Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA

draft

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# Table of Contents

LIST OF ACRONYMS .................................................................................................................. 5

1. Introduction ............................................................................................................................. 10
   1.1. Methodology .................................................................................................................... 11

2. Status Of Aquaculture In Botswana ...................................................................................... 12
   2.1. History of aquaculture in Botswana ............................................................................... 12
   2.2 SME Aquaculture .............................................................................................................. 14
   2.3. Stocking of Dams ........................................................................................................... 17
       2.3.1. Tigerfish stocking as a tourism development strategy ........................................... 18

3. Biophysical conditions for aquaculture ................................................................................. 20
   3.1. Temperature .................................................................................................................... 20
   3.2. Water ............................................................................................................................. 23
       3.2.1. The Limpopo ......................................................................................................... 23
       3.2.2. The Okavango Delta ............................................................................................. 23
       3.2.3. The Chobe ............................................................................................................. 25
       3.2.4. Commercial aquaculture in impoundments ......................................................... 27

4. Culture Species ....................................................................................................................... 29
   4.1. Catfish ............................................................................................................................ 29
   4.2. Tilapia .............................................................................................................................. 29

5. Markets .................................................................................................................................. 31
   5.1. Local market .................................................................................................................... 31
   5.2. International markets ...................................................................................................... 33
   5.3. Regional markets ........................................................................................................... 34

6. Institutional environment ........................................................................................................ 35
   6.1 Botswana’s Policies to Promote Aquaculture ................................................................. 35
   6.2 Government Departments ............................................................................................... 37
       6.2.1 Department of Wildlife and National Parks ............................................................ 37
       6.2.2 Department of Environmental Affairs .................................................................... 39
       6.2.3. Department of Agriculture ................................................................................... 40
   6.3. Botswana Bureau of Standards (BOBS) ..................................................................... 42
   6.4. Business and Financial Institutions ............................................................................. 43
       6.4.1. Foreign investment ................................................................................................. 43
       6.4.2. Commercial Finance .............................................................................................. 43
       6.4.3. BEDIA ................................................................................................................... 43
       6.4.4. IFSC ....................................................................................................................... 44
       6.4.5. CEDA ..................................................................................................................... 44
       6.4.6. LEA ......................................................................................................................... 45
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA
Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries
Management Plan of the Okavango Delta

6.5. Education and Training.................................................................................. 46
  6.5.1. Botswana College of Agriculture .............................................................. 46
  6.5.2. DWNP training courses by international consultants ............................ 46
  Figure 3. Botswana College of Agriculture recirculating tilapia system. .......... 46
  6.5.3. DWNP Aquaculture Literature ............................................................... 47
  6.5.4. DWNP Website ..................................................................................... 47

7. Infrastructure ........................................................................................................ 48
  7.1. General infrastructure .................................................................................. 48
  7.2. Agricultural Infrastructure ......................................................................... 48
  7.3. Aquaculture infrastructure .......................................................................... 48
    7.3.1. Mmadinare Hatchery ........................................................................... 48

8. Barriers to aquaculture development ................................................................ 50
  8.1. A nonexistent aquaculture sector and necessary economies of scale ......... 50
  8.2. Technical skill and experience required for aquaculture ......................... 50
  8.3. Access to land and water ........................................................................... 51
  8.4. Misconceptions surrounding the viability of aquaculture ....................... 51
  8.5. Inadequate market information .................................................................. 52
  8.6. Government red tape ................................................................................ 52
  8.7. Lack of entrepreneurial skills ..................................................................... 52

9. Conclusion ............................................................................................................ 54

10. Draft Aquaculture Development Plan for Botswana ......................................... 55
    10.1. Subsistence Aquaculture Strategic Plan .................................................. 56
    10.2. SME Aquaculture Strategic Plan .............................................................. 57
    10.3. Commercial Aquaculture Strategic Plan ................................................. 58
    10.4. Aquaculture Based Recreational Fishing and Tourism ......................... 59
    10.5. Aquaculture Development Strategy: Cross-cutting Issues .................... 60

References ............................................................................................................. 64

Appendices ........................................................................................................... 67

Appendix 1. Consultative workshop: Gaborone 24th March 2011: Programme; Attendance Register; Discussion......................................................... 67
Appendix 2. Consultative workshop: Francistown 29th March 2011: Programme; Attendance Register; Discussion .......................................................... 82
Appendix 3. Key informants that were consulted during the stakeholder consultation process ... 92
Appendix 5. Observed shortcomings of Mmadinare Hatchery ............................. 97
Appendix 7. Twenty Common Questions On Aquaculture. DWNP Fisheries Division Booklet ... 101
Appendix 8. Dams stocked with fish from Mmadinare Hatchery .......................... 109

SOGES
List of tables, figures and photographs

Figure 1. Tilapia value chain (Source courtesy of EnvirofishAfrica) ............................................................ 15
Figure 2 Images of the investigating team’s visit to Jackalas II Village and dam. ................................. 18
Figure 3. Average daily water temperature over 10 years recorded at Kasane Airport .................. 20
Figure 4. Roadside fish seller in Gaborone ............................................................................................... 31
Figure 5. Botswana College of Agriculture recirculating tilapia system ........................................ 46
Figure 6. Mmadinare Hatchery at Letsibogo Dam (Selebi-Phikwe) ....................................................... 49

Table 1. Fish farming enquiries at the DWNP office in Gaborone ...................................................... 14
Table 2. System unit costing – tilapia ponds (data supplied courtesy of EnvirofishAfrica) .......... 16
Table 3. Effect of temperature on tilapia under culture conditions (courtesy of EnvirofishAfrica) ...... 22
# LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACP</td>
<td>African, Caribbean and Pacific Group of States</td>
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<tr>
<td>ADSB</td>
<td>Aquaculture Development Strategy for Botswana</td>
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<tr>
<td>ALCOM</td>
<td>Aquaculture for Local Communities</td>
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<tr>
<td>BDC</td>
<td>Botswana Development Corporation</td>
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<tr>
<td>BEDIA</td>
<td>The Botswana Export Development and Investment Authority</td>
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<tr>
<td>BNVL</td>
<td>Botswana National Veterinary Laboratory</td>
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<td>BOBS</td>
<td>Botswana Bureau of Standards</td>
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<td>CEDA</td>
<td>Citizen Enterprise Development Agency</td>
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<td>Department of Wildlife and National Parks</td>
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<tr>
<td>EDD</td>
<td>Economic Diversification Drive</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<tr>
<td>EUS</td>
<td>Epizootic Ulcerative Syndrome</td>
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<td>Food and Agriculture Organisation</td>
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<td>PEIA</td>
<td>Preliminary Environmental Impact Assessment</td>
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<td>Convention on Wetlands signed in Ramsar Iran in 1971</td>
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<td>SADC</td>
<td>Southern African Development Community</td>
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<td>SME</td>
<td>Small to Medium Enterprise</td>
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<tr>
<td>SPEDU</td>
<td>Selebi Phikwe Economic Diversification Unit</td>
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<td>Sub Saharan Africa</td>
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<td>Tawana Land Board</td>
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<tr>
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<tr>
<td>WUC</td>
<td>Water Utilities corporation</td>
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**Executive summary**

This report presents an “Aquaculture Development Strategy for Botswana” (ADSB). The project was initiated as part of the European Union ACP Fish II Programme at the request of the government of Botswana. The process to develop the ADSB was facilitated by a technical team comprising of aquaculture consultants appointed by SOGES S.p.A. and staff of the Department of Wildlife and National Parks’ (DWNP) Fisheries Division. The ADSB is based on a series of consultative stakeholder workshops, interviews with key persons, and a review of the relevant literature, policy and legislation, carried out between January and April 2011. The draft ADSB was discussed at a National stakeholder workshop in Gaborone on 26 April where a second draft ADSB and the final ADSB were presented to senior government officials in a Validation Workshop on 28 April 2011.

The first part of the ADSB report presents an assessment of the status and potential of aquaculture in Botswana, and a strategic diagnostic analysis of the opportunities and constraints facing aquaculture development in the country. This is followed by recommended strategies and operational objectives to develop aquaculture in Botswana.

Although Botswana possesses no dedicated aquaculture policy or supporting legislation, it was identified as a means of diversifying agriculture production in Botswana under the National Development Plan 9 (NDP9). A strategic goal of NDP9 was “to promote fishing farming in Botswana”, as a successful aquaculture industry would help to diversify the economy; enhance rural livelihoods and protein supply and reduce the country’s dependence on imported fish. Funding was made available for the establishment of a state hatchery situated at the Letsibogo Dam at Mmadinare which was built in 2008. Further funding for the Mmadinare Hatchery was provided under NDP10 for improvements to the facility and technical training of staff. The Botswana Government has created a favourable institutional environment for the development of new sectors such as aquaculture. The DWNP Fisheries Division (FD) was designated as the lead agency in promoting aquaculture development. Their efforts have resulted in a high degree of awareness of aquaculture as a farming activity amongst ordinary citizens and business people alike. The Mmadinare government hatchery produces fingerlings for supply to aspirant fish farmers and for stocking dams for rural communities. Fisheries Division staff at Mmadinare, Gaborone and Maun provide a limited range of technical information and support to aspirant farmers. A steady flow of Botswana citizens seeking a small enterprise opportunity visit the Fishery Division offices in Gaborone and Mmadinare on a daily basis, where they are supported in their attempts to establish aquaculture businesses. Requests for financing aquaculture business plans are regularly received by Botswana’s development finance institutions (the Local Enterprise Authority – LEA, and the Citizen Enterprise Development Agency CEDA). Unfortunately no commercial aquaculture projects have successfully been established in Botswana to date due to the various constraints which exist to aquaculture in Botswana.

The physical conditions for aquaculture in Botswana are below optimal, in part due to a scarcity of suitable water, but primarily because average water temperatures are lower than the optimal range.
growth of 25-30°C for warm water fish species such as tilapia and catfish. The northern region below Kasane provides the most suitable ambient water temperatures. In the southern areas of the country, options for heating water and overwintering fish (such as vegetable tunnels) will need to be implemented to obtain commercially competitive production rates. The prospects for aquaculture in the Okavango Delta region are not promising due to the sensitive conservation status of the area, bio-physical constraints, and distance from services and urban markets.

The choice of species and the sourcing of fish with genetics suitable for farm production is a further constraint in Botswana. Indigenous tilapia species do not grow fast enough to be profitable in comparison to the Nile tilapia, which has been selected for fast growth, and which has become the standard farmed tilapia species around the world. A poor market image and correspondingly low prices currently eliminate African catfish as a good candidate species in the Botswana and South African markets, although potential may exist for export to African countries which value this species. Importing genetically improved tilapia strains is an option in catchments where the Nile tilapia is already present (Zambezi, Limpopo) but the species and associated diseases and parasites pose a potential risk to sensitive aquatic ecosystems. Fish farms utilizing introduced species would need to be excluded from sensitive areas and strict measures would need to be enforced to ensure that escapes, whether accidental or intentional, would not occur. An alternative strategy would be to improve the growth characteristics of indigenous species by selective breeding programs, but this would be an expensive long term strategy.

In terms of subsistence level aquaculture, the efforts of the DWNP Fishery Division in stocking impoundments with tilapia and catfish fingerlings produced from the Mmadinare hatchery for rural communities have proven successful in a number of dams. Local communities have benefited from having fish in previously sterile dams. For example, at the Jackalas II village dam, the Dam Committee came up with an innovative strategy of selling fishing licences to anglers. Such projects thus have the potential to allow rural communities to derive cash income from tourism in addition to the subsistence food value of the fish.

An additional high value tourism activity linked to aquaculture is the stocking of large impoundments with tigerfish for recreational angling. This would support Botswana’s policy of promoting tourism on its dams. Tigerfish were successfully introduced into Letsibogo dam in an experiment. There is a huge economy associated with fishing tourism and a healthy population of tigerfish would attract international anglers and potentially provide the basis for a local tourism industry including lodges, houseboats, guides and services. Fishing based tourism is thus a means of creating jobs, and entrepreneurial and livelihood opportunities for local communities.

A key constraint to the development of aquaculture as a small to medium size farming enterprise (SME) activity, is the absence of an established aquaculture sector and value chain in Botswana. Experience with SME aquaculture promotion in Botswana reveals that the activity is not currently viable as a stand-alone business. Options for supporting SME aquaculture development include minimising input costs through integration with other farming activities e.g. using irrigation dams for stocking fish. On-farm research and a pilot project is required to benchmark production performance in low-input integrated systems in order to provide a business model with realistic input
costs and expected production output. The DWNP media promotion of SME aquaculture should be suspended until a viable production model is available. The absence of an aquaculture service means that a pioneer farmer will need to establish a vertically integrated business operation which includes the installation of basic infrastructure, seed supply, grow-out, feed manufacturing, an abattoir, processing and packing facilities, marketing, and cold chain distribution. A minimum sized economic production unit would thus be quite large (probably over 100t), requiring a significant investment that is beyond the means of small entrepreneurs. Therefore, an initial strategic objective should be the establishment of at least one large commercial aquaculture enterprise which has the critical mass to establish an aquaculture value chain in Botswana, and provide a regular supply of product in sufficient volume to the local market.

Botswana’s programme of building dams and the NDP10 objective of developing irrigation schemes offers a potential opportunity for establishing commercial aquaculture. The Ministry of Agriculture is considering the establishment of an integrated agriculture/aquaculture and agro-processing hub in Pandamatenga region based on water drawn from the Zambesi River. If a project of this nature were to proceed, it would be able to kickstart the industry and allow small farmers to enter aquaculture production as ‘satellite’ on-growers supplying product into the value chain established by the pioneer commercial farm. An initial, large scale commercial aquaculture operation would need to include international support and backing as there is a paucity of local skills and experience in commercial fish farming. Botswana has a range of incentives for foreign investment and is generally considered a good place to invest.

The physical and species constraints point towards the use of high intensity production systems where an appropriate tilapia strain would need to be cultured at high densities so that water could be cost effectively heated or where use could be made of waste heat from industrial cooling processes.

The price of intensively cultured fish produced would thus be relatively high, and the product would need to fetch a correspondingly high market price to be competitive. The local market for farmed fish is a relatively unknown quantity in Botswana. Although the Batswana people are traditionally not fish consumers, retailers report that fish is growing in popularity and that whenever tilapia supplies are regular, demand seems to grow. Most local demand is currently satisfied by frozen tilapia from China which retails at around P30, too low a price to compete against given the likely production input costs in Botswana. However, if local production could meet the criteria of distributors, then protection mechanisms against cheap imports, such as compulsory declaration of product origin and the trademarking of local names (e.g. “Botswana Bream”), could come into play. The international market for farmed tilapia would not be an option for local producers due to an oversupply with cheaply produced Asian and Latin American product. The regional market may hold some potential but this needs more research, as neighbouring countries, such as Zambia, Zimbabwe and Malawi, which have established tilapia aquaculture, appear to enjoy certain comparative advantages.

