in 2013. Lower river flows that were seen at the conclusion of the study period may be responsible for the decline in turbidity measurements. No statistically significant patterns were found in the turbidity and pH data, according to a Mann-Kendal analysis ($p>0.05$) of the data.

Pungwe River Sediment Load

Data on sediment loads were gathered for hydrological station F22 from the hydrological seasons of 2001–2002 to 2012–2013. There were no data from the 2008–2009 season through the 2011– 2012 season in the station's data set.

During the hydrological season of 2005–2006, the annual sediment load in the Pungwe River, as measured by Hydrological Monitoring Station F22, reached its peak value of 131,720 tonnes (see Figure 6). The following season, in 2006–2007, saw the lowest level ever, 1,352 tons. Overall, across five seasons, sediment loads varied from 10,000 tonnes to 40,000 tons, with three outliers totaling 118,681, 131,720, and 1,352 tons. The station's average river sediment load was 45,366 tons, with a standard deviation of 50,576 tonnes.

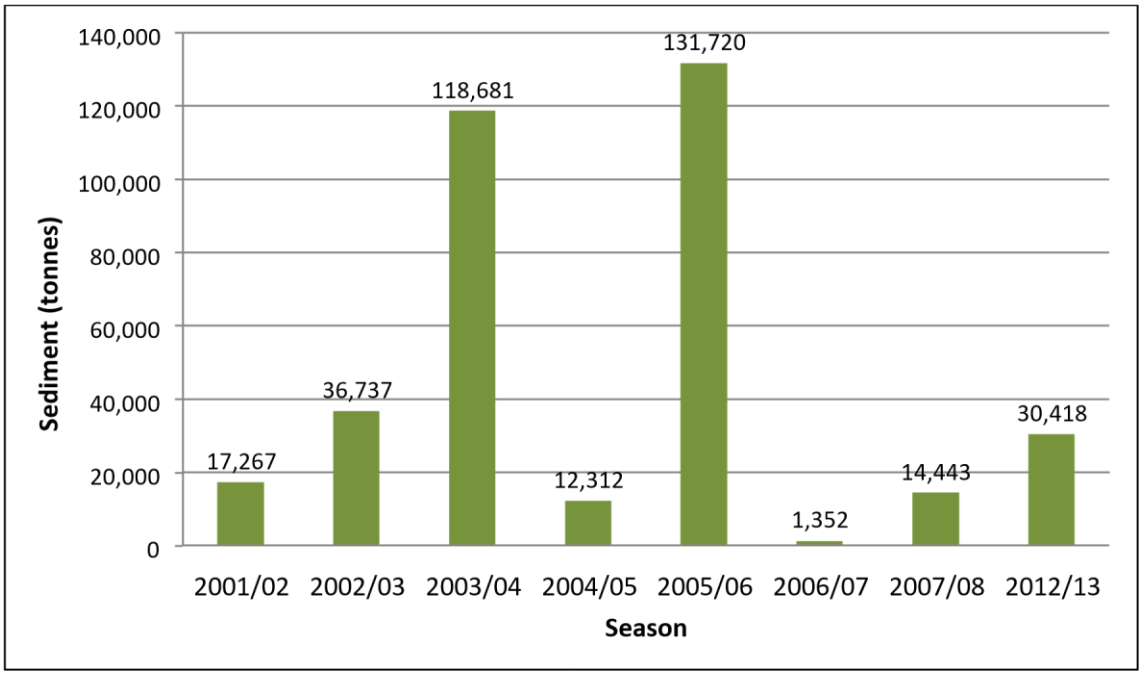

Figure 6: Annual sediment load at F22
Source: ZINWA Sediment load Database, 2015

The monthly sediment load shows exact pattern as the annual load. The yearly loads and monthly loads for the eight seasons are both less than 40,000 tons, however the 2003/04 and 2005/06 seasons had two figures that distorted the overall trend in the graphs (Figure 4). These two figures were 102,407 and 118,568 tonnes, respectively. Since 280,000 m^3/s, or 85% of the yearly flow of 330,000 m^3/s, went through station F22 in March 2006 alone (Figure 5), it is possible that flash floods were to blame for the elevated level of sediments during the 2005–2006 season. For the six-month sample season, the average monthly sediment load was 7,561 tonnes, with a standard deviation of 22,832 tonnes. No highly significant trend was found in the data according to Mann-Kendal analysis ($p>0.05$).

Pungwe River Runoff Trends

There were records for 17 hydrological seasons in the runoff database. The information spanned the years 1996/97 through 2012/13. All high and low flows during the study period were included in the data set, which had gaps of less than 10%.

