ANNEX 6 - Fisheries Management Framework

Fish Stock Assessment in Major Dams in Botswana

Project ref. N° SA-3.2- B15

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Country: Botswana

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Assignment by:

Landell Mills

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“The content of this document does not necessarily reflect the views of the concerned governments.”
Fish Stock Assessment in Major Dams in Botswana

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Name of individual consultant
Professor Ian Cowx

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<th>Description</th>
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<tr>
<td>ACP</td>
<td>African, Caribbean and Pacific Group of States</td>
</tr>
<tr>
<td>ADSB</td>
<td>Aquaculture for Development Strategy for Botswana</td>
</tr>
<tr>
<td>ALCOM</td>
<td>Local Community Development Programme</td>
</tr>
<tr>
<td>CBNRM</td>
<td>Community Based Natural Resources Management</td>
</tr>
<tr>
<td>CEDA</td>
<td>Citizen Enterprise Development Agency</td>
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<td>BDOT</td>
<td>Botswana Department of Tourism</td>
</tr>
<tr>
<td>DWNP</td>
<td>Department of Wildlife and National Parks</td>
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<tr>
<td>FAO</td>
<td>United Nation Food and Agriculture Organization</td>
</tr>
<tr>
<td>FD</td>
<td>Fisheries Division</td>
</tr>
<tr>
<td>FMPOD</td>
<td>Fisheries Management Plan of the Okavango Delta</td>
</tr>
<tr>
<td>NDP9</td>
<td>National Development Programme 9</td>
</tr>
<tr>
<td>SADC</td>
<td>Southern African Development Community</td>
</tr>
<tr>
<td>ToR</td>
<td>Terms of Reference</td>
</tr>
<tr>
<td>TNA</td>
<td>Training Needs Assessment</td>
</tr>
<tr>
<td>VDC</td>
<td>Village Development Committee and Dam Committee</td>
</tr>
<tr>
<td>WUC</td>
<td>Water Utilities Corporation</td>
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Acknowledgements

The consultants wish to thank the numerous members of the Fisheries Division of the Department for Wildlife and National Parks, especially Balisana Marotsi, Choto Choto, Montshwari Molefe and Thethela Bokhutlo. We would also like to thank all the various stakeholders consulted for providing valuable insights and data, and the fishers for helping understand the problems they face.
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Executive summary

The fisheries sector in Botswana is composed of mainly inland fisheries. The majority of the national fish production is from the Okavango aquatic system but demand for fish exceeds supply, especially in urban centres. Therefore other fishing and fisheries opportunities need to be developed to relieve the current pressure on the existing fisheries whilst creating employment, generating income and also providing a diverse, good quality diet for the rural communities and the population in general. One possible opportunity is to exploit the fish stocks in dams and reservoirs, but their fishing potential is not yet properly known. To explore this opportunity Botswana, requested funding under the ACP Fish II Project “Strengthening Fisheries management in ACP Countries” to support activities aimed at setting up a monitoring system to carry out stock assessment in the major dams in the country and to provide training to local concerned staff of the Fisheries Division (FD) of the Department for Wildlife and National Parks (DWNP). This document provides an overview of the status of the fisheries of the large dams based on existing knowledge and limited experimental fishing, identifies the key issues constraining the development of the fisheries and offers an outline fisheries management framework for the large dams in Botswana.

The Fisheries guidelines and management framework were validated at a workshop with FD and stakeholders, and comments from the consultations were fed back into the final documents.

Several conclusions and recommendations were forthcoming for the project:

- Little is known about the fisheries and environmental characteristics of the major dams in Botswana or the community dams. It is recommended the FD engage with WUC to promote integrated management of the reservoirs for multiple use, rather than trying to develop the fisheries in isolation.

- The Fisheries Sector is under resourced and the knowledge base in the division has been impaired. There is a need for a comprehensive review of the role of fisheries in provision of food security and rural livelihoods as well as continuous FD staff development to enhance skills and capacity to work from a wider environmental perspective.

- The major dams are unlikely to fulfil a major role in terms of fish production to supply urban areas in Botswana but there is a need to explore their potential in supporting local needs and tourism in terms of recreational fisheries. It is possible recreational fishing may contribute considerably more in terms of economic development and sustainable livelihoods.

- The current project was targeted at the major dams, but the presence of multiple local community dams and their likelihood to support local fisheries production and livelihoods was recognised. It is recommended these are included in the fishery assessment and development programme.

- The fish hatchery at Mmadinare represents a major asset but is largely under-utilised. It is recommended that the hatchery is rehabilitated to support stocking of the community dams, development of materials for stocking the major dams as appropriate and to act as a demonstration unit for fish farming in the country.

- Fisheries staff are under-resourced and require considerable training on stock assessment methodologies, fish ecology and data analysis and interpretation to improve their capacity improve stock assessment in the major dams but also other large fisheries in Botswana and thus position the sector as a major contributor to food security and rural livelihoods.
1. **Background**

The fisheries sector in Botswana, with no proximity to the oceans, is composed of inland fisheries and aquaculture. While the contribution of the fisheries sector to the national economy is insignificant (0.002% of GDP), the sector is certainly an important provider of income, employment and food security in some rural areas. The majority of the national fish production (averaged about 238t per year in the last 10 years based on Food and Agriculture Organization [FAO] statistics) is from the Okavango aquatic system where conflict between commercial fishers and recreational fishing promoters is a real concern. Therefore other fishing and fisheries opportunities need to be developed to relieve the current pressure on the existing fisheries whilst creating employment, generating income and also providing a diverse, good quality diet for the rural communities and the population in general.

One possible opportunity is to exploit the fish stocks in dams and reservoirs, but their fishing potential are not yet properly known. In the 1980s and 1990s an initiative was undertaken through the Aquaculture for Local Community Development Programme (ALCOM) led by the Food and Agriculture Organization (FAO) to conduct preliminary surveys for assessing the potential for developing fisheries in small water bodies in the southern part of Botswana. However, the methodologies were unsustainable since there was no appropriate involvement of local communities and not much was done with regard to capacity building. Following approval of a project proposal from Botswana aimed at developing the fisheries in the major dams of the country, the ACP Fish II Project “*Strengthening Fisheries management in ACP Countries*” with funding from the European Union, supported activities aimed at set up a monitoring system to carry out stock assessment in the major dams in the country and to provide training to local concerned staff of the Fisheries Division (FD) of the Department for Wildlife and National Parks (DWNP). The British company Landell Mills Development Consultants was contracted to undertake consultancy activities to produce the following as deliverables to the Fisheries Division in Botswana.