Institutionally, a lack of coordination between public sector organisations and the lack of an aquaculture sector development policy constrains the creation of an enabling environment for investment in aquaculture in Botswana. The lack of designated land and water for aquaculture currently frustrates potential investors, despite the promotional efforts of DWNP. A coordinated
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA

Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

government approach to establish designated aquaculture sites, through the setting aside of land and water in areas of the country most suitable for aquaculture, facilitation of EIAs and other preliminary planning processes, and provision of basic infrastructure, would facilitate investment into the sector. Development zones or clusters for beef and dairy have been successful in aiding those industries in the country in the past. A single government agency entry point should be created whereby potential investors could be guided through the initial bureaucratic phases of the investment process. Botswana’s investment promotion agency, BIDEA, has facilitated similar initiatives for other sectors. However, given the physical, biological and economic constraints outlined above, a careful economic feasibility and due diligence appraisal would be required to inform any decision to invest public sector funds in the promotion of a commercial aquaculture cluster or hub.

Based on the strategic diagnostic analysis of the status and potential of aquaculture in Botswana, the recommended strategic and operational objectives of the draft Aquaculture Development Strategy for Botswana are presented in a synoptic tabular form, which is divided according to sectorial activity areas, visibly:

1) Subsistence Aquaculture
2) SME Aquaculture
3) Commercial Aquaculture
4) Aquaculture-based Recreational fishing and Tourism

The recommended Strategic and Operational Objectives for each sectorial activity area are classified thematically, namely :- Institutional, Research and Technology Transfer, Production, Training and Information Dissemination, Markets and Ecological. A recommended time frame is attached to each operational objective, namely, 1, 3, 5 and 10 years.
1. Introduction

A levelling off of the wild fishery harvest combined with world population growth, an increase in the standard of living for the middle classes, and an increased awareness of the health benefits of eating fish, have resulted in substantial rise in the price of fish and seafood worldwide (FAO, 2010). This has stimulated the development of the aquaculture around the world, which has been growing at 8% per annum for two decades and is the fastest growing animal production sector in the world (Brugère & Ridler, 2004; FAO 2010). Almost fifty percent of the world’s fish supply now originates from aquaculture, and cultured fish such as salmon, tilapia and Vietnamese catfish (Pangassius) are now a global commodity (Brugère & Ridler, 2004; FAO, 2010).

Aquaculture development in Africa has lagged behind the rest of the world, although in recent years governments have increasingly taken steps to the sector (Moehl, 1999). Historically, the development of aquaculture in sub-Saharan countries has gone through a series of phases. In the 1950s-1970’s aquaculture was introduced in Africa by the colonial administrations, but there was little knowledge or technical understanding and production did not become established outside of state hatcheries (Hecht 2000). From 1970 to the mid 1990’s, aquaculture was promoted as a rural subsistence farming activity with significant donor support, R&D and government investment in seed supply and extension to farmers. This period resulted in some commercial success in countries such as Nigeria, Madagascar, Cote d’Ivoire, Zambia and South Africa, but on the whole the promotion of small scale aquaculture was unsuccessful (Hecht 2000). From 1995 onward, donor support for aquaculture development declined, but commercial aquaculture began to emerge spontaneously in a number of countries due to a rise in fish demand and price which made aquaculture increasingly viable (FAO, 1996; Hecht, 2000).

Aquaculture production in Sub-Saharan Africa nonetheless remains insignificant in global terms, contributing 0.13% and 13.6% to total World and African aquaculture production respectively (FAO, 2010). The contribution by aquaculture to GDP in the target countries is negligible, ranging from 0.001% to 0.715%. Aquaculture production only contributes 2.03% (72,334 mt) to the total fisheries yield of the target countries (3.6 million mt) (FAO, 1996; FAO, 2010; Hecht, 2000).

The prospectus is however not altogether discouraging. It is projected that aquaculture production in Sub Saharan Africa will by 2013 be between 208,600 and 380,400 mt per annum (FAO, 2010). Total aquaculture production in the 17 target countries between 1998 and 2003 has increased by 61% from 44,962 mt to 72,334 mt (Hecht, 2006). Per capita fish consumption has decreased significantly in many African countries over the last 30 years which is a worrying trend for policy makers (FAO 2010). This is an effect of increased population growth and a decreasing in African wild fish catch. High value fish exports from Africa are expected to decrease over the next decade and imports of low value fish will increase (FAO 1996; Hecht, 2006). The price of fish in Africa is thus destined to rise significantly, whereas the price for traditional sources of protein such as beef, poultry and pork is likely to fall (FAO, 2010). This will favour the development of aquaculture for high value species (Hecht, 2000).
At present Botswana has no aquaculture production and is a net importer of approximately 2,900t of fish annually (Appendix 4). Most fish products, such as tinned pilchards or frozen hake fillets, are imported from South Africa. Aquaculture has been identified as a means by which Botswana can achieve the development goals of reducing its reliance on imported food. The Botswana National Development Plan 9 (NDP9) set the strategic goal of promoting fish farming in 2003 and the Fisheries Division of the DWNP was been mandated as the agency to lead the development of aquaculture. A state hatchery was developed at Mmadinare, personnel trained and DWNP staff allocated to providing technical assistance and advice on fish farming.

Their efforts thus far have succeeded in raising public interest in aquaculture as an enterprise opportunity, but despite their best efforts to develop the industry, commercial aquaculture in Botswana has not become established. In order to address this problem, the DWNP responded to an invitation from the European Union for fisheries projects in the Africa Caribbean Pacific (ACP) countries under the EU ACP Fish II programme. Technical assistance was requested to formulate an ‘Aquaculture Development Strategy for Botswana’. It was envisaged that the strategy could guide government to draft a clear policy which will give rise to the development of sustainable aquaculture in the country.

The EU ACP Fish II tender for Botswana was awarded to SOGES S.p.A., and a team of experts from South Africa was appointed to form a technical team together with members of the DWNP Fishery Division.

1.1. Methodology

In order to analyse the status and potential of aquaculture in Botswana, the technical team assembled all available literature on aquaculture in the country. They visited aquaculture facilities, fish farmers current and past, and potential sites. Three public consultative stakeholder workshops were held in Maun, Gaborone and Francistown. Minutes and attendance registers of the latter 2 workshops are appended as Appendices 1-2. Key individuals were privately consulted (listed in Appendix 3). Wherever possible, information and perceptions about fish and aquaculture were solicited, for example, by stopping at informal roadside fish markets, investigating supermarket freezer shelves, ordering bream in restaurants, interviewing taxi drivers about their eating habits, questioning lunchtime food hawkers, and chatting to a former owner of a Pick ’n Pay Hypermarket franchise in Gaborone. The collective knowledge gathered by all of these means were synthesised and forms the basis from which the status and potential of aquaculture in Botswana could be analysed. Each section concludes with a diagnostic summary of issues requiring strategic intervention. These issues informed the strategic and operational objectives defined of the draft Aquaculture Development Strategy for Botswana.
2. Status Of Aquaculture In Botswana

There is currently no commercial aquaculture in Botswana, despite significant interest in the opportunity by many citizens and efforts by the government to promote its establishment. Aquaculture production in terms of tonnage and value is effectively zero. Aquaculture activity is limited to a state hatchery at Mmadinare, which produces fingerlings and provides technical advice, and a few individuals who have built small production facilities which cannot be considered commercially operational. In this section we describe the history and current status of aquaculture activities in Botswana.

2.1. History of aquaculture in Botswana

Aquaculture in Botswana started to receive attention during the 1980’s and 1990’s through the ALCOM (Aquaculture for Local Communities Development Program sponsored by the United Nations FAO, which undertook a number of activities, organised meetings and produced a number of publications on small scale rural aquaculture in Southern Africa (ALCOM 1996a; ALCOM 1996b; ACOM 1999). ALCOM’s objective was to address the region’s problem of “poor and undernourished rural populations where animal proteins are particularly needed” by promoting fish production (ALCOM 1996b). The thrusts of ALCOM activities were technical, focusing on the dissemination of technology for smallholder farmers and low input farming in impounded water bodies (ALCOM 1999). Fingerling production was underlined as the main technical constraint to aquaculture in Botswana at the time (ALCOM 1996a). The outcome of these activities has been the Botswana government’s policy of 1) promoting SME aquaculture and 2) stocking dams with fingerlings produced by the Government Fisheries Division hatchery at Mmadinare.

There have been several attempts to establish both small scale and large scale commercial fish farms by various parties over the ensuing years. (Commonwealth Secretariat 1989; Hinrichsen and Nermark, 2007; Shaft Nengu, DWNP, Pers. Comm., March 2011). The Commonwealth Report of 1989 listed several aquaculture proposals that had been submitted to government since the 1980’s. The largest of these was for the development of a 40ha freshwater prawn (Machrobrachium rosenbergii) farm at Kasane and interest in the development of Marron, catfish and tilapia farms in various parts of the country, all of which failed to come to fruition (Shaft Nengu, DWNP, Pers. Comm., March 2011). At the time of this report there were two private sector aquaculture initiatives:

- Mr P.J. Bestelink was involved in pond and cage culture of the three spot bream (O. andersonii) in the Western Okavango using technical advice from Rhodes University. At the time of the report he was experiencing a number of production problems, including high mortality rate of the fry and fingerlings, poor conversion ratios, reduced oxygen levels and marketing constraints. The project eventually failed (Mosethanyane,1997).

- Mr J. Seaman was producing catfish and tilapia as a complementary exercise to a crocodile farm in Maun. The exercise was designed to use the effluent water from the farm and to supplement the crocodiles with the grown fish.
A number of other projects were being proposed or evaluated at the time:

- A series of small ponds amounting to 0.1ha were under construction at Notwane (to the south of Gaborone Dam by M Sampson and D Bookbinder. Their intent was to produce 500g *O. Mossambicus* for the Gaborone hotel market.

- 10 ha of ponds were being developed at Shashe Dam by a certain Mr Thompson

- BDC Chobe Farms Pty were proposing ten half hectare ponds for bream production for local tourist hotels

- Brink Holdings Farm was also proposing 10, half hectare ponds for bream close to Gaborone Dam. Pig manure was going to be used for fertilising the ponds.

Nermark & Hinrichsen, in their 2008 Okavango Delta Aquaculture Development Guidelines list the following aquaculture activities in 2008:

- *Agrosolar*, an irrigation based agriculture business outside Mochudi, initiated the farming of tilapia, catfish and some other local species in farm ponds and concrete raceways or tanks.

- *The Sanitas Nurseries* undertook some aquaculture activities as a practical trial towards testing the viability of fish farming within the framework of their existing water management systems for horticulture. Some fish were kept for brood stock material and some schools were supplied with fingerlings. The project was suspended due to water restrictions during a drought period.

- Bream Farms (Pty.) Ltd. was granted permission to farm 150 tons of tilapia per annum in cages in the Gaborone Dam with a hatchery downstream of the dam. The farming of freshwater crayfish was also proposed.

- Male Investments presented a business plan (in 2004) for a high-tech catfish farm, using a SA turn-key system, for supply to the export market. The business promoter realized that the export market was not yet established and no venture was initiated.

- A company had applied for land at the Bokaa Dam for the purpose of intensive recirculation based farming of tilapia and possibly catfish. An alternative site on private land outside of Mochudi was also being considered, but no development had taken place.

None of these projects came to fruition either (Trevor Mmopelwa & Ulf Nermark, Pers. Comm., March 2011). Problems reported have ranged between unavailability of appropriate land or water, poor business planning or technical and/or biophysical constraints.

The conclusion of a report on a proposed P15million project to culture 3000 t/a catfish for export using satellite farmers for production illustrates the challenge that has faced most aspirant aquaculture investors:

“Considering the physical resources available in the country, the only feasible form of commercial aquaculture is that of intensive tank culture of tilapia. While this is a technical option, it does not stand up to even the most elementary financial analysis and is concluded to be economically unfeasible.” (Mmopelwa 2003).
The government of Botswana has supported aquaculture throughout because it believes that a successful aquaculture industry could help to diversify the economy, enhance rural livelihoods and protein supply, and reduce the country’s dependence on imported fish. Aquaculture was identified as a means of diversifying agriculture production in Botswana’s National Development Plan 9 (NDP9) and the promotion of fish farming was one of its strategic goals and funding was made available in the NDP9 for the establishment of a state hatchery situated at the Letsibogo Dam at Mmadinare. Further funding for the Mmadinare Hatchery was provided under NDP10 for improvements to the facility and technical training of staff. Guidelines for the development of aquaculture in the Okavango were drawn up in 2008 (Nermark & Hinrichsen, 2008) and in 2010, the MoA invested heavily in the Zambezi Integrated Agro-Commercial Development Project Consolidated Feasibility Report (Ministry of Agriculture, 2010).

Interestingly, many of the issues identified in this current analysis echoed findings in both the 1989 Commonwealth Report and again 10 years later in Nermark and Hinrichson’s report, confirming that there are fundamental barriers to development of aquaculture in Botswana which still need addressing if the status quo of failed SME aquaculture is to change.

### Strategic Diagnostic Analysis

It is clear from the history of aquaculture in Botswana that despite interest from investors, available support from funding agencies, political will to promote aquaculture to substitute imported fish and to diversify the economy, that commercial aquaculture has not proven economically viable to date.

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2.2 SME Aquaculture

The Botswana government’s policy of promoting aquaculture has generated great interest in fish farming as a small to medium size enterprise opportunity. The Gaborone DWNP office has handled an increasing number of aquaculture enquiries since 2008 (Table 1). The Mmadinare and Maun offices also receive regular requests for assistance with aquaculture planning.

| Table 1. Fish farming enquiries at the DWNP office in Gaborone |
|-----------------|-----------------|-----------------|-----------------|-----------------|----------|
| Year            | 2008            | 2009            | 2010            | 2011- to April  | Total    |
| No enquiries    | 1               | 11              | 33              | 27              | 72       |

However, no fish farms have become established due to:

- The relatively high input costs of establishing and operating a fish farm.
- The lack of an aquaculture service sector and value chain.
The farmers lack of aquaculture technical skills and experience.

Economically, SME aquaculture production can only be viable if input costs are minimal. If capital is spent on building ponds, pumping infrastructure, buildings and pelleted feed the input costs become too high to make fish farming profitable. Substantial investments are required for establishing the value chain needed for commercial tilapia production (Figure 1).

![Figure 1. Tilapia value chain (Source courtesy of EnvirofishAfrica)](image)

A desktop financial analysis of SME tilapia production in southern Botswana revealed that the capital costs of a 10 pond unit would be significant (Table 2), and the production cost per over P30/kg. A low input / low management scenario of the system operating on the approach of pond fertilization and a single summer growth season was reported to be able to yield, depending on the site, between 2070 and 3380 kg per annum at a cost per unit of P33 / kg and P54 / kg. Constraints to this scenario were the high initial setup costs (R1 080 665), single growth season, low yield and feed transport costs. A second scenario based on indoor intensive culture in a heated, re-circulating system was found to be able to yield approximately 23 tons per annum at a cost per unit production of P24 / kg to P29 / kg, dependent on feed conversion efficiency. The intensive recirculation options
was more management intensive than the pond culture option, requiring skilled labour, higher input costs and increased risk. Considering that individually packed, gutted, scaled, frozen Chinese Tilapia could delivered for throughout Botswana for P31/kg, SME aquaculture does simply not appear to be competitive at the present time.