Hydrological Monitoring Station F22 Pungwe Katiyo. In the following year, the season begins in October and concludes in September. Since the station's debut, the 1996–97 season streaming have only lasted two months. Since the station's opening during the 1996–1997 hydrological season, there was a decline in discharges. Due to shifting precipitation patterns, a long-term hydrograph also demonstrated a decline in peak discharge across one season to the next.

Annual flows peaked during the 1996–1997 season and have since decreased for the 17 seasons that the station has recorded data for. The flows had a pattern that was comparable to the monthly flows. The highest recorded annual flow was 1,669,338 m^3, while the lowest was 31,306 m^3. The average annual outflow was 495,613 m^3, and the discharges' standard deviation was 507,692 m^3.

Water Quality Parameters, Runoff, and Sedimental Load in Relation

According on data gathered at Hydrological Monitoring Station F22, Figure 7 depicts a regression line and comparison of the link between discharge and sediment load in the Pungwe

River. A linear positive correlation between the amount of water washed away and the matching amount of sediment present in flowing water is depicted in the figure. With a coefficient of determination (r2) of 0.1718, the equation, however, is unable to predict outcomes with great accuracy. Two exceptionally high values of sediment loads in the seasons the years 2003 and 2004 and 2005/06 had a significant impact on the regression equation. The graph demonstrated that as river flow increased, so did the amount of sediment in the water.

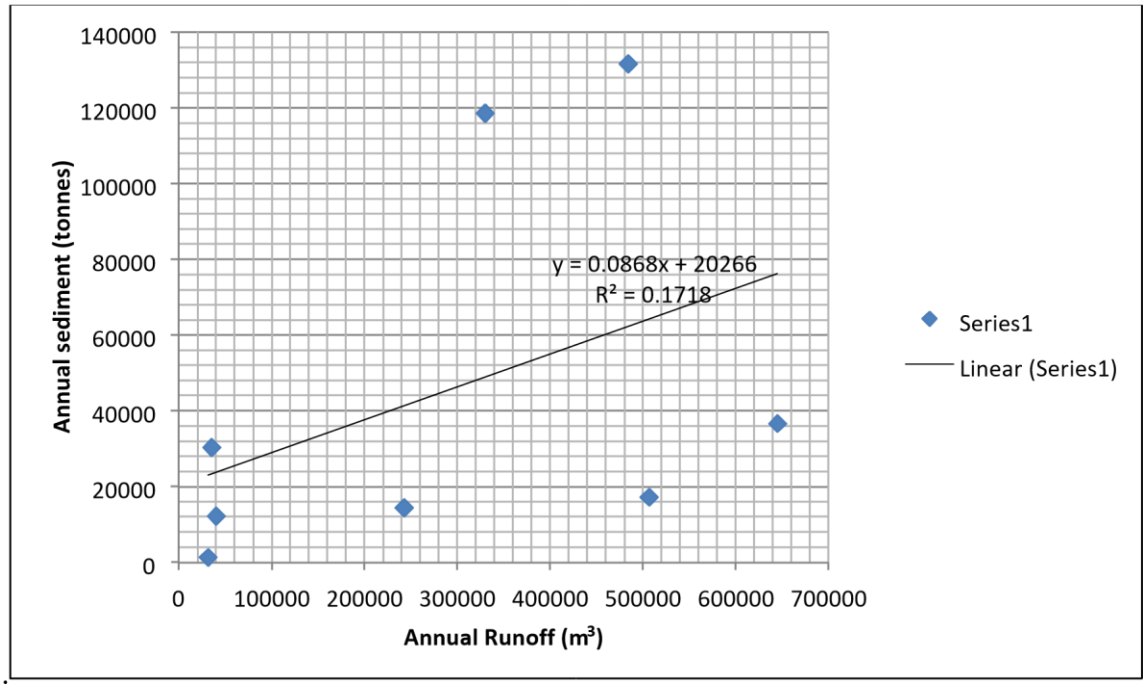

Figure 7: Annual runoff and river sediment load interactions
Source: ZINWA Sediment Load Database, 2015

The link between pH and sediment load in the water of the Pungwe River is depicted by a regression line and comparison in Figure 8. The graph demonstrates a negative linear relationship that exists between pH and sediment load, which means that as the river's sediment load rises, the pH of the water will also rise. The runoff of fertilizers from fields into the river basin may be to blame for the pH reduction into the acidic range. This supported reports regarding highflow bank crops from water and environmental management specialists. Additionally, the equation's coefficient of determination (r2) is incredibly low, at 0.0329. The accurate examination of water quality changes has been greatly impeded by large data gaps and brief water sample intervals.