The purpose of the project was:

- To assist the FD of the DWNP in undertaking a fish stock assessment in the selected dams in order to determine the status of fish stocks; and
- To strengthen FD capacity for continued monitoring to ensure sustainable utilization of resources.

The expected outputs from the project were:

- Devise preliminary study on the presence and abundance of the fish stocks in the major dams (Gaborone, Shashe, Letsibogo, Bokaa, Nywane);
- Develop guidelines for development of fish stock assessment/monitoring methodology

Both components of these outcomes are reported elsewhere, but is was recognised early on in the project that preparing a sampling programme and guidelines for sampling the dams fell short of the needs of the FD. This report provides guidance on the potential management framework for the dams given a range of scenarios.

The general strategy for preparing the management framework is outlined in Figure 1. This strategy encompasses the various actions required to meet the objectives of the framework and in particular:

- Used project management techniques to solve problems and produce a strategy for their execution.
- Provided knowledge of the technical policy and background to potential conflicts of use of resources in the dam systems.
- Developed a plan based on comparison of status of the dam fisheries with objectives as defined by the FD and national fisheries policy.
- Ultimately (although not part of this exercise) developed an action plan with projects and
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- Recognised the need for an integrated approach to management of resources to minimise conflicts and optimise use.

This approach specifically does not just deal with technical issues targeting the fisheries and their effectiveness or limitations, it works within a national policy framework and attempts to address societal and prevailing ideas and values and accounts for institutional frameworks, i.e. fit within the regulations and legislation.

**Figure 1. Outline strategy for development of the Kafue Flats fisheries management plan.**

The framework addresses the following main elements:

- The status and characteristics of the dam fisheries as known. It should be noted that further information of the fisheries is urgently required, including spatial and temporal trends in the fisheries exploitation patterns, gear characteristics, characteristics of the fishing activities.
- Outcomes of consultations with FD, WUC staff, fishing communities and stakeholders to ensure their participation in development of the management process.
- Issues impacting on the fisheries, including main constraints relevant to the development of a management framework.
- The information was drawn together to develop a management framework for the major dams and community dams in Botswana with objectives commensurate with the desired outcomes of stakeholders and Government.

A full consultation of the proposed management needs to be carried out by the FD with key communities to engage stakeholders and expedite adoption and uptake of the proposal.
2. Background information on major dams in Botswana

Five major dams were originally considered under this programme (Gaborone, Bokaa, Shashe, Letsibogo and Nnywane), but flowing visits to various large dams in Botswana, it was recommended that Ntimbale and the newly flooded Dikgatlhong dam are included in the assessment as well as smaller irrigation reservoirs that could potentially be sources of fish for local communities. There are several hundred of these irrigation dams in the eastern part of Botswana and they can potentially contribute significant amounts of fish to local communities to support food security issues.

The major dams are located throughout the Limpopo river system in Botswana (Figure 1). All dams are created by impoundment of the river (Figure 2). They range in size and the way the water is utilized (see Figure 3 for variability in water levels). For example, the water level in Letsibogo dam (Figure 3d) are utilized to ensure high levels at Gaborone Dam (Figure 3a). Bokaa, by contrast is drawn down and is currently (October 2012) at dead storage level (Figure 3b).

The major dams are of varying sizes, depths and topographs (Table 1). The largest and deepest in Letsibogo but this will be superseded by Dikgatlhong when flooded. No information is available on the productivity of the systems but all have a similar conductivity range (240-300 µS) suggesting relatively high ionic concentrations that probably reflect the catchment geology.
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a) Gaborone dam

b) Bokaa dam

c) Letsibogo dam
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Figure 2. Google Earth images and photos of major dams in Botswana.

Table 1. Baseline information on large dams in Botswana (source Mmopelwa 2000)

<table>
<thead>
<tr>
<th>Dams</th>
<th>Area km²</th>
<th>Catchment area km²</th>
<th>Depth max m</th>
<th>Depth mean m</th>
<th>Conductivity uS</th>
<th>No of species</th>
<th>Licensed fishers</th>
<th>Average CPUE (kg/net)</th>
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<tr>
<td>Gaborone</td>
<td>19</td>
<td>4300</td>
<td>18</td>
<td>6</td>
<td>263</td>
<td>15</td>
<td>4</td>
<td>0.41</td>
</tr>
<tr>
<td>Shashe</td>
<td>17</td>
<td>3650</td>
<td>10</td>
<td>3.3</td>
<td>245</td>
<td>19</td>
<td>4</td>
<td>12.32</td>
</tr>
<tr>
<td>Letsibogo</td>
<td>18</td>
<td>3570</td>
<td>30</td>
<td>10</td>
<td>297</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Bokaa</td>
<td>6.6</td>
<td>3570</td>
<td>6.5</td>
<td>2.2</td>
<td>248</td>
<td>5</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Nnywane</td>
<td>0.55</td>
<td>238</td>
<td>12</td>
<td>4</td>
<td>281</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Not exploited
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Figure 3. Water levels in dam. (Red line = Phase III drought level; brown line = dead storage level).
Figure 3 cont. Water levels in dam. (Red line = Phase III drought level; brown line dead storage level).
3. **Status of the fisheries in the major dams**

3.1 **Review of existing information**

A review of the technical documents available on the fisheries resources of the major dams revealed that little data exist for the target systems. There has been little information collected or studies conducted on the fisheries since 2000. Summary information is listed in Table and data on fisheries production in Figure 4. It is important to realise that the increase in fisheries production in 1999 was probably a result of persons normally recruiting to military service being orientated towards exploiting the dams.

The bulk of the fish harvest in Gaborone comprised bream and barbels with few other species caught, especially in 2002. By contrast the bulk of the catch in Shashe was *Labeo* species with some barbels (Figure 4).