Table 2. System unit costing – tilapia ponds (data supplied courtesy of EnvirofishAfrica)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>UNIT PRICE</th>
<th>UNITS NEEDED</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 Ha POND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth moving</td>
<td>R35 000,00</td>
<td>1</td>
<td>R35 000,00</td>
</tr>
<tr>
<td>PVC dam liner</td>
<td>R65 000,00</td>
<td>1</td>
<td>R65 000,00</td>
</tr>
<tr>
<td>Drain system</td>
<td>R1 500,00</td>
<td>1</td>
<td>R1 500,00</td>
</tr>
<tr>
<td>SUB TOTAL</td>
<td></td>
<td></td>
<td>R101 500,00</td>
</tr>
<tr>
<td>HOLDING SUPPLY DAM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth moving</td>
<td>R35 000,00</td>
<td>1</td>
<td>R35 000,00</td>
</tr>
<tr>
<td>PVC dam liner</td>
<td>R30 000,00</td>
<td>1</td>
<td>R30 000,00</td>
</tr>
<tr>
<td>Drain system</td>
<td>R3 000,00</td>
<td>1</td>
<td>R3 000,00</td>
</tr>
<tr>
<td>SUB TOTAL</td>
<td></td>
<td></td>
<td>R68 000,00</td>
</tr>
<tr>
<td>WATER DISTRIBUTION SYSTEM per POND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDPE black pipe (63mm)</td>
<td>R18,00</td>
<td>30</td>
<td>R540,00</td>
</tr>
<tr>
<td>Valve</td>
<td>R375,00</td>
<td>1</td>
<td>R375,00</td>
</tr>
<tr>
<td>Fittings</td>
<td>R150,00</td>
<td>1</td>
<td>R150,00</td>
</tr>
<tr>
<td>SUB TOTAL</td>
<td></td>
<td></td>
<td>R1 065,00</td>
</tr>
<tr>
<td>HUSBANDRY EQUIPMENT &amp; LABOUR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheelbarrows</td>
<td>R800,00</td>
<td>2</td>
<td>R1 600,00</td>
</tr>
<tr>
<td>Seine nets</td>
<td>R1 500,00</td>
<td>2</td>
<td>R3 000,00</td>
</tr>
<tr>
<td>Tools</td>
<td>R2 000,00</td>
<td>2</td>
<td>R4 000,00</td>
</tr>
<tr>
<td>Storage shed</td>
<td>R20 000,00</td>
<td>1</td>
<td>R20 000,00</td>
</tr>
<tr>
<td>SUB TOTAL</td>
<td></td>
<td></td>
<td>R28 600,00</td>
</tr>
</tbody>
</table>
2.3. **Stocking of Dams**

The DWNP Fishery Division has been stocking impoundments with fingerlings produced from Mmadinare Hatchery since its completion in 2009. A list of stocked impoundments is provided in Appendix 8. The stocked fish are intended to enhance the livelihoods of the communities associated with the dams, either through direct harvesting of the fish for consumption or sale, or by means of income from recreational fishing.

The irregular rainfall pattern that characterises Botswana has necessitated the construction of many impoundments for water storage. The Water Utilities (WUC) and the Ministry of Agriculture (MoA) have constructed impoundments across the country and communities and farmers have built irrigation and livestock watering dams on their land. Several dams have been sampled and stocked with fingerlings from the Mmadinare fish hatchery by the Fisheries Division (Appendix 8). Three community dams, Mogopane and Mmasenyetse dams (30 and 70km from Gaborone respectively) and Jackalas No. 2 have been selected to be used by the Division as pilot projects for fish utilization by communities.

In order to gain more insight into DWNP’s dam stocking initiative, the project technical team visited the Jackalas II village community whose stock enhancement project is the most established of the stocking initiatives. A kgotla meeting (village meeting), which included members of the Village Development Committee and Dam Committee, was held with the kind permission of the chief and issues concerning the project were discussed. This was followed by a site visit of the dam, images of which are shown below (Figure 2).

The dam was constructed by the MoA primarily for watering cattle, and its administration delegated to the community of the Jackalas II village. The dam committee consisted of 12 members, (7 of whom are women) which are responsible for all matters related to the dam. Following discussions with DWNP, the dam was stocked with tilapia from the Mmadinare hatchery. Few people in the village knew how to catch fish, but the village started to receive visitors wanting to come and fish on the dam on weekends. Many of these customers were expatriates from neighbouring countries who valued and knew how to catch fish, or who were simply seeking a weekend get-away from nearby Francistown. The Dam Committee discussed the situation with themselves and with DWNP. They decided to start selling fishing licences to visitors and instituted a ‘pay per use’ system for fishing on the dam.

The scheme has worked reasonably well, generating a modest income for the villagers. A new tarmac road and electricity supply to the Jackalas II village has resulted in a steadily increasing stream of people visiting the dam and fishing. The committee reported that it welcomes 3-5 “customers” each week. Customers are charged P50 for catching up to a maximum of 5 fish a day of whatever size. Locals are charged P10 for the same privilege. If customers do not catch their allotted fish, they may return for one more trip on the same license to fill their bag limit. National fishing permits do not apply to this private water body, but the national fishing two month closed
season is enforced in January and February. The community has profited from the stocking program and the committee gathered an income of P7,200 from fishing permits in 2010. The dam committee expressed the view that they would like to enhance the earning potential of the dam by fencing it, providing visitor accommodation and facilities and patrolling the dam against poachers.

Figure 2 Images of the investigating team’s visit to Jackalas II Village and dam.

The value of the fish stock enhancement project has been amply demonstrated, however to increase income further the tourism potential of the site needs to be developed. The project needs advertising, signage, accommodation, and training in hospitality in order to continue to grow. As the DWNP Fishery Division do not have this expertise or experience, it would be appropriate for the Botswana Department of Tourism or other appropriate agency to promote the project further.

2.3.1. Tigerfish stocking as a tourism development strategy

The viability of stocking tigerfish to promote recreational fishing and enhance international tourism earnings was investigated in Letsibogo dam, one of the largest dam in Botswana. In 2009, tigerfish, *Hydrocynus vittatus*, were translocated from Schroda Dam (Limpopo Province, South Africa) by a team of researchers as part of an environmental baseline study (Tomschi et al 2009). The fish not only thrived but benefited the ecology of the dam by competing with exotic bass and predating undesirable mixed strain of tilapia, both of which were relocated by ignorant anglers (Gordon ‘O Brian. Pers Comm., March 2011).

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 (Tomschi et al 2009). As tiger fish are a highly valued species for sports fishermen, an established population in the dam would attract significant tourist numbers and income provided that appropriate access and facilities were provided. For example, tiger fishing on the Phongola Dam in South Africa supports a number of fishing tour operators, lodges, houseboats, numerous service industry opportunities and an annual fishing competition that attracts several hundred boats. As Letsibogo Dam is situated just off the main route to the North close to Francistown road, it is easily accessible to self-drive tourists. The capacity of the DWNP Fishery Division and Mmadinare Hatchery provide the requisite capacity for establishing a tiger fish population in Letsibogo Dam, which could create a major regional fishing tourism destination.
To realise the opportunity, an integrated plan with participation and support by relevant government ministries would be required, particularly the Water Utilities Corporation which controls access to the land and water surrounding the dam.

### Strategic Diagnostic Summary

SME fish farming based on capital inputs for farm construction and pelleted feed purchase is not economically viable at this point. A substantial potential exists for the numerous impoundments in Botswana to be stocked with fish for low or zero input fish farming to promote food security and income for local communities and small farmers. The DWNP Mmadinare Hatchery provides the capacity to stock dams, but the facility requires more resources for maintenance and technical training of staff to be effective. DWNP Fisheries Division should thus discourage small scale aquaculture activities that require costly inputs and encourage the stocking of existing dams for low input aquaculture or put and take fisheries where the benefits substantially outweigh the costs.
3. Biophysical conditions for aquaculture

Fish need certain physical conditions in order to be able to reproduce and grow to market size. The two most important are an appropriate temperature and suitable quality water.

3.1. Temperature

Botswana has a mostly arid climate characterised by large diurnal temperature fluctuations: hot summer days alternate with cold nights. Winters are mild, but temperatures can plummet below freezing at night, particularly in the South of the country.

Temperature data recorded over the ten years from 1998 to 2007 in Kasane – the most Northern and thus warmest part of the country (17°49” S; 25°9” E; Elevation: 960 Metres) revealed a large diurnal fluctuation in temperature even during summer months (Figure 1; data courtesy of TAHAL). Although daily average high were in the range of 26 – 34 degrees C in summer, average daily lows varied from 18 to 20ºC in summer and dropped to 8-15ºC in the months of April to September. Average water temperatures are likely to track the median air temperature and be below the minimum 25°C required for optimal fish growth from April to October.

Figure 3. Average daily water temperature over 10 years recorded at Kasane Airport: 17Deg49Min S; 25Deg9Min E; elevation 960m

In the South, average annual water temperatures measured at the Motswane Dam (25°S, 26°E) which supplies Gaborone in the South, ranged from 25.6°C at noon to 23.5 ºC at sunrise (read at the surface) in summer and 25ºC to 11ºC respectively in winter. Average yearly water temperature was
19° C, well below the optimal growth range of 25-30°C required for warm water fish (Commonwealth secretariat 1989).

Traditionally farmed animals such as cattle, pigs or chickens are warm blooded, meaning that they have physiological mechanisms which enable them to control their body temperature. Fish on the other hand are cold blooded and the ambient temperature therefore has a fundamental effect on their wellbeing: when temperatures fall, their metabolisms slow down. Each species has its own preferred range of temperatures within which they can thrive. For warm water fish, when temperatures drop below the minimum of their preferred range, the animals will experience stress, will cease to feed or grow, and will start to become vulnerable to disease and mortality (Table 2.)
Table 3. Effect of temperature on tilapia under culture conditions (courtesy of EnvirofishAfrica)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Growth</th>
<th>Health</th>
<th>Reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>32°C</td>
<td>Optimal</td>
<td>Good</td>
<td>Frequent</td>
</tr>
<tr>
<td>31°C</td>
<td>Reduced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30°C</td>
<td>Reduced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29°C</td>
<td>Marginal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28°C</td>
<td>Feeding ceases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27°C</td>
<td>Marginal</td>
<td>Reduced</td>
<td></td>
</tr>
<tr>
<td>26°C</td>
<td>Feeding ceases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25°C</td>
<td>Reduced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24°C</td>
<td>Reduced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23°C</td>
<td>Reduced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22°C</td>
<td>Reduced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21°C</td>
<td>Inhibited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20°C</td>
<td>Inhibited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19°C</td>
<td>Inhibited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18°C</td>
<td>Inhibited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17°C</td>
<td>Handling can lead to stress induced lethality</td>
<td>Lower lethal limit</td>
<td></td>
</tr>
<tr>
<td>16°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
As water temperatures fall below 28ºC, reduced metabolic activity of tilapia results in a rapid decline in growth rates (Balarin & Haller 1982, Chervinski 1982). Considering the temperature data presented, commercial aquaculture is not viable in the South of the country and is at best marginal in the North.

Water temperatures can be increased by using thermally controlled production systems such as horticultural tunnels with recirculating water. This forces aquaculture production to be conducted in a highly intensive manner to ameliorate the cost of the heating. This would have a significant effect on the business model of aquaculture initiatives. An alternative would be to utilise waste heat from industrial cooling water if this were available.

### Strategic Diagnostic Summary

Temperatures in Botswana are not high enough to support year round growth of tilapia, placing Botswana’s at a comparative disadvantage compared to tropical countries with year round optimal growing temperatures. Production would thus need to be seasonal or facilities would need to be heated for over-wintering fish by artificial means. In either case the profitability of the operation would be reduced. The market price of the product would need to be high enough to compensate for high production costs. An alternative would be to establish fish farms with access to waste heat from industrial cooling.

#### 3.2. Water

Significant amounts of water are required for commercial aquaculture as a continuous source of fresh water is required to dilute waste products. Botswana is a landlocked country with an arid climate, erratic rainfall and a flat topography. There are few permanent water bodies and water is generally a scarce resource.

The only significant natural permanent water bodies are the Limpopo river in the South Eastern Tuli Block, the Okavango delta complex in the North West, and a short stretch of river frontage along the Chobe River in the north east of the country.

##### 3.2.1. The Limpopo

The Limpopo system is already highly utilized for irrigating crops and other industry. The flow is erratic and the land is mostly privately owned. Water temperatures are sub-optimal for warm water fish culture in the winter.

##### 3.2.2. The Okavango Delta

While the abundance of water and fish in the Okavango Delta creates a possible opportunity for aquaculture, many factors detract from the suitability of the Okavango delta as an environment for aquaculture development. Primary amongst these is that the delta is an ecologically sensitive area with a highly diverse and complex fish population. Exotic fish species such as Nile tilapia that would be suitable candidates for aquaculture would pose a severe risk to the indigenous tilapia species
which play a vital role in the health of the ecosystem and form the base of the fishery. The vulnerability of the delta is highlighted by the fact that large scale, irrigated agricultural development of the fringes of the Okavango Delta is not envisaged (Ministry of Agriculture 2004).

The notion of promoting aquaculture in the Delta has gained currency among fishermen and resource managers as a means of supplementing fish stocks, ameliorating pressure on wild stocks, alleviating areas of potential conflict around resource use, and creating small to medium size enterprise opportunities (Nermark and Hinrichsen, 2007; pers. obs., Shakawe and Maun, Jan.-Feb., 2011). In stakeholder consultative workshops conducted in Shakawe and Maun during the present project, fishermen repeatedly requested that aquaculture be promoted to solve the problems they were experiencing in the fishery (Shipton, outcome of the consultative workshop, 2011). The reality is that aquaculture as modern farming activity is a vastly different undertaking to artisanal fishing, and not a suitable substitute in economic, social or ecological terms. Fish can be caught for a fraction of the price that they can be farmed, and fish stocks in the Delta are healthy. An analysis of fisher needs revealed that they are rather faced with post-harvest processing and marketing constraints, and not a shortage of fish (Shipton, outcome of the consultative workshop, 2011). The underlying issue is one of fisher education levels and business skills, which need to be addressed to empower them to gain more value from the fish they catch. Misconceptions and unrealistic expectations about the nature of aquaculture need to be addressed.

In response to a perceived need to address the issue of aquaculture in the process to develop the Okavango Delta Management Plan, The BiOkavango Project commissioned a consultancy to prepare guidelines for aquaculture in the Okavango Delta (Nermark and Hinrichsen, 2007). While the report provided guidelines on application procedures for starting an aquaculture enterprise, it did not evaluate whether aquaculture was in fact an appropriate development activity for the Delta. While the advantages and disadvantages of the bio-physical aspects of the Okavango environment for aquaculture were listed in terms of aquaculture production, the report was silent on ecological and economic considerations. This is unfortunate as the report uncritically perpetuates the notion that aquaculture is an appropriate sustainable development activity for the Okavango Delta.