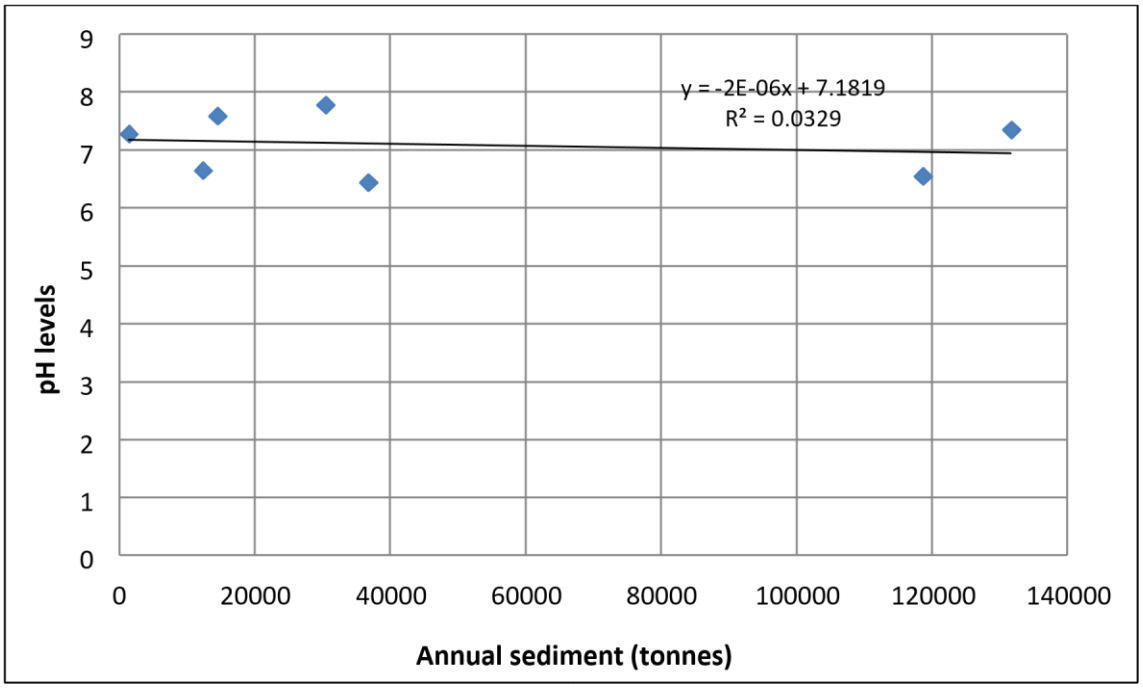

Figure 8: Annual sediment load and pH relationships
Source: ZINWA Sediment Load Database, 2015

DISCUSSION

Sediment Load, Chemical and Physical Water Quality Trends

Data collection on water quality and sediment load in the Pungwe River Basin was inconsistent. The two organizations in charge of water and the environment did not gather data between 2007 and 2013 during that time. The evaluation and comparison of current and historical trends in water quality in the Pungwe River have been hampered by the lack of data on sediment load and water quality.

Interactions between Institutions in Environmental Management

Effective institutional interaction is crucial for addressing the complex environmental challenges facing the Upper Pungwe River Basin and ensuring the sustainability of its natural resources and communities. Even as an information source for the PSCC during the plenary council meetings, the EMA took no active part in water management. EMA and Mutasa RDC have collaborated closely with land resource management organizations including AREX and the Commission of the Ministry of Land and Forests. To eliminate stream banks management, deforestation, gold panning, and water pollution, they needed to strengthen their relationships with organizations that manage water resources.

Some water-intensive environmental issues have a history of being handled by environmental management committees without the involvement of water management organizations, particularly the PSCC. The Mutasa District Manager's Office coordinated institutions for managing water resources and the environment because it was responsible for all district-wide government ministries and agencies.

There was little contact amongst water and environmental management entities at the river basin level. This was shown by the fact that while PSCC and community committees hardly interacted, EMA, ZINWA, and Mutasa RDC continued to be actively involved in environmental management in the Pungwe River Basin. Managing the environment, as shown by the survey's findings. Since environmental resources were utilised at lower levels,

institutional relations concerning environmental management were weaker there and greater at the provincial level.