The key issues from the data review is that available information is inadequate to make an assessment of the status or potential yield in the short term because there are no longer term data series and it is impossible to carry out catch assessment surveys because there are insufficient fisheries exploiting the dams to adopt a classic catch assessment strategy. Consequently, an approximation of the potential yield was obtained using the environmental correlation method linking fisheries production to the morphoedaphic index (Table 2). The potential yield from the reservoirs falls between about 100 and 200 kg/ha/yr which is typical for reservoirs of this type in Africa. The slightly high potential yield in Bokaa is almost certainly a function of the small size of the dam.

**Table 2.** Baseline information (source Mmopelwa 2000) and predicted potential yield from major dams in Botswana using environmental correlation methods (MEI morphoedaphic index)

<table>
<thead>
<tr>
<th></th>
<th>Area km²</th>
<th>Conductivity µS</th>
<th>Depth mean (m)</th>
<th>MEI</th>
<th>MEI Estimated production (kg/ha/yr)</th>
</tr>
</thead>
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<tr>
<td>Gaborone</td>
<td>19</td>
<td>263</td>
<td>6</td>
<td>43.8</td>
<td>126.1</td>
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<tr>
<td>Shashe</td>
<td>17</td>
<td>245</td>
<td>3.3</td>
<td>74.2</td>
<td>159.6</td>
</tr>
<tr>
<td>Letsibogo</td>
<td>18</td>
<td>297</td>
<td>10</td>
<td>29.7</td>
<td>106.0</td>
</tr>
<tr>
<td>Bokaa</td>
<td>6.6</td>
<td>248</td>
<td>2.2</td>
<td>112.7</td>
<td>192.4</td>
</tr>
<tr>
<td>Nnywane</td>
<td>0.55</td>
<td>281</td>
<td>4</td>
<td>70.3</td>
<td>155.8</td>
</tr>
</tbody>
</table>
Figure 4. Trends in fisheries production from Gaborone and Shashe dams (top panel) and species composition of catches by weight in Gaborone (middle panel) and Shashe (bottom panel) (source Mmopelwa 2000 and FD Annual report 2002/3).
3.2 Fisheries surveys carried out under ACP 2 project

Because of the lack of information on the major dams, the programme was set up to carry out some provisional fisheries surveys during the duration of the project. Gillnet surveys were set up using the standard protocol established as part of the project on five of the dams (Letisibogo, Shashe, Nnywane, Ntimbale and Dikgatlhong) and supplemented by some recent surveys carried by the FD on others. All data were collected with a fleet of gillnets with mesh sizes from 12-150 mm and samples were taken in different zones of the reservoirs representing shallow and deep areas. In addition surveys were carried out in vegetated areas if they existed in the reservoirs. The surveys were carried out in September 2012 and repeated in October 2012. No surveys were carried out on Gaborone because of an investigation into a drowning or Bokaa because the reservoir was almost dry and difficult to access.

In all surveys the fish were sorted for each mesh size, indentified and measured (nearest mm) and weighted (g). Data were stored imported to Excel and analysed for the following characteristics either in Excel or in the software package PRIMER.

3.1.2 Species composition

The gillnet surveys provided good insight into the structure of the fish communities in the reservoirs sampled (Figure 5). The dominant species by number varied between the reservoirs. *Schilbe intermedius* was the main species in Dikgatlhong by both number and biomass. By contrast *Barbus trimaculatus* was the main species by numerical in Ntimbale and Shashe but *Clarias gariepinus* contributed the highest biomass. *Clarias* also was a primary contributor to the biomass on Letsibogo and Nnywane but *Labeo rudii* was important both numerically and by weight in Letsibogo whilst *Oreochromis* species were important in Nnywane. Importantly large-mouth bass was confirmed in Letsibogo and Nnywane and is known to also exist in Gaborone. The numbers caught were sample but this probably reflects the sampling method. Discussions with angers and fishers indicated that the Letsibogo and Gaborone supported good stocks of these species with fish up the 4 kg not uncommon.

![Figure 5. Species composition by number (left) and weight (right) of gill net catches in reservoirs sampled under ACP2 programme.](image)

This change in species composition was confirmed using Multidimensional Scaling (MDS) based on the Bray Curtis similarity index, where three distinct types of reservoirs with significantly different species composition were discriminated (Figure 6). Letsibogo and Nnywane cluster because of the presence of large-mouthed bass, whilst Shashe and Ntimbale were grouped because of their similarly diverse fish communities and dominance of *Barbus trimaculatus*. Interestingly, the fish community structure in Ntimbale shifted towards that in Shashe between 2010 and 2011 and probably reflects a
maturing of the community in the years flowing flooding and approaching the composition of the fish community in Shashe which has been flooded for considerably longer and has probably stabilised. Dikgathlong was isolated and this probably reflects the early flooding stage of this reservoir and the dominance of riverine species. It is expected that reservoir will become dominated by lacustrine type species, especially \textit{Barbus} and \textit{Oreochromis} species, as the reservoir matures and the community will probably become similar to Shashe and Ntimbale, given their close proximity on the Shashe river system.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure6.png}
\caption{MDS plot of species change in gill net catches from major dams in Botswana.}
\end{figure}

One aspect of the gillnet surveys carried out in September and October 2012 was testing differences in fish catches between different zones of the dams (deep, shallow or shallow vegetated). Clear differences in the fish communities were found between the different zones of the same reservoirs (Figure 7), and this was confirmed by MDS analysis (Figure 8). The isolation of Ntimbale unknown zone was caused by the appearance of \textit{Barbus poechi}, and it must be queried whether this was an isolated shoal of fish resident in the system following flooding.
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Figure 7. Species composition by number of gill net catches in different zones of major reservoirs sampled under ACP Fish II programme.

Figure 8. MDS plot of species change in gill net catches from different zones of major dams in Botswana.

3.1.3 Gear selectivity

One aspect of the use of gill nets that must be considered when using gillnets is that of gear selectivity. Gillnets are notoriously selective and thus outputs should be adjusted to give a true representation of the population using appropriate software such as SELECT or the selectivity function in PASGEAR.
Insufficient data were available for existing studies or the ACP sampling events to undertake such an analysis but an analysis of the mean lengths from each mesh size (Figure 9) provides an indication of the selection characteristics of the fleet of gill nets used. There is clear selectivity for three (*O. mossambicus*, *C. gariepinus* and *L. rudii*) of the 4 species where sufficient data were available. There was probably no obvious selectivity for *B. trimaculatus* because of its small size and predominance in small mesh sized nets only. However, the data highlight the feasibility of setting mesh size regulations for the fishery.