The reality is that there are serious constraints to the development of aquaculture in the Okavango Delta region, and it would be appropriate for the Botswana government not to actively promote aquaculture as an enterprise opportunity in this region. The constraints to aquaculture in the delta include the following:

Ecological Constraints:

- The Okavango Delta Management Plan goal is to conserve the ecological character or the Okavango Delta ecosystem and promote sustainable development activities. Any form of in-water aquaculture such as cage culture is thus an undesirable technique due to its potential impact on the pristine and oligotrophic ecosystem, and the potential conflict with tourism and fishing activities.
- Alien species such as Nile tilapia cannot be considered due to biodiversity considerations in the Delta.
- The ecology of the Okavango floodplains renders them unsuitable for pond development.
Biophysical Constraints:

- Water availability varies considerably with season and global weather cycles, particularly in the southern Delta near the commercial infrastructure hub of Maun.
- High porosity of the sandy soil makes it unsuitable for earthen ponds.
- Low winter temperatures effectively limit production to the summer months, unless fish are housed in an enclosed facility which retains heat.
- Oxygen levels plummet when flood waters recede due to decomposition of large quantities of organic matter carried from the floodplains. High mortalities due to low oxygen levels caused a farm in the western Okavango to be abandoned in the 1980’s (Commonwealth Secretariat, 1989).
- The indigenous candidate species Three spot bream (*Oreochromis andersonni*) and red breast tilapia (*Tilapia rendali*) are unproven in terms of their production characteristics, and have not been selected for improved production traits.
- Options for aquaculture sites are very limited. Any production facility would probably need to be land based, utilising pumped ground or river water in a contained facility (e.g. vegetable tunnels).

Economic Constraints:

- The production costs of aquaculture products are higher than wild caught fish, limiting the market to more expensive products which effectively exclude local communities as a potential market.
- Aquaculture products will require modern processing and packaging facilities in order to deliver a top-quality product, thereby increasing capital costs and the minimum size economic production unit.
- The Okavango Delta’s remote location will increase production costs due to the transport costs associated with sourcing inputs such as feeds and equipment, and distributing products to urban centres.
- The market size and price for locally farmed bream species is unknown.
- The regional market demand and price for catfish is currently too low to justify farming it.
- Imported, frozen Chinese Nile tilapia (gutted, whole) are delivered to Maun for approximately P30/kg and it is unlikely that a local farmed product would be able to compete at this price.

The overall conclusion is that an aquaculture operation in the Delta region would of necessity need to be a fairly large, vertically integrated, intensive farming operation, with an inherent comparative production cost or market advantage compared to other regional locations. Under current conditions, large scale investment in aquaculture would probably be more attractive is neighbouring countries such as Zambia or Zimbabwe with warmer winter temperatures and closer proximity to urban markets where fish is consumed.

3.2.3. The Chobe

The Chobe River joins the Zambezi where Botswana borders Namibia, Zimbabwe and Zambia in the North East of the country. The Water Utilities Corporation (WUC) has proposed the construction of a pipeline linking the Chobe to the North South Carrier, the ultimate purpose of which is to supply Gaborone with drinking water. A series of development nodes along the length of the pipeline have been planned in order to promote agro-industry in areas where otherwise there would be insufficient
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA
Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

water to support it. One of the motivating factors for the development nodes is that payment for the use of the water by private enterprise will partially ameliorate the construction cost of the pipeline.

The first of these schemes has been proposed for the arable farmlands near Pandamatenga Village, approximately 60km to the south of the Chobe. A feasibility report commissioned by the Ministry of Agriculture was recently undertaken by TAHAL, an Israeli engineering group who have successfully developed similar projects elsewhere in the world (Ministry of Agriculture, 2010). The resulting document, The Zambezi Integrated Agro-Commercial Development Project Consolidated Feasibility Report, proposed a 39,000 t.p.a. tilapia farm integrated with chickens, oilseed, flowers, fruit and other crops. Aquaculture feeds would be manufactured in site from soya oil cake and suitable processing by-products from the other farming activities. At the time of writing the project had undergone a due diligence appraisal by Deloitte’s consultants, but the Ministry of Agriculture had not commented on the feasibility of the project (Mr Neil Fitt, Agriculture Coordination Hub, pers. comm., February 2011). The aquaculture component of the project was generally deemed by individuals familiar with the project to be over-ambitious primarily due to market constraints. A more prudent development strategy would be to have a phased development in terms of aquaculture production, beginning with a minimum economic size production unit, and then growing production in response to the emerging market demand.

While any future proposed aquaculture development scheme at Pandamatenga would of necessity require careful planning and economic feasibility analysis, the fundamentals of the concept potentially provide Botswana with its best opportunity for establishing commercial aquaculture in the country. The inherent comparative advantages would be:

- The scheme provides conditions to achieve a critical production volume justifying the investment in infrastructure and providing sufficient product to supply regional markets with a regular supply.
- Feeds are made on site from primarily locally grown ingredients greatly reducing feed and transport costs.
- Capital and running cost reduction through synergies with other agricultural and agro-processing activities.
- The clustered nature of the development justifies the dedicated infrastructure and high level skilled personnel required.
- The planned bridge at Kasane into Zambia locates the site on a major transport route and demand in Zambia is high.
- The temperatures in the northern region where Pandamatenga is located are the most favourable for aquaculture in Botswana.
- The use of genetically improved Nile tilapia with good aquaculture production characteristics could be considered as the proposed irrigation scheme is not situated in a permanent water course and fish could not escape and invade aquatic ecosystems.
3.2.4. Commercial aquaculture in impoundments

The Water Utilities Corporation (WUC) was established by the Water Utilities Corporation Act of 1970 (Laws of Botswana CAP 74:02) with a mandate of providing potable water to Botswana's urban centres.

A parastatal in the Ministry of Minerals, Energy & Water Affairs, the Water Utilities Corporation's infrastructure includes five dams, namely Gaborone, Nnywane (near Lobatse), Shashe, Bokaa, Letsibogo (near Mmadinare) and the North South Carrier water Scheme. The Corporation supplies clean, safe drinking water to 34% of Botswana's population and takes great pride in being able to support the potable water requirements that supports mining, manufacturing, commercial and domestic activities in Sowa, Francistown, Selebi-Phikwe, Gaborone, Lobatse and Jwaneng. Water quality standards adopted by the Corporation include those of the Botswana Bureau of Standards (BOBS) and the World Health Organisation (WHO). In all cases the quality achieved by the Water Utilities Corporation exceeds the set standards.

The need for storing water in Botswana has resulted in the development of many storage dams in the country. Various projects have been conceived for developing commercial aquaculture in these dams, using cage technology, or for pumping water from the dams. There are problems with both approaches:

- Fish reared in cages cannot forage for natural food and therefore require feeding in the form of a pelleted diet. Pelleted diets are expensive and the feed contains macronutrients (nitrate and phosphates) which enrich the water. Enriched water supports the growth of microalgae which adds significantly to the expense of processing the water to the purity required for human consumption. WUC have a policy to restrict nutrification of municipal dams for this reason.

- Extracting water from the major storage dams in a country with the limited water resources and erratic rainfall patterns such as Botswana, is inherently problematic. Water in Botswana is a strategic resource and in times of drought it is unlikely that WUC would favour aquaculture over people.

The carrying capacity of dams for supporting aquaculture has however never been investigated. It is not known at what scale an aquaculture operation would start to compromise water quality. Carrying capacity models are readily available and should be applied so that policy decisions can be made on the basis of calculated figures (whether cage aquaculture would compromise water quality and at what scale the threshold to water treatment would be reached.

The other impoundments in the country are smaller cattle watering and irrigation dams, neither of which are suitable for commercial aquaculture. Pumping subterranean water has restrictive cost implications.
Strategic Diagnostic Analysis

The only area with suitable water and ambient temperatures suitable for commercial aquaculture would be in the north of the country where water could be extracted from the Chobe-Zambezi system.
4. Culture Species

Botswana has a diverse indigenous fish population. Two groups of fish are suitable for aquaculture in Botswana: catfish and various bream species (members of the tilapia family).

4.1. Catfish

The African sharptooth catfish (*Clarias gariepinus*) occurs throughout Botswana in permanent as well as temporary water bodies. Culture technology for catfish farming is well developed regionally and these skills could be easily transferred to Botswana. *Clarias* have the ability to breath atmospheric oxygen via lung-like structures in their heads. They can therefore be cultured at very high densities (up to 500kg/m$^3$) with little water exchange. Under the right conditions they exhibit fast growth, favourable food conversion ratios (FCR), can be fed with diets low in fishmeal and are extremely hardy and disease resistant. Biologically, they are thus good aquaculture candidates (Hecht, 1993; Uys, 1993).

There are however substantial problems with the marketing of catfish. The potential for local marketing is poor and it was primarily for this reason that the industry largely collapsed in South Africa (Hecht, 1993; Uys, 1993). The beliefs of certain religious groups prevent their consumption because of their lack of scales and people by and large prefer bream. Some Batswana do eat catfish, but it fetches a low price.

There are also issues with export markets. Foremost among these is that in comparison with other catfish species that are available to farmers in the Americas (*Ictalurus* spp.) and the Far East (*Pangassius* spp.), *Clarias* is poorly accepted. African catfish fillets tend to be off-white, and often contain visible traces of blood (Hecht, 1993; Uys, 1993).

A potential market for catfish exists in central and west Africa, but to penetrate these markets catfish would need to be cultured at very large economies of scale or waste heat to compensate for suboptimal temperatures found in Botswana.

**Strategic Diagnostic Analysis**

Unless significant efforts are made to develop a favourable product and improve its image, catfish will not fetch prices high enough to warrant commercial production.

4.2. Tilapia

Botswana has a diversity of indigenous tilapine species, especially in the Okavango Delta (Merron 1988). Most of these species are however not ideal for aquaculture because they either exhibit slow growth or do not attain a large enough size (Chervinski, 1982; Merron 1998). *Oreochromis andersonii* (three spot tilapia); *O. macrochir* (green head tilapia) and *Tilapia rendalii* (red breasted tilapia) have all been cultured in Botswana at some point with no sustainable commercial success (Commonwealth Report, 1989). The Mozambican tilapia (*O. mossambicus*) is an additional indigenous candidate specie for Botswana which occurs in catchments flowing into the Limpopo system (Gordon O Brian, Pers Comm, 2011; Shaft Nengu. Pers. Comm., 2011). The growth rate of
this wild species is low in comparison to the Nile tilapia, reducing its appeal as an aquaculture candidate species (Balarin & Haller, 1982).

The problem with using wild species for aquaculture is that they are genetically adapted for survival rather than growth (Chervinsiki, 1982). The non-indigenous Nile tilapia (*Oreochromis niloticus*) has been selectively bred for faster growth and improved fillet yield, and has emerged as the foremost species for aquaculture in the world (FAO 2010). The Nile tilapia ‘GIFT’ (genetically improved farmed tilapia) strain is now used extensively in commercial facilities throughout the tropics, including other sub-Saharan African countries (e.g. Zimbabwe and Zambia). Improved tilapia strains are significantly more profitable to culture than wild species and the technical requirements of farming them (e.g. breeding and nutrition) have been established (Balarin & Haller, 1982). Commercial aquaculture in Botswana would profit from the introduction of improved tilapia strains. However, the biological mechanisms that have allowed for genetic improvement of tilapia species also pose a biodiversity risk (Wohlfarth & Hulata, 1981).

Due to biodiversity considerations, the DWNP Fishery Division is reluctant to issue permits for the introduction of *O. niloticus*, however, a permit may be issued after strict consideration of the culture system and the ecological and biodiversity implications. Tilapia are reproductively very plastic, and interspecific hybridisation is commonplace (Wohlfarth & Hulata, 1981). If foreign species introduced for aquaculture were to escape, they could present a real threat to indigenous tilapia biodiversity and could be particularly damaging to sensitive conservation areas such as the Okavango Delta. These biodiversity considerations confine tilapia aquaculture to indigenous species for farming in sensitive aquatic habitats such as the Okavango delta. However, Nile tilapia and their hybrids are present in Mmadinare Dam and the Limpopo catchment. Improved Nile tilapia could thus potentially be cultured in these catchments without impacting biodiversity. Importing new tilapia stock would require very strict biosecurity procedures to ensure that 1) they were properly quarantined to prevent the introduction of infectious diseases and parasites (such as EUS), 2) the farmed fish could not escape into nearby water bodies.

The potential also exists for improving the genetics of indigenous Botswana species. The best candidate for this would probably be *O. andersonii* which grows to a large size and is a generalist feeder capable of digesting plant matter. Work in this regard is being conducted by the newly built Kamutjonga Inland Fisheries Institute (KIFI) in Namibia. It would make sense for the DWNP Fisheries Division to join this research effort as a collaborator, rather than invest in its own aquaculture research facilities in the Okavango region.

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<th>Strategic Diagnostic Analysis</th>
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<tr>
<td>Protocols governing the use of foreign tilapia strains need to be established and indigenous strains need to be developed, preferably though collaboration with regional facilities</td>
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5. Markets

5.1. Local market

Besides import statistics for fish products, there is no published data on the market demand for fish in Botswana. The information presented here was a result of stakeholder consultations and informal communications in Botswana.

Botswana has a small population of approximately 2 million people (CIA 2011), who are not historically a fish eating nation. Only small communities in and around the Okavango Delta and Chobe river systems have traditionally included fish as part of their diet. This is changing, especially in urban areas where an educated and increasingly empowered population are aware of the health benefits and culinary opportunities that fish provides. Botswana’s per capita income of roughly USD 6,742 as of 2007 makes it a middle-income developing country (US Commercial service, 2009). Most of the fish consumed in Botswana is imported: 2,382,086 kg (at a value of P43,245,) and 2,931,723 kg (at a value of P57,473,837) were imported during 2009 and 2010 respectively. The majority of this was in the form of tinned pilchards and sardines from Namibia and South Africa (Appendix 4).

Low fish consumption in Botswana is generally not linked to a cultural taboo against eating fish\(^1\), but rather a lack of regular availability and knowledge on preparation (Oarabile 2006). This has been confirmed repeatedly during this study by a variety of stakeholders. The project technical team took the opportunity to informally interview a range of people they encountered during their travels in Botswana: from taxi drivers, farmers and waiters to lodge managers and business people. All responded that they enjoyed eating fresh fish and would eat more if it were more readily available.

Most fish consumed in urban areas is imported from South Africa in the form of frozen hake products or tinned pilchards, both marine in origin. There is a small market for high value frozen fillets in supermarkets and restaurants in urban areas and in tourist lodges and hotels. An informal inspection of supermarket freezers revealed that frozen tilapia fillets imported from South Africa (most likely of Chinese origin) were being sold for P85/kg, while frozen whole fish were being sold at P32/kg. This contrasted with well packaged and presented South African hake fillets in adjacent freezers that were priced at only P60 per kg. This indicated a particular demand for frozen, freshwater fish in Gaborone.

Figure 4. Roadside fish seller in Gaborone

\(^1\) Certain local religious groups do not eat fish without scales such as catfish.
Historically, the main consumers of fish in the urban centres have been people with a traditional culture of eating fish; namely people of West and Central African, or Asian descent. The local market however does appear to be growing as urban educated Batswana start to diversify their diets.