Participation of Stakeholders in Environmental Management

Because they relied on the environment for their livelihood, local actors attempted to assure good environmental management through their active engagement. The fact that 50% of committee chairs were women demonstrates how extensively involved women were in environmental management. Environmental management piqued the interest of traditional leaders. The Traditional Chiefs Act, which places custody of all natural resources in their hands, has been used frequently by the traditional chiefs who serve on these committees. The questionnaire replies from the environmental management committees make this clear. Therefore, these two significant institutions required an allocation of authority and a division of responsibilities. As a result, local stakeholders were actively involved in environmental management, albeit it was not obvious how they worked with the PSCC to address environmental problems including water.

Also Multi-stakeholder platforms (MSPs) are forums that bring together different stakeholders to exchange information, share experiences, and develop joint strategies for addressing environmental challenges. In the Upper Pungwe River Basin, MSPs have been established to facilitate dialogue between government agencies, civil society organizations, and local communities on issues such as water management, land use planning, and biodiversity conservation. Partnership agreements are formal agreements between different stakeholders to work together towards a common goal. In the Upper Pungwe River Basin, partnership agreements have been established between government agencies, non-governmental organizations, and local communities to promote sustainable land use practices, improve water management, and protect biodiversity.

Efficiency of Institutions for Environmental Management

Due to institutional holdups and practical challenges, certain environmental governance committees hadn't yet been formed, which cost the corresponding agencies money. The tasks of the PSCC and neighborhood environmental management committees provide as evidence of the overlap between the responsibilities of the water resources and environmental management organizations involved. The duties of organizations like the EMA, PSCC, Environmental Management Committees, ZINWA, and collection advice have all been subject to overlaps in Zimbabwe's environmental management legislation (Naome et al., 2012).

In Zimbabwe, institutional responsibilities for managing water and environmental resources were overly divided, with one organization in charge of measuring sediment contamination and another in charge of conducting water turbidity tests. Due to conflicting institutional agendas and sample times, this led to data gaps and inconsistencies. In the upper Pungwe River watershed, there was no institutional or legal framework for coordinating water and environmental management efforts.

CONCLUSIONS

The Upper Pungwe River basin faces a number of environmental management challenges, including deforestation, soil erosion, water pollution, and habitat degradation. To address these challenges, a range of policy interventions and implementation strategies can be considered, including:

- Strengthening legal and regulatory frameworks: This could involve the enactment of environmental laws and regulations that aim to protect the Upper Pungwe River basin, and the enforcement of existing laws and regulations. This can be done through

collaboration between government agencies responsible for environmental management and other stakeholders.

- Promoting sustainable land use practices: This could involve promoting sustainable agriculture practices, such as conservation agriculture, agroforestry, and sustainable forestry practices, which can help to reduce soil erosion and deforestation.
- Encouraging public participation and awareness: This can involve raising public awareness about the importance of environmental conservation and the impacts of environmental degradation. This can be done through education and outreach programs, public campaigns, and community engagement.
- Strengthening monitoring and evaluation: This could involve the development of a reliable monitoring and evaluation system to ensure that policies and interventions are achieving their intended outcomes. This can be done through the use of remote sensing technology, water quality monitoring, and other techniques.
- Promoting sustainable tourism: This could involve promoting eco-tourism in the Upper Pungwe River basin, which can help to generate income for local communities and promote environmental conservation.

Overall, effective policy implementation would require collaboration and coordination between multiple stakeholders, including government agencies, civil society organizations, and local communities.

RECOMMENDATIONS

Based on the challenges facing the Upper Pungwe River basin, here are some recommendations for environmental management:

- Conservation agriculture: Encourage the adoption of conservation agriculture practices that help to reduce soil erosion and improve soil health. This includes practices such as no-till farming, crop rotation, and the use of cover crops.
- Reforestation: Promote reforestation efforts to mitigate the effects of deforestation. This can be done through the establishment of community forests, reforestation programs, and the promotion of sustainable forestry practices.
- Water quality monitoring: Develop a comprehensive water quality monitoring program to track the levels of pollutants in the river and identify sources of contamination. This will help to inform policy decisions and intervention strategies.
- Public awareness campaigns: Launch public awareness campaigns to educate local communities about the importance of environmental conservation and the impacts of environmental degradation. This can be done through community meetings, radio programs, and social media campaigns.
- Sustainable tourism: Promote sustainable tourism in the Upper Pungwe River basin that respects the environment and supports the local economy. This can include the development of eco-tourism initiatives, such as bird watching, hiking, and wildlife watching.
- Collaboration and stakeholder engagement: Foster collaboration and engagement between government agencies, civil society organizations, and local communities in the development and implementation of environmental management policies and programs.

Overall, effective environmental management in the Upper Pungwe River basin will require a multi-faceted and collaborative approach that addresses the root causes of environmental degradation and promotes sustainable practices.

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