![Figure 9](image)

**Figure 9.** Mean length (± SD) for *B. trimaculatus, O. mossambicus, C. gariepinus* and *L. rudii* caught in different experimental gillnet mesh sizes.

### 3.1.4 Mean length and weight of fish caught

Because a standard fleet of gillnets was used in each reservoir during the surveys, it is possible to compare the mean length and weight of fish species caught in the different systems (Figure 10). For the species examined (*B. trimaculatus, O. mossambicus, C. gariepinus, L. rudii* and *Schilbe inermis*) there were distinct differences in the mean length and weight between reservoirs for *O. mossambicus* and *C. gariepinus*. It appears that the mean size of *O. mossambicus* was larger in the unexploited reservoirs Nnywane and Dikgatlhong than in the exploited reservoirs (Letsibogo, Ntimbale and Shashe) and the converse was found for *C. gariepinus*. This suggests some impact of fishing exploitation on the size structure of the fish stocks, although this conclusion must be treated with caution as it is based on a small, and probably inadequate, data set. It is an aspect that is worthy of further evaluation once better data are available.
Figure 10. Mean length (± SD) [top] and weight (± SD) [bottom] for *B. trimaculatus*, *O. mossambicus*, *C. gariepinus*, *L. rudii* and *Schilbe intermedius* caught by standard gillnet fleets in different reservoirs.

### 3.3 Fisheries of small community dams

Little work has been carried out to assess the status of the fish stocks in small community reservoirs, although a visit to Jacklass 2 suggests these are valuable assets and offer an opportunity for local community groups to optimise benefits of the resources. There appears to be willingness to develop these systems and provide either a local source of fish for the community or open them up to leisure activities. Irrespective, there is a fundamental need to include these systems in any fishery development plan. The only information available was that of Nermark (2001) (Figure 11) which suggests they support good stocks of *O. mossambicus* and in some cases *Clarias*. These are of a good range of sizes (Nermark 2001) and thus would support viable subsistence fisheries for the local communities. It is also possible the fish stocks, where they are shown to be limited, could be supplemented by stocking, perhaps making use of the Mmadinare hatchery as supply units.
Figure 11. Species composition by number of gillnet catches in small community reservoirs (Source: Nermark 2001).
4. ISSUES AND OPTIONS

4.1 Context

In order to identify the key issues affecting the fisheries of the major dams in Botswana, it is necessary to compare the policy objectives for the resources in the country with the status of the fisheries from a holistic perspective to identify the shortcomings in present fishery management. In this context the policy objectives for fisheries are considered at the national and sector level as follows.

**Botswana Strategic Objectives**

- Botswana has a National Strategy for Poverty Reduction to provide people with opportunities to have a sustainable livelihood through the creation of permanent productive jobs or facilitating self employment.
- The strategy seeks to provide safety nets for those not able to take advantage of aforementioned opportunities and also to address risks and vulnerabilities affecting the people.

**DWNP Mission**

- To conserve the fish and wildlife of Botswana in consultation with local, regional and international stakeholders
- Promote and facilitate sustainable utilization of fish and wildlife resources through active participation of citizens.

The key issues and options for management of the fisheries of the major dams are reviewed in Section 4.2 and summarised in Table 3. In this context it was recognised that fisheries is only one user amongst several resource users of the dams, as highlighted in Figure 12, and thus a holistic approach to management and sustainable development of the fisheries is required. It should be noted that there appears to be an unbalanced allocation of financial and human resources to fisheries due to the placement of the sector in the bottom of the hierarchy of priorities. Options for development are reviewed in Section 5 as a perspective for addressing the issues.

![Figure 12. Interaction between resource users at major dams in Botswana](image-url)
### Table 3. A summary of the key issue and options for management of the major dams in Botswana

<table>
<thead>
<tr>
<th>Issues /Constraint</th>
<th>Options/interventions</th>
<th>Consequence</th>
<th>Priority</th>
<th>Actors</th>
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<tr>
<td><strong>Capture fisheries and aquaculture</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Unknown status of stocks and recruitment dynamics.</td>
<td>Improve data collection, storage and utilisation – including using fisher log books Expand fisheries monitoring and assessment function – including reporting</td>
<td>Improved understanding of the exploitation potential for the dams and increased provision of fish to local and major urban markets Long-term understanding of fisheries dynamics</td>
<td>High</td>
<td>FD, DWNP, fishers</td>
</tr>
<tr>
<td>Exploitation pressure of dams minimal, although not fully quantified encouraging poaching and reduction in market value. Access restrictions – limited number of fishing licenses available encourages poaching and theft from nets.</td>
<td>Raise awareness of importance fisheries in political arena Increase exploitation of dams commensurate with stock assessment outcomes Promote recreational fisheries potential - link with tourism</td>
<td>Increased availability of fish to domestic markets, improved food security and diversification of rural livelihoods.</td>
<td>High</td>
<td>FD, DWNP, fishers WUC, BDOT</td>
</tr>
<tr>
<td>Under-utilization of 300+ community dams for fisheries and recreational purposes</td>
<td>Develop generic management plans for different types of dams, based on temporary/permanent nature and primary use.</td>
<td>Opens up opportunities for generating local supplies of fish in remote rural areas and diversification of livelihoods.</td>
<td>Medium</td>
<td>FD, DWNP, district councils</td>
</tr>
<tr>
<td>Confusion over licence requirements – WUC for access, but also requirement for DWNP fishing licence. Relates to both commercial and recreational fisheries</td>
<td>Need to improve cooperation between FD and WUC</td>
<td>Increased revenue and opportunities to develop logbook catch assessment recording systems.</td>
<td>High</td>
<td>FD, DWNP, WUC,</td>
</tr>
<tr>
<td>Unregulated introduction of fish species – Large-mouth bass into Gaborone, Nnywane andLetsibogo; tigerfish into Letsibogo</td>
<td>Control stocking of predator species - especially tiger fish Create awareness of threats from species introductions</td>
<td>Protect stocks and biodiversity in dams and associated river system.</td>
<td>High</td>
<td>FD, DWNP, WUC, Fishers.</td>
</tr>
<tr>
<td>Potential for Mmadinare hatchery not achieved.</td>
<td>Create awareness on value and economic viability of aquaculture. Develop farming techniques for indigenous fish species of high commercial value</td>
<td>Utilises investment in Mmadinare hatchery and promotes production potential of dams</td>
<td>Medium</td>
<td>FD, fish farming enterprises, NGOs</td>
</tr>
</tbody>
</table>
## Promote sustainable aquaculture linked to stocking of dams – especially community dams