A small amount of freshwater fish is marketed and sold in the urban centres mostly by informal traders selling dried or fresh fish on the roadside. At an informal fish market in Gaborone, the fish were primarily catfish and *O. mossambicus*, being sold per piece; P20 for small fish (up to about 800g) and P40 for larger fish (up to 3kg) – gutted and head on. The fish were fresh and appeared to be of good quality.

An interview with a small farmer outside of Gaborone who has marketed tilapia grown at his small holding, as well as imported product from Zimbabwe, suggested that there was a market for approximately 10 tons per week of fresh tilapia (head on, gutted) to the Gaborone market. He has not attempted to produce to meet the market demand because of the capital cost involved. He would need to invest in temperature controlled facilities to ensure consistent growth of fish in summer and survival of the stock through winter, as well as processing facilities close to town.

A former owner of a “Pick n Pay” supermarket in Gaborone related that the store had imported tilapia from Lake Harvest in Zimbabwe, and which has created a growing demand for the product. Weekly imports of 500kg stock would typically sell out in two days. However, the supply became unpredictable and the demand quickly fell away once this happened.

The majority of the demand for tilapia in Botswana is currently satisfied by cheap frozen product imported via Johannesburg from China. Chinese Tilapia is available in lodges and restaurants throughout the country. It is imported into Botswana by the company “Seafood Wholesalers” (Gaborone) and distributed by “Senn Foods” countrywide. The price (including delivery to the customer) is P31.20/kg for whole 300 g fish (gutted and gilled) in individual plastic bags. Vacuum packed fillets are delivered for P81/kg (Mr Phin Mackenzie, Senn Foods, Francistown. pers comm., March 2011). Chinese tilapia were ordered and eaten by the project team in a local lodge and proved to be of excellent quality and freshness.

The manager of a food distribution company reported that they had been approached by several aspirant fish farmers wishing to test the market. They had responded positively, indicating they purchase a locally produced fish as long as it met minimum criteria of quality, presentation and regular supply – a minimum quantity was not prescribed. None of the enquirers had been able to supply fish to this specification.

Current farm input costs indicate that it would not be possible to produce a locally farmed tilapia at a price competitive with Chinese imports in Botswana\(^2\). The Ministry of Agriculture (though its trade

\(^2\) The project technical team aquaculture specialists estimated a local production cost of P30-32/kg assuming an intensive production system in tunnels, a feed cost of P10.80/kg (imported from South Africa excluding import duties), and a feed conversion ratio of 1.5.
policy and the Department of Trade and Industry’s (DTI) Economic Diversification Drive (EDD) does provide some protection for local producers to protect them from imported agricultural products by means of “trade restricting import permits” (Ministry of Agriculture, 2011). However, before government could implement these restrictions, on imported Chinese tilapia for example, local producers would need to prove that they could supply the market reliably with a quality product. Competiveness of the local product could be enhanced by creating a trademarked brand for “Botswana Bream” and enforcing labelling on imported fish products.

**Strategic Diagnostic Analysis**

Growing the local market for cultured fish would require a regular supply of farmed product and a marketing campaign. There appears to be sufficient local market demand to support at least one commercial tilapia farm producing 100-200 tons per annum. Product differentiation, promotion of a locally grown, quality product could be means of establishing a competitive advantage for Botswana farmed fish.

**5.2. International markets**

The international demand for white fish fillets is increasing, particularly in the EU and the United States (Fitzimmons 2011; Julian Van Der Nat, TAHAL Group, February 2011). Farmed fish products in these markets are gaining popularity due to their traceability, quality and consistency of supply. The market for farmed white fish in the EU is supplied primarily by Pangassius catfish imported from Vietnam, while tilapia is the most important farmed fish in the American market (Patrick Sorgeloos, Laboratory of Aquaculture, Gent University. Pers Comm, February 2011). The USA is the largest international market for tilapia, and growing. It imported 183,400 tons in 2009 with a value of $696.1m, an increase from the $482.7m imported in 2006 (Fitzimmons 2011).

China accounts for 90% of the frozen tilapia fillet market in the US, while Ecuador supplies 30% of the fresh fillets. Other major producing countries are Taiwan, Ecuador, Indonesia, Honduras and Costa Rica (Fitzimmons 2008; Josupeit, 2010). The Chinese supply of tilapia looks set to increase, as supply of frozen fillets was up 28% year-on-year in first half of 2010 (Josupeit, 2010). Overall, the international price of tilapia is falling due to an increase in production of the main producing countries (from $3 per kg in 2008 to $2.77 in 2009) due to a combination of oversupply and world economic crisis (Josupeit, 2010). The Free on Board (FOB) wholesale price for frozen tilapia fillets (100-300g) from China in January 2011 was between $2.40-2.60. Fresh tilapia fillets – with a US origin, commanded a wholesale price between $3.60 and $3.90 (Fitzimmons 2008, 201; Josupeit, 2010).

The low international price of farmed tilapia, and lack of a comparative production advantage in Botswana means that tilapia production as a whole or filleted frozen commodity would be uncompetitive, either for export or the local market. Alternative marketing strategies would need to be considered to obtain a price which justifies farm input costs, for example, the supply of fresh,
unfrozen whole fish and fillets to lodges, hotels, restaurants and upmarket retail outlets. The South Africa market in particular is under supplied with fresh fish.

**Strategic Diagnostic Summary**

It is unlikely that frozen Tilapia produced in Botswana would be able to compete with internationally traded tilapia from established aquaculture countries. Local farmed fish should seek to obtain a price premium by supplying fresh fish to the local and regional hotel, restaurant and retail market.

**5.3. Regional markets**

Botswana’s neighbours in the region are potential market destination. There may also be a potential niche demand in South Africa for unfrozen (fresh) tilapia fillets for the high end market (DTI, 2007).

Nigeria is a potentially large market for aquaculture products including tilapia and catfish where average annual fish consumption is 9.2kg per capita (see static.globaltrade.net/files/pdf/20101213155333.pdf). The urban market for fish in Nigeria is projected to grow at 3% per year purely through population growth. The market is estimated to have the potential to consume 2.6 million tons of fish, with an estimated value of $1.8 billion. Total seafood imports are estimated at $796,250,000. Aquaculture supplied approximately 143,000 tons in 2008– only 1% of total fishery supply (FAO, 2010).

SADC agreements eliminate border tariffs between signatory nations, keeping the cost of regional exports lower.

Lake Harvest farms in Zimbabwe have been successfully marketing high quality tilapia products in the Southern African region for several years, proving the potential. In order to take advantage of these markets, a realistic model of cold chain distribution would need to be developed and more information regarding the regional market for farmed fish would need to be compiled, possibly through divisions of DABP (see below).

**Strategic Diagnostic Analysis**

The regional market for tilapia is an interesting option that warrants further investigation. Unfrozen product would command a higher price than frozen fish and have a competitive advantage over imports from Asia.
6. Institutional environment

Botswana has established a conducive institutional environment for promoting the development of a new sector such as aquaculture. The country is characterised by good governance, political stability, sound financial institutions, a relatively low crime rate, investment in key infrastructure, social services and citizen education. Botswana’s development policies and supporting government and parastatal agencies have created a favourable investment climate and support exists for establishing new economic sectors which can diversify the Botswana economy.

6.1 Botswana’s Policies to Promote Aquaculture

Botswana does not possess a comprehensive aquaculture sector development policy and strategy, however the development of an aquaculture industry has been considered by the Botswana government since the 1980’s (Commonwealth Secretariat, 1989; Government of Botswana, 2002; 2010a; 2010b; Ministry of Agriculture, 2010). Aquaculture as a sector is not mentioned in any of Botswana’s legislation, probably because no aquaculture production has become established, and there has consequently been little need to develop legislative instruments to promote and regulate the sector.

Since 2003, limited government support has been provided to promote the development of fish farming through Botswana’s National Develop Plans 9 and 10. Government efforts to promote aquaculture through the Fishery Division of the DWNP stimulated considerable interest in aquaculture as a small to medium size farming enterprise. However, despite this support, no viable aquaculture enterprises have emerged in Botswana. The public sector support provided for aquaculture development in Botswana under various policies is reviewed below, followed by a diagnostic analysis.

Botswana’s national economic development strategies are given substance through its series of National Development Plans (NDP) which outline specific interventions with budgets and timeframes. The National Development Plans have been implemented since 1966 with the current plan being the tenth National Development Plan (NDP 10, Government of Botswana 2009) which began in 2010. Aquaculture has received limited support both in NDP 9 (2003-2009), and NDP 10 (2010-2016).

Aquaculture and fishery development were included in the NDP 9 (Section 10.70; Government of Botswana, 2002) as part of Botswana’s strategy to diversify its agricultural sector. The NDP 9 (Section 10.95) provided for:-

- The encouragement of fish farming through aquaculture.
- The establishment of a fish hatchery at Letsibogo Dam, which resulted in the Mmadinare fish hatchery which was intended to stimulate interest in aquaculture and provide fingerlings and technical support to prospective fish farmers.
Under NP 9, the government Fishery Division, which resided under the Ministry of Agriculture until its transfer to the Ministry of Wildlife, Environment and Tourism in April 2003, was capacitated to operate the Letsibogo Hatchery and provide advice and technical assistance to aspirant fish farmers. This execution of the mandate arising from NDP 9 has continued to the present time focussing mainly on aspirant small to medium size enterprise development.

The Botswana government has made development finance support available for aquaculture feasibility studies and financing through the Botswana Citizen Entrepreneurial Development Agency (CEDA) and the Local Enterprise Authority (LEA) as part of their mandates to promote citizen enterprise and small, medium and micro- enterprise (SMME) development. As far as could be established, none of the aquaculture business plans received by either LEA or CEDA has been considered to be viable, and consequently no loans have been granted to prospective fish farmers.

The NDP10 (Government of Botswana, 2010a; 2010b) does not specifically refer to aquaculture as a sector targeted for development, however, one of the NDP 10 Agriculture strategies is to focus on the potential for commercial irrigation farming in the northern Pandamatenga area and in areas bordering new dams (NDP 10, Volume 1, section 9.255). The development of irrigation schemes creates a potential opportunity for aquaculture development. In order to realise potential competitive advantages in the agriculture sector, ND10 states that “Government will strive to provide the conditions to attract private investment through provision of infrastructure such as roads, electricity, water and telecommunications and technology necessary to enhance productivity and production.” (NDP 10, Volume 1, section 9.256).

The above NDP 10 objectives informed the planning and feasibility study for an integrated irrigated agriculture, aquaculture and agro-processing scheme in the northern Pandamatenga area (Ministry of Agriculture, 2010a). The proposal, compiled by TAHAL Group Engineering Consultants, envisaged a 60 km pipeline from the Zambezi River to supply an integrated irrigation scheme which would include various crops, fruit, and 40,000t aquaculture production of catfish and tilapia. It was envisaged that the water carrier and infrastructure for the scheme would be funded by government, while the Tahal group would promote the required private sector investment in the agricultural activities. At the time of writing, the proposal had just undergone a due diligence appraisal by Deloitte’s consultants and the Ministry of Agriculture’s view on the viability of proposal was still undecided. Individuals familiar with the proposal were generally of the opinion that the aquaculture component was over-ambitious, given the uncertainties about the markets for the products and cost of the scheme. While the fundamental concept of integrating aquaculture with irrigated agricultural production is a sound one, which merits government support for infrastructure provision, a phased approach to building the aquaculture production volumes as market demand becomes more certain would be more prudent.

The Botswana government’s Fishery Division was moved from the Ministry of Agriculture to the Department of Wildlife, Environment and Tourism (MEWT) in 2003 and thus Under NDP 10 initiated in 2010 (Government of Botswana, 2010b), MEWT was provided with a budget for:

- Consultancy services at Letsibogo Fish Hatchery for staff capacity building and skills development (NDP 10, volume 2, Item 09433).
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA
Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

- The completion of NDP 9 spillover projects for the construction of a fish hatchery at Letsibogo Dam (NDP 10, volume 2, Item 09434).

The NDP 10 was however silent on the Botswana governments strategic approach to aquaculture development, and the support to MEWT for the Mmadinare hatchery development was provided in isolation of any comprehensive goal orientated policy or strategy to promote aquaculture sector development. As a result, a visit to the facility by the project Technical Team revealed that the facility is not very effective, in that it lacks clear goals and is constrained operationally by a lack of running costs, equipment (no vehicle), and relatively inexperienced staff.

Policy and Legislative Diagnostic Analysis

Botswana’s interventions in support of stimulating the development of aquaculture are similar to support measures provided in other countries, where 1) a state hatchery is established to provide technology and seed, and 2) development finance is provided to pioneer farmers. While these support measures are not in themselves inappropriate, what has been lacking is a comprehensive analysis of the potential of aquaculture in Botswana based on economic fundamentals, the possible competitive advantages of aquaculture production in Botswana, and constraints to establishing a new agricultural sector. The current review of the status and potential of aquaculture revealed that the economic case for aquaculture in Botswana is marginal, that the barriers to entry into aquaculture for small to medium size enterprises are virtually insurmountable. Thus, a rethink of the aquaculture strategies emanating from Botswana’s NDP9 policy of promoting fish farming is required as continued commitment of public sector resources to aquaculture promotion with no apparent support from government in terms of establishment of infrastructure and support services is wasteful. Options for aquaculture development based upon a holistic evaluation of the status and potential of aquaculture in Botswana are provided in the ACP Fish II project’s “Aquaculture Development Strategy for Botswana”.

6.2 Government Departments

6.2.1 Department of Wildlife and National Parks

The Fisheries Division of the DWNP within the Ministry of Environment, Wildlife and Tourism (MEWT) is the lead agency for aquaculture in Botswana. Fisheries was originally housed within the Ministry of Agriculture with the primary function of diversifying the opportunities for agriculture and enhancing livelihoods of rural communities in line with the country’s national development Plans (NDP) 9 & 10. In 2003, the Fisheries Division was moved to DWNP of the Ministry of Environment, Wildlife and Tourism where the fisheries component (as opposed to the aquaculture component) was more logically accommodated.

The Fisheries Division has never had a clear policy directive to follow in terms of aquaculture development and the staff handle a range of aquaculture related issues including the:

- Promotion of aquaculture and dissemination of information
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA

Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

- Assisting aspirant farmers with technical information and supporting loan applications.
- Assessing land for aquaculture potential.
- Issuing licenses for the capture and farming of species.
- Making inputs into aquaculture environmental assessments.
- Supporting investors interested in large scale aquaculture projects.
- Organising, funding and conducting training workshops.
- Breeding fish and producing fingerlings from Mmadinare hatchery.
- Distributing fingerlings to clients.
- Stocking impoundments with fish and providing extension service for supporting communities.

In addition, the same Fishery Division staff are responsible for managing natural fish populations in Botswana’s main rivers and dams, performing fish stock assessment surveys, promoting fishing among communities, issuing fishing permits, enforcing compliance and responding to issues that arise such as fish kills.