| Fisheries research and information system | Insufficient knowledge on fish stocks and fishing activities | Encourage research on the fisheries biology, ecology, limnology and socio-economic aspects | Results from experimental gillnet surveys available but need improvements  
Accelerates research activities  
Widens research base and enables higher education institutions to support research | High  
High  
Medium  
High  
Medium  
High  
High  
Medium  
High | FD, DWNP, Research Institutions  
WUC, resource users, donor community  
FD, DWNP, Research Institutions  
WUC  
FD, DWNP, Research Institutions  
WUC  
FD, DWNP, Research Institutions  
WUC  
FD, DWNP, Research Institutions  
WUC | 

| Inadequate dissemination and application of research results | Enhance central database and improve access  
Create a system of discussing management issues and research findings  
Disseminate information at appropriate technical level to meet demands of end users/recipients  
Improve flow of information and feedback between researchers, management and resource users | Increases availability of data to all but compromises data ownership and increases professional rivalry  
Increases collaboration  
Improves communication between institutions  
Widens knowledge base and promotes sustainable fishing | High  
Medium  
High  
High | FD, DWNP, Research Institutions  
WUC  
FD, DWNP, Research Institutions  
WUC  
FD, DWNP, Research Institutions  
WUC | 

| Fish marketing systems | Marketing infrastructure largely informal and lacks central marketing beaches or facilities  
Establish formal landing beaches with suitable marketing infrastructure.  
Improve sanitary conditions at landing sites | Establishes formal trading that can be used to monitor catches and regulate any untenable exploitation practices  
Improves income to fishing communities.  
Improves fish quality for local markets attracting higher prices | High  
Medium | FD, VDC, Fishing communities, traders, consumers  
FD, VDC, Fishing communities, traders, consumers  
FD, VDC, Fishing communities, traders, consumers | 

| High post-harvest fish losses | Develop proper preservation, processing and storage methods  
Encourage private | High standard of hygiene  
High quality of fish for local markets  
More income to fishers | High | FD, VDC, Fishing communities, traders, consumers  
FD, VDC, Fishing communities, traders, consumers |
### Fish Stock Assessment in Major Dams in Botswana

#### Organisation and capacity of service institutions

<table>
<thead>
<tr>
<th>Problem Statement</th>
<th>Proposed Solution</th>
<th>Impact/Expected Outcomes</th>
<th>Implementing Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate trained staff in fisheries and related fields [FD staff from largely from wildlife background]</td>
<td>Develop a training programme for fisheries staff in various disciplines. Train community leaders in various disciplines</td>
<td>Improved management of the resource</td>
<td>FD, NWNP, VDC, Fishing communities, NGOs, Universities &amp; colleges,</td>
</tr>
<tr>
<td>Inadequate funding for development and management of fisheries</td>
<td>Develop projects with donor agencies and collaboration with regional development projects.</td>
<td>Provides much need field and laboratory equipment, computing facilities Sustained management of fisheries resources</td>
<td>FD, NWNP, NGOs</td>
</tr>
<tr>
<td>Weak and inadequate extension services</td>
<td>Engage more fully with fishing communities through community management arrangements Develop a training programme for fisheries staff in extension activities</td>
<td>Encourages stakeholder involvement and sense of ownership of the fisheries</td>
<td>FD, NWNP, Fishing communities, NGOs, Universities &amp; colleges,</td>
</tr>
<tr>
<td>Relationship and collaboration with complimentary institutions needs strengthening</td>
<td>Adopt integrated approaches to fisheries and ecosystem management.</td>
<td>Strengthens management of fisheries resources</td>
<td>FD, NWNP, Universities &amp; colleges,</td>
</tr>
</tbody>
</table>

#### Integrated aquatic resources management

<table>
<thead>
<tr>
<th>Problem Statement</th>
<th>Proposed Solution</th>
<th>Impact/Expected Outcomes</th>
<th>Implementing Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water level management can affect fisheries survival, recruitment and exploitation, e.g. Letsibogo and Bokaa</td>
<td>Undertake a full economic evaluation of the loss of ecosystem services as a result water level</td>
<td>Fisheries are recognised as an equal partner in the ecosystem function. Provides full economic value of fisheries and biodiversity, so importance of fisheries is recognised and taken up in political framework</td>
<td>FD, NWNP, WUC</td>
</tr>
<tr>
<td>Uncontrolled development around dams resulting in concerns over water quality.</td>
<td>Need to adopt assessment strategy that links to management objectives of reservoirs with fisheries</td>
<td>Fisheries are recognised as an equal partner in the ecosystem function.</td>
<td>FD, NWNP, WUC</td>
</tr>
</tbody>
</table>
| Limited recreational facilities but problems with theft, litter and defecation    | • Develop recreational facilities at dams  
• Develop ecosystem services assessment (valuation) Promote recreational fisheries  
• Angling competitions Link to wildlife tourism (beware conflict with bird watchers) | Develop policies and procedures on dam use and recreation | FD, NWNP, WUC, BDOT |

### Community participation
### 4.2 Fisheries issues

- Dams can potentially support productive mixed fisheries with yields of 100-190 kg/ha/yr, although this needs further validation from intensive stock assessment over several years.
- Key marketable are species present in the dams with catfish, breams, barbels, silver *Labeo* and large-mouth bass prevalent on most systems, but they appear to be under-utilized.
- There are differences in the relative species composition (numbers and biomass) between dams, which reflect either the age of the reservoir, i.e. time since flooding, or the presence of introduced species (large mouthed bass). These dams should be managed for fisheries exploitation according to their stock composition. The newly flooded dams (Ntimbale and Dikgatlhong should be fished to exploit the typical explosion of the fisheries following flooding and the explosion of riverine fish production before the reservoir is colonised by lacustrine species and the riverine species largely disappear from the system. Those dams containing large mouthed bass (Gaborone, Nnywane and Letsibogo) should be promoted for recreational fisheries in addition to the commercial exploitation.
- The potential exploitation of the large number of community dams is largely unexplored. These represent valuable assets to the communities and could provide a local source of fish protein. Where the dam is of a temporary and only filled for part of the year, opportunities to stock the dam with fish from Mmadinare hatchery should be considered an option. This would also provide an option for utilization of the hatchery.
- Fisheries are given low priority in development of natural resources in Botswana, yet they are important assets for helping improve rural livelihoods and provide an opportunity to meet internal demands for fresh fish. Nonetheless there is a need to improve post harvest conditions and marketing to maximise the benefits accruing from these fisheries.
- There is inadequate support for fisheries stock assessment throughout Botswana, but particularly for large dams, and the procedures for assessing the status are poorly defined. The Standard Operating Procedures for carrying out stock assessment of these dams prepared as part of the project should be adopted with immediate effect and assessment of the full potential of these dams realised. Unfortunately, equipment for field sampling and data analysis are inadequate and needs updating and resourcing appropriately.
- Facilitates for data recording, storage and reporting are weak and need improvement. It is critical all data are stored in a central database and backed up regularly.
- Issues associated with the development of the aquaculture sector and utilization of Mmadinare hatchery have been discussed by Soges (2011). However. it is worth noting that considerable benefits can be gained from integrating the hatchery into wider fisheries development through provision of stocking material for both the major dams and the numerous community dams.
The latter has already been undertaken on a limited scale (Appendix 2), but there is the opportunity to upscale the provision of stocking material, especially in community dams that are of a temporary nature where it is likely that fish could be grown to hand size before the dam dries up. Presently the hatchery is operating well below its capacity as there is not yet a high demand for fingerlings. Therefore the aquaculture development opportunity highlighted by Soges (2011) should be given priority.

- The presence of large-mouth bass in several dams and the recent introduction of tigerfish into Letsibogo without formal consent are of great concern. There is an urgent need to establish appropriate legislation to prevent similar indiscriminate actions occurring in the future. It is recommended that options to exploit the well-established stocks of large-mouth bass are explored (see below) and that further stocking of tigerfish is prohibited until a full environmental impact assessment is undertaken and even then a precautionary approach is adopted.

4.3 **Fish marketing systems**

- The project implementation confirmed the lack of marketing infrastructure and considerable post-harvest losses found by Davies and Britz (2011) when compiling the fisheries management plan for the Okavango. There is an acute lack of marketing infrastructure, market chains, or distribution networks. This is coupled with poor post-harvest processing, hygiene and storage of products leading to considerable losses and poor quality product. Indeed, fish spoilage was identified as a key issue constraining development of the sector. If the overall objective is utilise local fish sources to meet internal demand, there is an urgent need to establish formal marketing chains and provide the infrastructure to process the fish in a hygienic manner through the provision of water, sanitary facilities and ice/refrigeration at landing beaches. It is suggested that cooperatives are promoted to provide opportunities to sell fish to traders with the capacity to transport fish fresh to urban centres. This will not only utilise the fish more sustainably but meet local market demands. This issue is discussed in detail in Davies and Britz (2011).

4.4 **Organisation and capacity of service institutions**

- There are recognised weaknesses in data acquisition, management and dissemination. This information is fundamental for the successful regulation and management of the fisheries and thus needs strengthening and given strategic goals and programming.
- There is a general lack of knowledge about the ecology of fish species in the area in relation to the aquatic environment. A comprehensive research programmes emphasising the ecohydrological drivers of the dam fisheries should be instigated in conjunction with national universities, external research institutions and appropriate NGOs.
- Preliminary assessment suggests that the fisheries sector is under resourced and the knowledge base in the department has been eroded. There is a need for a comprehensive review of the role of fisheries in provision of food security and rural livelihoods. This needs to be linked to mechanisms to encourage central government to provide adequate financial and human resources for the management of fishery resources. It is suggested that the ecosystem services model proposed in Section 5.3 will provide the framework for raising this political awareness.

4.5 **Integrated aquatic resources management**

- There is considerable confusion over licensing for fishing on the major dams. WUC provides licences for access to the dam but most fishers, especially recreational fishers, are unaware of the need for additional fishing licence from DWNP. The Fisheries Division acknowledge that
WUC is in charge of supplying municipal water to the public but not to control fishing activities in the dams since it is the mandate of conservation is for DWNP. This is a loss of a small, but significant, revenue stream for the FD, but also an opportunity to assess the status of the fisheries through logbook schemes. As proposed by Davies and Britz (2011), it is recommended that ‘all fishing licenses in WUC dams, both recreational and commercial, are issued by the wildlife department and that WUC should only issue permits to fishermen for entering and utilizing their private property as regulation No 17 in the fish protection regulations, 2008 suggests’. This licensing should be linked to a logbook scheme to provide information on catches to the FD to aid understanding the status of the stocks.

- Tourism contributes about five percent to Botswana’s national GDP, the second largest after mining, and the country has introduced a policy of using its dams to grow tourism (Davies and Britz 2011). The existence of good stocks of largemouth bass in several of the reservoir should be explored, particular in the recreational fisheries sector. There is considerable demand for quality bass fishing in Africa and examples of the potential for promoting the fisheries through competitions (see Box 1). Contact should be made with the BASS International representatives in South Africa (Albert Olivier, PO BOX 203, Blackheath.7581, Cape Town, South Africa - ao.goodimp@iafrica.com; www.sabaa.co.za) and Zimbabwe (Dave Clipstone, PO Box ST123, Southerton, Harare, Zimbabwe - winclip@winfield.co.zw) to explore opportunities.
- The tourism potential of the dams should be enhanced by private investment in infrastructure and faculties to support the needs of leisure activities, such as sanitary facilities, car parking, small lodge or BBQ area. This would allay fears of pollution that persist with WUC.
- Although tigerfish has been indiscriminately introduced into Letsibogo, it appears to not have established. It is recommended that no further introductions are allowed under the disguise, or otherwise, of tourism, and in fact they should be actively discouraged until such time that an environmental impact assessment has proven the benefits and proved there is no risk to existing stocks, biodiversity an ecosystem functioning in the dams and the adjacent rivers.

### Box 1: Newspaper report highlighting the potential for recreational bass fishing

**African angler shows off big bass**

A Zimbabwe B.A.S.S. Federation Nation member caught a 13-pounder

By John Neporadny Jr.