6.2.1.1 Promotion of aquaculture

DWNP releases a wide range of information with the primary aim of promoting aquaculture as an economic activity (Mogomotsi Diane, Wildlife Officer in the Information Services Unit, pers. comm, 23 March11). These include:

- Regular features and news clips in The Department of Wildlife’s weekly radio program broadcast every Thursday night on national television.
- Inserts on the Ministry of Agriculture’s TV show (in the last 2 years, 3 aquaculture inserts have been broadcast).
- Aquaculture workshops are held to which the press is invited.
- News bulletins by the press – (Mmadinare hatchery was covered on national TV)
- School groups are taken to Mmadinare hatchery as an outing as part of their agriculture syllabus.

These efforts have resulted in a high level of awareness of aquaculture amongst people in Botswana. As a result of these efforts, a steady stream of entrepreneurs approach the FD for
support with starting aquaculture businesses. The Fisheries Division has developed an internal procedure for guiding these applicants through the process of starting an aquaculture business.

6.2.1.2. Technical advice
Most aspirant fish farmers have no knowledge of aquaculture besides a little information gleaned from internet searches. They therefore need to be educated about the basic fundamentals. The Fisheries Division have produced a number of booklets on aquaculture and supply applicants a basic guide to aquaculture entitled: “Twenty Common questions on Aquaculture and Fish Farming Guidelines” (Appendix 6). Fisheries officers also spend long periods of time in discussion with applicants educating them. The tone of these consultations is generally encouraging and fisheries officers are enthusiastic about aquaculture. Up to five fisheries officers spend time following up applications as part of their general daily duties. The division sees up to 5 applicants a week. Applicants are received at any time of the day, without appointments and often interrupt the normal working schedule.

6.2.1.3. Assessment of land
Fisheries officers visit the applicant’s land if they are requested to do so. Their assessment is compiled in a letter which is issued to the applicant and normally submitted to Land Board to support the application for land.

6.2.1.4. Assistance with management plan
Fisheries staff help applicants to compile a management plan which forms part of the business plan that is submitted to funding agencies for consideration. Despite the efforts of Fisheries (DWNP has assisted 126 applicants), no small aquaculture businesses exist in Botswana.

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<td>Fisheries officers spend a great deal of their time and resources encouraging and supporting would-be small scale aquaculture farmers. The applicants also expend their own resources on compiling their applications, often using professional accountants and business advisors, with associated costs of travel, etc.. The experience in Botswana to date demonstrates that under current circumstances, small to medium size aquaculture is not an economically viable enterprise opportunity. The Fisheries Division should thus re-prioritise its operational focus in terms of aquaculture to promoting low input stocking of dams, possibly establishing a tiger fish population on Letsibogo Dam, and providing technical support to any proposed development economically viable large scale commercial aquaculture. Information dissemination on aquaculture to the general public should be reactive instead of pro-active to reduce the amount of staff time spent addressing general enquiries about aquaculture as a small enterprise.</td>
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6.2.2 Department of Environmental Affairs
The Department of Environmental Affairs (DEA) within the Ministry of Environment, Wildlife and Tourism has the mandate for implementing Botswana’s Environmental Impact Assessment (EIA)
procedures in respect of aquaculture. Currently the EIA process in Botswana is activated and driven by the Preliminary Environmental Impact Assessment (PEIA) as prescribed by Section 6(1a) of the EIA Act or 2005. This process is associated with a PEIA application form, which should be completed in consultation with other authorising bodies such as the Department of Water Affairs (DWA) and the Tawana Land Board (TLB).

A PEIA is a short report informing the DEA that a prescribed activity or development is being considered. Due to the specific information requirements for aquaculture, the following list of additional information should be included when the PEIA is being completed for aquaculture:

- The production species that is being considered.
- The production system that is being considered.
- Water requirements and discharge methods.

The main purpose of a PEIA is to provide sufficient information to allow DEA to determine whether a detailed EIA is required before the implementation of the proposed aquaculture activity. The PEIA should be submitted at the concept or pre-feasibility study stage of the project cycle in order to prevent over planning before the necessary authorisation process has commenced.

To facilitate the application process, the form can be accompanied by a management plan that outlines the environmental impacts and mitigation measures.

Based on the PEIA information, the DEA will either exempt the venture from a full EIA or require that such an EIA be conducted. The outcome / decision could be subject to certain conditions.

Botswana possesses a variety of institutions geared toward assisting the establishment of new agricultural industries. A successful beef industry has been built within this environment and as other novel agricultural sectors (such as ostrich) grow, these institutions are strengthened. The development of appropriate commercial aquaculture would find ample support within this general environment.

6.2.3. Ministry of Agriculture

The Department of Agriculture (DOA) possess capacity for the implementation of sophisticated systems and protocols for the development of livestock industries, which could be applied to aquaculture if the sector was deemed economically viable. The MOA has a good track record when it comes to supporting agriculture ventures once they have been proven viable. For example when the ostrich industry reached a critical mass, the government constructed an abattoir to support the development of the industry (Botswana NDP9). MOA structures that may be relevant to aquaculture development are described below.

6.2.3.1. The Department of Agricultural Business Promotion (DABP)

The Department of Agricultural Business Promotion (DABP) was established to promote a commercialized, diversified, sustainable and competitive agricultural sector through business skills
transfer, market access negotiations, and promotion of agricultural cooperatives and associations. (http://www.gov.bw/en/Ministries--Authorities/Ministries/MinistryofAgriculture-MOA/Departments-of-MOA/Department-of-Agricultural-Business-Promotion-DABP/). The various divisions of DABP are well equipped to support new industries such as aquaculture:

The division of Agricultural Cooperatives is responsible for analysing, formulating, and implementing agricultural cooperative policies. These include registering, auditing and inspecting agricultural cooperatives and to monitoring performance of these entities. This entity could be helpful in setting up clustered aquaculture production units in a development node.

The Division of Farm Management analyses farm data and uses it to help farmers make decisions and informs policy. The division also focuses on improving farmers' basic business skills and conducts micro-surveys, which generate information for project design.

The Division of Agricultural Trade is responsible for promoting International Trade through participation in Trade Negotiations and implementing and monitoring of trade policies and agreements.

The Division of Agricultural Marketing of The Department of Agricultural Business Promotion (DABP) is responsible for analysing, formulating and implementing agricultural marketing policies and regulations. This includes among other things, providing marketing information, developing marketing networks and channels, and conducting market research and intelligence.

6.2.3.2 Aquatic Veterinary Services

The Botswana National Veterinary Laboratory (BNVL) is a public diagnostic laboratory with a small research component. BNVL is under the supervision of the Director of Veterinary Services and has some tests accredited by the South African National Accreditation System (SANAS). The laboratory has twinning and collaborative arrangements within the region and worldwide. BNVL has capacity to offer general parasitology, bacteriology/mycology, tissue culture, immunoassay (e.g. ELISA), molecular diagnostics (e.g. PCR), histopathology, residue analysis, water quality analysis and food safety control.

There is no specialist in aquatic animal disease diagnostics at BNVL. However there are two officers trained in fish pathology and introductory fish medicine.

Botswana has legislation that deals with animal health controls (Diseases of Animals Act) and food safety issues (Food Control Act). Further legislation deals with protection of fish (Fish Protection Act). These laws are supported by regulations, the most recent being the Fish Protection Regulations of 2008.

Although there is considerable fragmentation, the role of government institutions provides clearly defined responsibilities. Department of Veterinary Services deal with certification and animal health issues, whereas local government authorities and the Ministry of Health cover food safety and
inspections. Botswana is a signatory of the Aquatic Biosecurity Framework for Southern Africa (OIE report, 2008). The OIE is in the process of training vets in the subcontinent.

Should commercial scale aquaculture require veterinary certification for exporting products, the existing structures provide required competent authority, but training in aquaculture and fish health aspects would be required.

6.3. Botswana Bureau of Standards (BOBS)

The Botswana Bureau of Standards (www.bobs.co.bw) which was created in 1995 is a parastatal organization that develops and implements national Botswana standards. Separate government ministries, parastatals, and private companies can develop standards specifically for their own institutions, however, only BOBS is recognized by the International Organization for Standardization (ISO) and has the authority to create national standards. The procedures used in the development of standards are tailored to comply with the WTO’s code of good practice for the development of standards.

<table>
<thead>
<tr>
<th>Strategic Diagnostic Analysis</th>
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<tbody>
<tr>
<td>Botswana has developed sophisticated supporting organisations for the development of a new agri-business sector such as aquaculture.</td>
</tr>
</tbody>
</table>
6.4. Business and Financial Institutions

The Government of Botswana is committed to creating an attractive climate for investment. Credit ratings received from Moody's and Standard & Poor's for Botswana were the highest given to an African country, ranking it equally with other successfully developing economies like the Republic of Chile, Saudi Arabia, Korea and Estonia (US Commercial Service, 2009). Botswana has a strong and well-managed minerals economy, coupled with a long record of political and macroeconomic stability. Botswana's financial sector is supported by sound policies and parastatal and private organisations which are described below.

6.4.1. Foreign investment

The Government of Botswana is committed to creating an attractive climate for foreign investment. The Government is actively encouraging the development of the private sector through an attractive taxation regime, the elimination of exchange controls and support for foreign direct investment in non-mining sectors of the economy. Botswana continues to develop a regulatory framework favourable to investors. The Government abolished all foreign exchange controls in February 1999. It has undertaken largely successful efforts to combat crime, including corruption. The Government has instituted low corporate tax rates, has increased the processing speed of applications for business ventures and is commitment to transparency.

6.4.2. Commercial Finance

Despite the strong presence of commercial finance institutions and availability of venture capital, commercial aquaculture in Botswana has not attracted investment. Aquaculture is perceived to be high risk for a number of reasons:

- The primary production technologies have not been proven.
- Markets have not been established.
- There is no proven track record of commercial aquaculture in Botswana.
- There is a paucity in Botswana of expertise in aquaculture - aquaculture requires highly technical and multidisciplinary skills.
- Staff of lending institutions are ignorant of aquaculture, and there is no experience of funding aquaculture within the financial lending institutions against which to benchmark new applications.

This may change if commercial aquaculture gains a foothold in the country.

6.4.3. BEDIA

The Botswana Export Development and Investment Authority (BEDIA) is an autonomous organization established in 1998 to promote investment in Botswana with a special emphasis on export-oriented manufacturing industries. BEDIA serves as the primary government contact point for both domestic and foreign investors. Through its One Stop Service Centre, BEDIA provides services for investor needs and aftercare to both new and existing foreign and citizen-owned enterprises. The Centre focuses on enabling investors in both the manufacturing and service sectors to secure all
clearances and approvals as quickly as possible under one roof. BEDIA promotes the sectors through incoming and outgoing missions as well as through direct mailing campaigns in the targeted markets, such as the European Union, South Asia, and southern Africa.

6.4.4. IFSC

Botswana’s financial services sector is developing rapidly through the International Financial Services Centre (IFSC), regulated by the Bank of Botswana. The IFSC provides a range of attractive incentives to foreign investors willing to base operations in Botswana.

6.4.5. CEDA

The Citizen Entrepreneurial Development Agency (CEDA) was established by the Government of Botswana to provide financial and technical support for business development with a view to the promotion of viable and sustainable citizen owned business enterprises. CEDA was established in 2001 in response to a recommendation made by the National Conference on Citizen Economic Empowerment (NCCEE) held in July 1999, in order to introduce the professional management of the Government financial assistance initiatives and to streamline the numerous projects providing similar schemes.

The Agency was established to address the need for coherent and holistic support for the development of small, medium and large scale enterprises through a soft window and packages offered through the subsidiaries. CEDA offers funding for capital expenditure, stock or working capital in new and existing business ventures. It also offers training and mentoring for new and seasoned entrepreneurs and business advisory services to entrepreneurs in various skills as identified through the needs assessment that is conducted during project monitoring.

CEDA offers a range of products and services which would be relevant to aquaculture:

- **The Young Farmers Loan** offers maximum loan of P500 000 for projects with repayment periods for loans ranging from 24-60 months depending on the value of the loan. The interest accruing during the grace period is capitalized.
- **The Ipelegeng Loan** is worth 500-500,000 for seasonal arable expenses that include but not limited to the following: equipment repairs, seeds, fertilizers, fencing, hiring of tractors etc. Loans are offered for a period not exceeding 12 months at an interest rate of 5% per annum.
- **The Credit Guarantee** enables Botswana citizens 18 years or more and Botswana citizen wholly owned businesses to bid for contracts that call for guarantees where their credit worthiness is not known or they do not possess sufficient security, for amounts of P500 up to P4,000,000. Credit Guarantee Period does not exceed 12 months and is subject to an arrangement fee of 2.5% charged on the guarantee amount. 1.5% per annum on outstanding loan amount for guarantees can be requested by the bank on behalf of client. No interest is charged.
Subsidised interest loans are only granted after business plans have been compiled and their viability assessed. If the loans are granted, the agency will facilitate training opportunities for management and staff and may also assist with company mentoring.

CEDA has been approached by a number of aspiring aquaculture entrepreneurs over the years. None of these applications have been approved. CEDA did not send representatives to either of the aquaculture stakeholder workshops.

6.4.6. LEA

The Local Enterprise Authority (LEA) assists with practical advice in the process of conducting feasibility assessments and preparing business plans. With assistance from LEA, other Government organs can be consulted in the process to achieve greater cooperation. LEA assistance can pave the way for possible CEDA funding and a memorandum of understanding exists between the two agencies.

LEA no longer considers stand alone aquaculture projects, but will assist when aquaculture is integrated with one of its mandated interests such as horticulture, where irrigation dams could be stocked with fish and supplemented with feed. LEA is currently involved with several such projects (Kereemang Moilwa. LEA. Pers. Comm., April 2011).

### Strategic Diagnostic Analysis

The financial and business environment favours foreign investment into large scale industrial manufacturing industries, especially where products are exported (such as large commercial aquaculture). Funding is also available for small and emerging farmers but thus far these agencies have not deemed investment in SME aquaculture to be economically viable.
6.5. Education and Training

Farming fish is a technically demanding activity, requiring high level training and sophisticated technology. Aquaculture development in many countries has been driven by a well established education system.

6.5.1. Botswana College of Agriculture

The Botswana College of Agriculture’s Department of Animal Science and Production offers a four month aquaculture course run over a full academic semester. The course was originally designed and taught by Mr Ulf Nermark in 2006. It has been refined and is now taught by Mr Neo Bagwasi. It is a degree course elective that can be taken by anyone enrolled at the College. The course outline is attached as Appendix 6. The number of students enrolled in the course has been declining over the years: 2007 - 140 students, 2008 - 70 students, 2009 - 28 students and 2010 - 22 students (Neo Bagwasi, Pers. Comm. 2011). This is probably due to the realisation that employment opportunities within aquaculture in Botswana are limited.

The college has a small recirculation facility for holding some tilapia which is used to teach some basic techniques such as handling fish, taking length/weight data and fish care. The facility is however very small and primitive and cannot provide students with real aquaculture experience. The facility is set up next to the College’s piggery and it would be ideal if a pond or two could be dug in the open land next to the piggery where tilapia could be stocked. Piggery waste could be washed directly into the pond where it would act as fertiliser for enriching the pond. Thus with very little input, the college would have a more appropriate demonstration unit where students could be taught the basics of fish farming (Figure 3).