JUL 7, 2012

BINDURA, Zimbabwe — A couple of Zimbabwe Federation Nation anglers pulled out double-digit largemouth bass three weekends in a row this spring from a local farm dam lake.

Capital City Chapter member Keiran Torr caught his largest bass over at 5 p.m. March 26, at the Butcombe dam reservoir. His 13.44-pound bass was taken on a green pumpkin plastic frog made by fellow Federation Nation member Itzi Noll.
5. MANAGEMENT FRAMEWORK FOR THE MAJOR DAMS

5.1 Context

A management plan is an explicit arrangement between the fisheries division and other recognized stakeholders, whilst a framework provides an outline the development of such a plan. The latter should provide the objectives for the fishery and other stakeholder groups and identify opportunities to realise those objectives, including mechanisms for on-going consultations, and the arrangements to ensure compliance and other information relevant to the management of the aquatic resources (FAO, 1997).

In this context, this document has so far set out the background and recent history of the fisheries of the major dams in Botswana. Thereafter the key factors that on the one hand threaten and conflict with the position of the fisheries potential and on the other offer opportunities and prospects for maintaining the flow of benefits from fisheries exploitation are analysed. To act as a guide as to how these activities be conducted, the following section provides a series of strategic goals that will serve to initiate the planning and implementation processes. The main elements of the management framework relate to those policy initiatives or practical actions (Strategic objectives) that are required to help set the overall management stage or alternatively relate to problems demanding attention to achieve sustainable development.

5.2 Overall objectives

5.2.1 Project purpose

To enable the large dams and community water bodies in Botswana to contribute to the local and national economy, and provide services that enhance the social wellbeing for current and future generations by 2018.

5.2.2 Guiding principles

The Management Framework for the large dams in Botswana is constructed around several guiding principles that provide the reference points from which to assess the relevance and quality of future activities. These principles are:

- The framework is devised in accordance with fisheries legislation. Although opportunities for local byelaws may be explored.
- The framework promotes “conservation and management of fish and the development of the aquatic resources.
- The framework should facilitate the participation of all stakeholders in both formulation and delivery.
- The framework should adopt an ecosystem approach to management.
- The framework emphasizes institutional and capacity building and the appropriate legal arrangements as a priority for successful participation.
5.2.3 Strategic goals

The framework orientates around strategic goals required to meet the overall objective of sustainable management of the fisheries and natural resources of the major dams, and operates within a 5-year timeframe (2013-2018). The strategic goals are:

1) Promote sustainable fishing effort within the framework of an adaptive management approach

2) Harmonize and strengthen the institutional arrangements for fisheries development, research and management

3) Strengthen the information systems for fisheries management, development and research

4) Establishment of an institutional arrangement using local community structures and mechanisms

5) Improve livelihoods of the rural communities dependent on the fisheries and aquatic resources in the major dams

6) Adoption of an ecosystem policy framework.

Each of these strategic goals is developed through a series of projects defined in Section 5.3. Details of project objectives and potential outputs are provided. Although each project has specific objectives, all activities are underpinned by the following overarching development objectives:

- To improve the livelihoods of rural communities.
- To increase fish supply to urban and rural communities (through more effective use of available fisheries resources at local and national levels).
- To create employment opportunities, particularly for rural communities.
- To promote a wider ecosystem approach to management of the dams to optimise use of the dams and minimise the potential impacts.

5.3 Management strategic goals

Strategic goal 1: Promote sustainable development of the major dams for fisheries and other activities within an adaptive management framework

Information suggests that the major dams support valuable fisheries both of indigenous tilapia and cyprinid species and non-native largemouth bass, plus possibly introduced hybrid *Oreochromis niloticus* and *Oreochromis mossambicus*. There is, however, the need to exploit the fisheries resources to the full, including less valuable species such as silver Labeo and *Barbus* species. One of the key issues is the limited number of fishing licenses issued at each reservoir that restrict legal exploitation and encourage illegal fishing. It may also be desirable to consider regulations (byelaws) to allow controlled fishing. Consequently, efforts should be made to understand the exploitation patterns of the fishers and the fishing pressure on stocks.

Project Title: *Promote sustainable fishing effort in the large dams in Botswana*

Objective

- Increase resources within FD and strengthen collaboration with WUC to undertake fishery assessment and enforcement activities, whilst exploring opportunities to exploit further the resources of the dams

Activities

i. Undertake intensive assessment of the status of the fisheries and in the case of newly inundated reservoirs the colonisation process and potential expansion of fisheries of the dams.
Fish Stock Assessment in Major Dams in Botswana

ii. Determine fishing patterns of fishers including fishing methods for small-sized fishes and their importance to rural livelihoods.

iii. Determine optimal access arrangements for the fishery, including increasing number of licenses.

Strategic goal 2: Harmonize and strengthen the institutional arrangements for fisheries development, research and management

Several shortcomings have been noted regarding the institutional arrangements for the fisheries sector associated with the major dams and Botswana in general. In order to ameliorate the current shortcomings of the institutions and harmonize the institutional environment, the following priority actions are necessary:

Project title: Develop a training programme for fisheries staff and stakeholders
Objective
- Improve human resource capabilities, both within fisheries management and communities, to enhance fisheries management activities through co-management.
Activities
i. Establishment of training courses to upgrade staff expertise.
ii. Develop fisheries training programmes with local and regional academic institutions.
iii. Participation in training programmes, short courses and workshops.
iv. Establishment and implementation of in-service staff development programmes for managers and researchers.

Project title: Enhance financial support for sustainable management of the fisheries resources
Objective
- Improve the capacity to undertake fisheries research and development activities, both within the FD and communities to enhance fisheries management activities.
Activities
i. Provision of adequate funds to the sub-sector from central governments and other sources, including bilateral, multi-lateral and NGO contributions.
ii. Enhance training of managerial staff, especially policy-makers and extension staff. This is intended to support the proposed co-management initiatives.

Strategic goal 3: Strengthening of information systems for fisheries management, development and research

The fisheries resources in the water bodies in Botswana are important for the local communities as source of protein and employment. Some of the issues identified relate to gaps in areas of research and poor flow of information from the fisheries authorities to the communities/stakeholders, and between fisheries research and management. It is therefore important to put in place a monitoring mechanism to ensure that fishing practices and management actions are not adversely affecting the stocks or livelihoods of fishing communities. There is therefore a need to address these limitations through the establishment of a fisheries monitoring strategy. With such monitoring arrangements, timely interventions can be actioned to prevent over exploitation of the fish stocks or disruption of ecosystem functioning.