6.5.2. DWNP training courses by international consultants

DWNP sponsor regular aquaculture training programs held at the Mmadinare Hatchery. The course “Fisheries Management and Technology” is broad, covering all the basic elements of aquaculture. The course is attended by Fisheries staff and entrepreneurs interested in starting aquaculture businesses. There are at least 3 training workshops annually which groups of between 20-30 people attend. Government funding is made available for transport, food and training.

Figure 5. Botswana College of Agriculture recirculating tilapia system.
6.5.3. DWNP Aquaculture Literature
The Department has compiled several booklets on aquaculture including:

- Tilapia Farming Extension Manual. 102pp
- Catfish farming Extension Manual 111pp
- Twenty Common Questions on Aquaculture (7)
- Fish Farming Guidelines.

These booklets are however not generally available, and people looking for information need to come to the offices of the Department and make photocopies or receive printouts if they request them.

6.5.4. DWNP Website
Hosted within the website of the Ministry of Environment, Wildlife and Tourism, the DWNP features a page titled: “Aquaculture” (http://www.mewt.gov.bw/DWNP/article.php?id_mnu=199). The page is however predominantly about fisheries and there is but a paragraph on aquaculture. The website is underutilized and has the potential to provide much of the technical background needed by aspirant farmers, for example the Division’s aquaculture booklets. As requests from entrepreneurs seeking information on aquaculture take up a great deal of time, web based information could relieve much of this burden. The website could also link to other relevant government websites; funding agencies and stakeholder institutions. There is a wealth of information on aquaculture in the region and links to valuable discussion groups like the Sustainable Aquaculture Research Networks in Sub Saharan Africa (SARNISSA) would link entrepreneurs to the broader sector.

Botswana has had ADSL in the country since 2006. Although there were only 120,000 official users in 2009 (http://www.internetworldstats.com/af/bw.htm), Internet Cafes are however available in most urban centres. Upgrading the website would be a task for an expert in the field.

Strategic Diagnostic Analysis
A variety of technical material and educational resources are available in Botswana. However, there is a distinct lack of practical aquaculture experience in the country with few people ever having worked on a functioning commercial fish farm. This has resulted in a general perception that aquaculture is less technically difficult than it is in reality. Education is thus based on theoretical knowledge and there is an urgent need to expose DWNP fishery staff to commercial aquaculture experience.
7. Infrastructure

7.1. General infrastructure
Botswana possesses an adequate national infrastructure for aquaculture. It has a good transport and logistical infrastructure, telecommunications, and power generation networks. However, due to the large size of the country and the small population, this infrastructure is mostly limited to the urban areas and arteries linking urban areas, leaving much of the rural areas of the country under serviced. 60% of the population lives in urban or peri-urban areas.

7.2. Agricultural Infrastructure
The agricultural sector is well developed and the intensive agriculture sector provides infrastructure which could support aquaculture feed development. Commercial feed for agriculture is distributed throughout the country, particularly for the beef and broiler chicken industries. Raw ingredients for feed production are generally not produced in sufficient quantity in Botswana. Consequently, most ingredients and whole feeds are imported, primarily from South Africa. Industrial support capacity specific to aquaculture is limited and virtually all aquaculture supplies and ingredients need to be imported.

7.3. Aquaculture infrastructure

7.3.1. Mmadinare Hatchery
Mmadinare hatchery located next to the Letsibogo dam in the Selebi Phikwe region, was funded through the government’s National Development Plan 9 (Figure 4). Construction was initiated in 2006 and fingerling production commenced in 2007 with the final handover of the hatchery facility in 2009.

The rationale for establishing the hatchery was to provide fingerlings for the development of rural small scale aquaculture. The hatchery has the capacity to produce 500,000, 50g fingerlings of mixed catfish and tilapia per year. The fingerlings are sold for 50 thebe per piece and are transported by FD to the desired water body. Presently, the hatchery is operating well below its capacity as there is not yet a high demand for fingerlings. At present 60 broodstock of approximately 450g are being held. The broodstock are kept outdoors in the summer and are moved into the hatchery building in winter when the temperature drops.

The facility possesses an administrative centre with reception and offices, a hatchery building with a sophisticated temperature controlled recirculating biological filter, 5 broodstock ponds and 17 nursery ponds and 3 growout ponds (several of which are covered with plastic agricultural tunnels to regulate temperature). All the ponds are concrete lined and supplied with through-flowing water from the dam.
Figure 6. Mmadinare Hatchery at Letsibogo Dam (Selebi-Phikwe)
It is currently staffed by 9 DWNP employees including a groundsman and 2 security guards. Staff have the following responsibilities:

- Collecting broodstock from the dam
- Producing fingerlings
- Issuing fishing licenses
- Environmental monitoring of the dam and patrolling for poachers

The facility has several shortcomings in design and operation, is poorly maintained and is not able to completely fulfill its mandate. A visit to the facility was made on 31 January 2011, the observations made during that visit are attached as Appendix 5.

Strategic Diagnostic Summary
Botswana possesses an excellent general and agricultural infrastructure. The only established infrastructure for aquaculture is the Mmadinare Government hatchery which is currently poorly maintained and operating below capacity. Any new aquaculture business in a rural area would probably require considerable infrastructure installation.
8. Barriers to aquaculture development

The barriers to the development of any industry are a combination of physical conditions and the perceptions held by those involved in the development. The consultative stakeholder workshops were extremely useful in identifying these barriers and separating the one kind from the other. It was of benefit to the stakeholders and for aquaculture in general that the public and representatives from government could interact so that the various perceptions could be shared. The barriers identified by stakeholders and the solutions that were discussed informed the platform from which the development strategy could be launched.

8.1. A nonexistent aquaculture sector and necessary economies of scale

One of the more important issues which needs to be considered when considering the establishment of a commercial aquaculture business is the issue of scale. There is currently no commercial aquaculture in Botswana. Any start-up operation would not only need to develop a growout facility in the form of ponds, tanks or cages where the fish can be reared to harvestable size, but all other value chain components including:

- Seed in the form of quality fingerlings supplied by a hatchery.
- Feed of a sufficiently high quality to sustain optimal growth.
- Abattoir facilities where fish can be slaughtered.
- Processing and distribution of the product to market.

All of these elements would thus need to be financed by the first investor increasing the initial investment cost. In addition, the lack of an established service industry (e.g. fish health services, equipment) increases the transaction costs of the farmer who will need to import them at a premium. This means that any commercial aquaculture venture would need to be completely vertically integrated and large enough size to achieve an economy of scale. A general rule of thumb for a vertically integrated tilapia production facility is considered to be a minimum of 100 tons per annum but profitability increases with an increasing production volume. Development and initial running costs would be several million Pula.

A large scale commercial aquaculture project would be a means to overcome this initial barrier to entry and establish an aquaculture value chain in Botswana. This would open the way by which small farmers could find a niche as satellite farmers with growout being outsourced to them.

8.2. Technical skill and experience required for aquaculture

Compared to terrestrial livestock, fish are difficult to culture for a number of reasons:

- A knowledge of water chemistry and experience in water management is thus required. Fish secrete waste directly into their environment and are obliged to respire the same water. They can therefore easily succumb to toxic build-up of ammonia in the water.
- They cannot be easily observed as they live under water. Diseases and stress are only noticed once the fish start to die. Disease spreads quickly though the aquatic environment
and it is difficult to eradicate disease once it has occurred and if it grows beyond a certain point, complete destruction of the stock and dry-out of the ponds is required.
• They cannot be easily bred by farmers and seed generally needs to be brought into the farm from a dedicated hatchery.
• There is no culture of keeping or farming fish in Botswana.
• Species are essentially wild strains that have not been genetically improved unlike livestock which has been bred for thousands of years.
• Tilapia stunt and catfish tend to cannibalise their siblings.
• They need to be carefully handled and preferably not handled at all.
• They need to be graded regularly into different size classes to promote ideal growth.
• They have numerous predators from frogs to otters and are easy targets for theft.

Farming fish is a high intensity, high input, technically and time demanding pursuit which requires expensive start-up capital and long term commitment. This has generally not been understood by aspirant small scale fish farmers in Botswana.

8.3. Access to land and water
Many aspirant aquaculturists, both small scale and large scale commercial have found it difficult to acquire land for farming fish. Similarly, many aspirant farmers have also expressed frustration with the Water Utilities Corporation (WUC) that they cannot farm fish in dams close to urban centres which are close to the market.

Mechanisms to address this would be the establishment of dedicated aquaculture zones where land could be set aside for aquaculture in the warmer part of the country with access to sufficient water. These aquaculture zones would then be convenient for the establishment of basic infrastructure such as roads and electricity. It would make sense for aquaculture businesses to cluster within these zones so that they could benefit from common support systems (e.g. veterinary laboratories and extension services, abattoirs, processing, transportation, feed, etc.).

8.4. Misconceptions surrounding the viability of aquaculture
As described elsewhere, the conditions in Botswana for small scale commercial aquaculture are far below optimal. Despite this and the other challenges, aquaculture has been promoted as a viable and desirable activity for all comers. This has led to frustration and time wasting for small farmers and the Fisheries Division who spend considerable resources going through the motions of investigating aquaculture projects, only to be turned down by funding agencies on the basis of non-viable business plans.

This perception is promulgated internationally. The following quote appears in the document Doing Business In Botswana: A Country Commercial Guide for U.S. Published by the US Commercial Service in 2009:

“There is considerable potential for the development of entrepreneurial fish farming in Botswana”
The only viable small scale aquaculture in Botswana at this stage would be very low input stocking of existing dams used for irrigation of crops or watering of livestock. This is borne out by the success of the Fisheries Division’s efforts in stocking dams with fingerlings from Mmadinare Hatchery.

8.5. Inadequate market information
Commercial aquaculture needs accurate information regarding markets so that realistic business models can be prepared. At present, little is known about either local or regional markets. Adding to this lack of knowledge is the effect that regular supply would have on the development of a local market. An additional market dynamic which needs to be understood is the commoditisation of aquaculture products such as tilapia from China and *Pangasius* catfish from Vietnam which are readily available in Botswana. These products should be seen as the benchmark against which a Botswana produced aquaculture product would have to compete.

8.6. Government red tape
Potential commercial investors have expressed frustration that getting aquaculture operations going is hampered by government bureaucracy. This is mainly because government does not have a coherent aquaculture strategy and the various government departments needed for inputs into aquaculture projects do not have set protocols for dealing with applications. Particular frustration was expressed with the Water Utilities Corporation, which is allegedly unsupportive of attempts to approaches to develop aquaculture on or next to dams. A possible solution to this would be to create a single government contact point for aquaculture which could take up the responsibility of collecting the required documentation from the various departments. The agency would need a clear mandate that would have approval at the level of director general. A logical home for this would be within BEDIA who have coordinated stop investment for other sectors.

8.7. Lack of entrepreneurial skills
Many aspirant farmers have gone through an exhaustive and expensive process of drawing up business plans, applying for land and collecting technical information only to have their applications for loans denied from agencies such as CEDA. Often this is perceived as “jealousy” or someone within CEDA “stealing” their ideas. The simple fact around the matter is that CEDA and other agencies have been acting responsibly according to their mandate. Aquaculture projects are rightly refused on the basis of unsound business plans being submitted. One of the most sorely needed skills amongst aspirant farmers are sound business skills. Although support for this is available from LEA and CEDA, applicants need to be empowered to do the sums themselves and adapt their plans according to the feedback received from funding agencies. Instead of reworking the numbers, applicants often lose faith and give up. The essence of entrepreneurship is being flexible and never giving up.
Strategic Diagnostic Analysis

In order for the barriers preventing the development of aquaculture to be overcome a realistic assessment of aquaculture needs to be made and solutions found that suit the prevailing conditions.
9. Conclusion

The efforts of DWNP in stocking impoundments with hatchery produced fingerlings demonstrates that subsistence aquaculture is worthwhile activity that should be expanded.

Conditions for commercial aquaculture in Botswana are limited by biophysical and market constraints. Botswana is at a competitive disadvantage compared to neighbouring countries. The strategy of promoting SME aquaculture as a business opportunity for small farmers and entrepreneurs has not resulted in farmers becoming established, and should be reviewed. As an aquaculture value chain is not established in Botswana, a vertically integrated commercial operation of at 100t p.a. will be required to establish economically viable production. An enabling environment for investment into aquaculture is required which requires cooperation between government departments to provide the necessary incentives and services, particularly access to land and water.

An exciting new opportunity is the stocking of fish, such as tiger fish, in dams for recreational angling to attract tourism development.

Botswana possesses a well developed institutional environment which can be harnessed to promote the opportunities that aquaculture offers, but structures and processes to coordinate the contribution of various government departments will be required.
10. Draft Aquaculture Development Plan for Botswana

The draft aquaculture strategic plan for Botswana is presented below. It is divided according sectoral activity areas, visibly:

6) Subsistence Aquaculture

7) SME Aquaculture

8) Commercial Aquaculture

9) Aquaculture-based Recreational fishing and Tourism


The recommended Strategic and Operational Objectives for each section are classified under ‘Thematic Areas’ namely:-

- Institutional
- Research and Technology Transfer
- Production
- Training and Information Dissemination
- Markets
- Ecological

A recommended time frame is attached to each operational objective, namely, 1, 3, 5 and 10 years.
## 10.1. Subsistence Aquaculture Strategic Plan

<table>
<thead>
<tr>
<th>Strategic Objective</th>
<th>Key Issues</th>
<th>Operational Objective</th>
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<tbody>
<tr>
<td><strong>Thematic Area: Institutional</strong></td>
<td></td>
<td></td>
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<tr>
<td>Provide public sector support for subsistence aquaculture to promote food security</td>
<td>1.1 Subsistence aquaculture is a non-commercial activity which requires Government support</td>
<td>DWNP takes responsibility for subsistence aquaculture, stock enhancement and community extension services. DWNP provided with resources to expand dam stocking and community extension programme in support of poverty eradication and food production. (Year 1)</td>
</tr>
<tr>
<td><strong>Thematic Area: Research and Technology Transfer</strong></td>
<td></td>
<td></td>
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<tr>
<td>Improve technology for stock enhancement of dams</td>
<td>1.2 Live fish transport</td>
<td>DWNP acquires a live fish transport unit with oxygen (Year 1)</td>
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<tr>
<td><strong>Thematic Area: Production</strong></td>
<td></td>
<td></td>
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<tr>
<td>Provide sufficient fingerlings for stocking</td>
<td>1.3 Mmadinare hatchery is under resourced and requires maintenance</td>
<td>An operational and resource plan for DWNP Mmadinare hatchery to supply sufficient fingerlings (Year 1-2)</td>
</tr>
<tr>
<td><strong>Thematic Area: Training and Information Dissemination</strong></td>
<td></td>
<td></td>
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<tr>
<td>Provide extension support to communities</td>
<td>1.4 Communities require information on fish harvesting, handling, consumption, dam management</td>
<td>DWNP extends it extension capacity and supporting training materials</td>
</tr>
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### 10.2. SME Aquaculture Strategic Plan