Project title: Enhance research, information gathering and dissemination on fisheries and other services of dams and other water bodies in Botswana
Objectives
- Develop ecosystem indicators, inventory and monitoring systems for fisheries and aquatic biodiversity
- Collect and evaluate data on the value of fisheries and biodiversity to the national and regional economies
Fish Stock Assessment in Major Dams in Botswana

Activities
i. Establish effective catch assessment for each dam through a logbook system to determine exploitation patterns.

ii. Carry out regular stock assessment survey programmes, conduct research on the biology and ecology of species of commercial importance to fill existing gaps in knowledge (expand on existing gillnet surveys).

iii. In response to information acquired, assess the exploitation pressures on the fisheries and modify progressively in accordance with adaptive management practices.

iv. Monitor dam water level scenarios and impacts on fisheries, biodiversity and ecosystem functioning

v. Establish genetic integrity of introduced *Oreochromis* stocks and adjust fish farming practices to use pure-breed *O. mossambicus*.

Strategic goal 4: Adoption of an ecosystem policy framework for the major dams

The major dams are under-utilised resources that could be exploited for a diverse range of activities to improve the well-being of nearby urban communities. This partially arises because of limitations of access to prevent water quality issues in the dams that are primarily intended for potable supply. Nevertheless, opportunities of developing the dams for recreational use should be explored to optimise the benefits and services that can be delivered to local communities.

Project title: The adoption of integrated development strategies to ensure optimal utilization of resources of the major dams

Objectives
- Formulation of integrated development strategies to match complexities, plural interests and interactions of the fishery with other sectors
- Promote recreational fisheries in the major dams through tourism and angling competitions.
- Develop the use of Mmadinare hatchery for production of suitable sport fisheries – largemouth bass [Note it is not recommended tiger fish is introduced into the dams]
- Develop the recreational facilities around the major dams to encourage active use.

Activities
i. Undertake full-scale ecosystem services analysis and valuation.

ii. Prepare integrated management plan for each reservoir.

iii. Introduce measures to ensure that key stakeholders have a clear understanding of each other’s needs, responsibilities and limitations.

iv. Work with the DoT and WUC and involve communities in active participation in the development of fisheries in the dams to expand the recreational use of the dams.

v. Promote annual recreational fisheries competitions in the major dams that support large-mouth bass.

vi. Develop the use of Mmadinare hatchery for provision of material for stocking community dams

Strategic goal 5: Enhance livelihoods of the rural communities dependent on the fisheries and aquatic resources in the large dams of Botswana

The remoteness of the dams (and other fisheries landing sites) to the major markets and general lack of a transportation and marketing infrastructure impose severe constraints on the utilization of the fisheries resources. Fish are readily spoiled once caught and hygiene and preservation are virtually absent within the communities. Inappropriate handling, including inadequate icing, is a major impediment to the full utilisation of the present catch and the lack of transportation systems means the products can only be sold locally or is sun dried and thus of low value.

Project Title: Improved marketing infrastructure and post-harvest strategy
**Objective**

- To develop appropriate methods of handling, preserving and marketing of the harvested fish for both local and national markets, to enhance quality of fish and their products and maximise income.

**Activities**

i. Development of marketing infrastructure at landing beaches

ii. Encourage private investment in the fishing communities

iii. Promote access to, and use, of ice.

### 5.4 Management and evaluation

Within the framework of any management activity, there is the need to develop strategies related to monitoring and evaluation of the outputs and outcomes of the actions. These are critical to ensure coordination of activities and programmes to assess whether targets are being achieved and allow adjustment of activities to support their continual improvement (adaptive management).

Periodic reports arising from monitoring and evaluation will also provide a pathway to feedback the success or otherwise of activities. This feedback will not only provide both communities and government institutions with confidence to continue with their investments, but it will also determine whether shifts in direction and targets are needed as knowledge improves. The primary outputs of monitoring and evaluation will include:

- Monitoring and reporting condition of the dam ecosystems, natural resources and pressures associated with their use.
- Evaluating and reporting on natural resources exploitation and management activities, and the outcomes in effecting change in natural resources condition.
- A common reporting framework using comparable information across the dams and from other fisheries in Botswana.
- Triggering further investigations or actions in response to evidence of degrading ecosystem or fishery status.
- Provision of basis for decision-making on amendments and improvements to the management of the dam ecosystems and fisheries.
- Document, provide feedback and disseminate results and lessons learned.

In order to ensure clarity and transparency in this implementation of the proposed framework, it is recommended that annual reporting is instigated to report on progress made, outputs delivered against targets, factors constraining delivery, actions to adjust against failure to deliver, financial auditing of service delivery and adjustments to the management actions to account for changing circumstances.

These technical reports will represent substantive contribution to specific areas, and should be used in efforts to disseminate relevant information and best practices at local, national and international levels, thus raising the profile of fisheries in the political arena. All reports should be made publically available on the DWNP website.

### 5.5 Learning and knowledge sharing

It is critical that progress and results from implementing the stock assessment of the major dams are disseminated within and beyond the region. In addition to production of project reports that are used in part to verify status and exploitation of the dams, there is a need to disseminate the outputs to a wider national, regional and international audience. This action will improve capacity and incentivize staff to
deliver quality outputs. In addition, a series of dissemination workshops should be organized at strategic intervals to inform stakeholders and enable feedback on the outcomes (benefits) derived from the actions.
6. References


FAO (1997) Technical guidelines for responsible fisheries, No. 4: Fisheries management. FAO, Rome


## 7. Appendices


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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Breams</td>
<td>439</td>
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<td>340</td>
<td>3939</td>
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## Appendix 2. Records of stocking in community dams and ponds.

### Community Dams and Ponds stocked since operation of Mmadinare Fish Hatchery

<table>
<thead>
<tr>
<th>Name of Dam</th>
<th>Date Stocked</th>
<th>No of Fish Stocked</th>
<th>Species</th>
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<td>Tonota C E</td>
<td>07/05/07</td>
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</tr>
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<td>Semane JSS</td>
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