<table>
<thead>
<tr>
<th>Thematic Area: Institutional and Organisational</th>
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<tbody>
<tr>
<td><strong>Strategic Objective</strong></td>
<td><strong>Key Issues</strong></td>
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</table>
| Government create an enabling environment for viable SME aquaculture | 2.1 SME under present circumstances is not economically viable as a stand-alone enterprise | 1. Government extend support from promotion and advice to on-farm research and pilot project promotion (Year 1)  
2. Government consider start-up capital grants and subsidies on supplies and services such as feed to support pioneer farmers |

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<tr>
<th>Thematic Area: Research and Technology Transfer</th>
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<tr>
<td>Benchmark technology required for SME aquaculture production systems</td>
<td>2.2 Economic feasibility</td>
</tr>
<tr>
<td>2.3 Pilot project on integrated aquaculture/agriculture system</td>
<td>Pilot project with existing small farmer close to DWNP offices. Benchmark production performance, input costs, etc. (Year 1-3)</td>
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<tr>
<th>Thematic Area: Production</th>
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<tbody>
<tr>
<td>Viable production models required</td>
<td>2.4 Integrated farming needs viability assessment</td>
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### 10.3. Commercial Aquaculture Strategic Plan

<table>
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<tr>
<th>Thematic Area: Institutional</th>
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<tbody>
<tr>
<td><strong>Strategic Objectives</strong></td>
</tr>
<tr>
<td><strong>Commercial Aquaculture (100t+ p.a.)</strong></td>
</tr>
<tr>
<td>3.2 Excessive red tape and lack of coordination between government departments constrains aquaculture project development</td>
</tr>
<tr>
<td>3.3 Prospective investors need to be informed of the opportunities provided by Botswana’s aquaculture development strategy</td>
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</table>

**Thematic Area 2: Research and Technology Transfer**

<table>
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<tr>
<th>Establish technology required for intensive aquaculture production systems</th>
<th>3.4 Economic feasibility of intensive systems unknown</th>
<th>Perform an economic feasibility study on the design of a minimum viable intensive aquaculture production unit for different production systems.</th>
</tr>
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<tbody>
<tr>
<td>3.4 Economic feasibility of intensive systems unknown</td>
<td>Perform an economic feasibility study on the design of a minimum viable intensive aquaculture production unit for different production systems.</td>
<td>Compare input production costs between Botswana and neighbouring countries to determine whether a comparative</td>
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### Thematic Area 5: Production

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<tr>
<td><strong>3.5</strong></td>
<td>Viability of cage culture on large dams unknown</td>
<td>Technical and economic feasibility study required on cage culture in large dams (e.g. dam carrying capacity, water quality impacts, production performance)</td>
</tr>
<tr>
<td><strong>3.6</strong></td>
<td>Establish an improved tilapia strain with competitive production traits</td>
<td>Import a disease free Nile tilapia strain for Mmadinare Hatchery (Year 2-3)</td>
</tr>
<tr>
<td><strong>3.7</strong></td>
<td>Water of 25-30°C required for competitive growth rates</td>
<td>Assess economic viability of tunnel systems (Year 1-3)</td>
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<td></td>
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<td>Identify sites with industrial waste heat that could be used to heat water (Year 1-5)</td>
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<td><strong>3.9</strong></td>
<td>All male tilapia required</td>
<td>Establish all male tilapia sex reversal technique at Mmadinare Hatchery (Year 1-2)</td>
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**10.4. Aquaculture Based Recreational Fishing and Tourism**

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<tr>
<th>Strategic Objective</th>
<th>Key Issues</th>
<th>Operational Objective</th>
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<tbody>
<tr>
<td><strong>Thematic Area: Institutional and Organisational</strong></td>
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<tr>
<td>Create an enabling institutional environment for tourism</td>
<td>4.1 Tigerfish and other sport fish offer an opportunity to establish recreational fishing and tourism facilities in Mmadinare</td>
<td>Conduct a financial, technical, and market feasibility study on establishing a (i) tiger fish and other recreational species population and (ii) tourism facilities on Mmadinare and other appropriate dams.</td>
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### 4. Aquaculture Development Strategy: Cross-cutting Issues

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<th>Thematic Area 1: Institutional</th>
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<tbody>
<tr>
<td><strong>Strategic Objective</strong></td>
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<tr>
<td>Establish an enabling environment for aquaculture in Botswana</td>
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</table>
Aquaculture mandate should be moved to Ministry of Agriculture. Year 1-3

Maintain effectiveness of ADSB. Year 1-5

**Thematic Area: Research and Technology Transfer**

| Undertake research and promote technology transfer to support the establishment of aquaculture in Botswana | 5.4 | Aquaculture research capacity is lacking | Establish an aquaculture research, training and project support hub at Mmadinare Hatchery
Perform benchmarking research on tunnel, cage and pond culture systems at Mmadinare Hatchery
Recruit an experienced aquaculture researcher to be based at Mmadinare Hatchery who will lead research and mentor staff |
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<tbody>
<tr>
<td>5.5</td>
<td>Information on performance of local tilapia species lacking</td>
<td>Undertake research on production performance and genetics of local tilapia species and hybrids</td>
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<tr>
<td>5.6</td>
<td>A facility for aquaculture research on Okavango and Zambezi system species is lacking</td>
<td>Cooperate with the Kamutjonga Inland Fisheries Research Institute in Namibia on aquaculture potential of Okavango aquaculture species such as three spot bream (<em>Oreochromis andersonii</em>) and red breast tilapia (<em>Tilapia rendalli</em>).</td>
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**Thematic Area: Training and Information Dissemination**
Provide education and training to support requirements of Aquaculture development in Botswana

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<th>Thematic Area: Markets</th>
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<tr>
<td><strong>Supply the Botswana market with locally produced fish</strong></td>
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<td>5.10</td>
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<td>5.11</td>
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<tr>
<td><strong>Supply regional market with Botswana</strong></td>
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<td>5.12</td>
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DWNP aquaculture staff require further education, training and experience in commercial aquaculture production techniques

Enroll at least one staff member for MSc level postgraduate training in aquaculture (Year 2-5)

Provide internships to all DWNP aquaculture staff on commercial aquaculture facilities in other countries (Year 2-5)

Communities require information on fish harvesting, handling, consumption, dam management

DWNP extends its extension capacity and supporting training materials (Year 1-3)

Media promotion of SME aquaculture not yielding desired outcomes

Reduce active media promotion of SME aquaculture to reduce demand on DWNP staff time from prospective SME farmers. Refocus on subsistence aquaculture promotion. Year 1.

Develop aquaculture information provision protocol which reduces demand on staff time. Year 1-2.

Improve aquaculture content of DWNP website. Year 1-2

Provide appropriate print matter on the basics of aquaculture. Year 1.
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA
Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

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<thead>
<tr>
<th>farmed fish</th>
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<th>products in the region</th>
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**Thematic Area: Ecological**

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<tr>
<th>5.1</th>
<th>National aquaculture zonation system</th>
<th>Map catchments which contain Nile tilapia and hybrids and those which have not yet been invaded.</th>
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<td></td>
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<td>Define catchment zones within which 1) stocking of dams and 2) intensive farming of Nile tilapia will be permitted</td>
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<td>Undertake a campaign to educate anglers on the effect of translocation of exotics and the zones where Nile tilapia can and cannot be distributed.</td>
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<th>5.2</th>
<th>Escape prevention</th>
<th>Intensive fish farms required to be designed to prevent escape of fish into natural water courses</th>
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<th>5.3</th>
<th>Live fish imports</th>
<th>Live fish imports to be undertaken under government supervision</th>
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<td></td>
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<td>Live fish imports to be certified disease free in country of origin</td>
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<td></td>
<td></td>
<td>Live fish imports to be quarantined according to FAO/ICES guidelines for introduction of exotic species</td>
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References


ALCOM 1996b. Aquaculture for local development and utilization of small water bodies in southern Africa. Joint evaluation by recipient countries, donor governments and FAO.


Feidi 2010. ‘Tilapia markets in the Middle East and North Africa: Demand trends and outlook’ Presentation at Third International technical and trade conference exposition in Tilapia, Kuala Lumpur October 2010; p.16


Fitzsimmons. 2011. Tilapia 2010 – Industry Continues to Grow in Importance Presentation, Kochi India, p.17


Josupeit (2010) World Supply and Demand of Tilapia (FAO); p.4


Mmadinare fish hatchery facility operators manual. Dept wildlife and National Parks. 38

Mmadinare fish hatchery facility water quality management manual.23

Mmadinare fish hatchery facility Fish Farm Management Manual. 110pp


Appendices

Appendix 1. Consultative workshop: Gaborone 24th March 2011: Programme; Attendance Register; Discussion.

<table>
<thead>
<tr>
<th>PROGRAMME</th>
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<tbody>
<tr>
<td>08h30 Registration</td>
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<tr>
<td>09h00 Opening prayer</td>
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<td>09h05 Introduction of Delegates/ Participants</td>
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<td>09h15 Welcome Remarks – MEWT/DWNP representative</td>
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<td>09h20 EU ACP 2 programme and workshop objectives – S. Nengu DWNP</td>
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<tr>
<td>09h30 Botswana Aquaculture Potential and Constraints – P. Britz SOGES</td>
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<td>10h15 Issues of clarity, general comments</td>
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<td>10h30 Tea</td>
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<td>11h00 Institutional/ Organisational Requirements for Sector Development – presentation P. Britz</td>
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<tr>
<td>11h30 General Discussion</td>
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<tr>
<td>13h00 Lunch</td>
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<td>14h00 Further discussion</td>
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<tr>
<td>15h00 Summary and way forward</td>
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<td>15h15 Closing remarks vote of thanks – MEWT/DWNP representative</td>
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<td>15h30 Tea</td>
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<tr>
<th>Attendance Register</th>
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Discussion of Botswana Aquaculture Potential and Constraints

Entrepreneur: Leatile Motshwane

Mr. Motshwane asked why Brussels has to have the final say over the project.

SOGES: Professor Peter Britz

Prof. Britz answered that the project proposal came from Botswana and Brussels is being guided by what Botswana wants, not the other way round.

Director of Fisheries in the DWNP: Shaft Nengu

Mr. Nengu responded that the EU is funding the project. They are interested in making sure that the product is of a sufficient quality. If Botswana does not agree that the product is of a certain quality, the EU would not accept it.

Fish farmer in Mogotsane: Richard Moleofe

Mr Moleofe suggested that regarding the constraints of the country [size] that the most important thing was to place aquaculture projects in clusters. An example of this was the way ostrich farming was clustered in Outshoorn in South Africa. A good example in Botswana was the Ghantzi cluster beef farming cluster. It is successful because services can be delivered efficiently. He suggested that SOGES consider this in their report.

SOGES: Professor Peter Britz

Prof Britz responded that this was an excellent suggestion and has been applied in many countries. Clusters could be helped by government in the form of infrastructure (such as roads or water supplies) and other synergies. The concept of aquaculture parks or clusters occurs worldwide. In Australia and Chile for example the concept of “joint actions” was promoted. This was when 3-4 farms joined together, they could achieve a critical mass which attracted help from government.

The Mirror newspaper: Kelebogile Bale

Ms Bale said that the policy of the land Board was that one person could own plots of a maximum of 5ha. Catfish are large fish and so 5ha would not enough to farm them.
SOGES: Professor Peter Britz

Prof Britz responded that fish did not necessarily need a lot of water and that anyway, larger ponds tend to evaporate too much. Catfish did not need much oxygen in the water to grow because they were air breathers anyway. In Vietnam catfish are grown at 350–400tons /ha. Catfish were therefore a good fish for farming in small areas. It was rather the marketing side of catfish that was the problem, not the technical side, although there is a potential market for catfish amongst African immigrants he said. Government had a responsibility to guide people and provide information regarding marketing and economics as there was insufficient information for aquaculture farmers.

Ministry of Agriculture: Mr Malaki Bowane

Mr Bowane asked whether there were breeding stock centres in the country and who owned them.

SOGES: Professor Peter Britz

Prof Britz replied that the hatchery at Mmadinare was functioning and fish were available from there for stocking.

Ministry of Agriculture: Mr Malaki Bowane

Mr Bowane further asked how water was warmed to cope with winter temperatures.

SOGES: Professor Peter Britz

Prof Britz responded that if fish ponds are placed under vegetable growing tunnels, the temperature could be raised by about 5°C. He warned however that the extra cost of the infrastructure would be a large investment and would need to be accounted for when doing the business plan. The extra starting cost would of course mean that the farmer would start from a position of competitive disadvantage.

Ministry of Agriculture: Mr Malaki Bowane

Mr Bowane then posed the question whether, besides bream and tilapia, which other species would be suitable for aquaculture and why Botswana was limited to local species.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu replied that the best species to farm with was Oreochromis niloticus and that the species had been recorded in the Limpopo river system. Farming them in the SE of the country would not be a problem, but that it would be a problem if the fish were introduced to the North of the country.

SOGES: Professor Peter Britz

Prof Britz agreed that the government was worried about niloticus interbreeding with fish in the Okavango. He added that other species to consider were ornamental fish with most species being imported from Asia but warned that it was a specialist enterprise. Carp were not good from a
marketing perspective due to their many small bones and so the opportunities were really limited to the various bream species and catfish.

**LEA: Kereemang Moilwa**

Mr Moilwa asked whether small enterprise developmental aquaculture projects were non starters in Botswana.

**SOGES: Professor Peter Britz**

Prof Britz replied that starting a small scale enterprises as standalone businesses would indeed be very difficult if they received no additional support. This was because all aspects of the business would need to be sponsored by the entrepreneur. To overcome this and make small businesses viable, the sector needed to get creative. One example of enabling effective small scale enterprise was satellite farmers in South Africa. In this example, the main commercial enterprise was encouraged (via government incentives) to outsource the growing phase of the fish to small farmers. The small farmers got their fingerlings and feed from the commercial enterprise and sold their produce back to them for processing and marketing. This was particularly effective for trout where the small farmers owned most of the water.

He added that government demonstration projects had not worked in the past as government did not do business well. The experience in Africa was that none of the government hatcheries had been successful and that it was too much to expect a small scale farmer to take on farming themselves and that a commercial scale project was needed to kick off the industry in Botswana.

**LEA: Kereemang Moilwa**

Mr Moilwa then asked what the difference was between aquaculture and fishing.

**SOGES: Professor Peter Britz**

Prof Britz responded that there were numerous differences between aquaculture and fishing, including:

- fishing required a very small investment compared to aquaculture
- the issues that needed to be dealt with were different: for eg the sustainability and management of the wild stock needed to be considered in fishing
- a different skills set was needed – aquaculture needed real entrepreneurs
- aquaculture needed a more coordinated approach than fishing

Aquaculture was therefore not a replacement for fisheries and it was a mistake to encourage fishermen to go into fish farming. It would be more applicable for farmers to turn to agriculture than aquaculture because it was so much easier. The only real potential for crossover would be the fishing of dams that would then be regularly restocked because the input costs (and thus the risks)
would be low. This as opposed to intensive fish farming where low temperature and poor genetic strains would be difficult to compensate for.

LEA: Kereemang Moilwa

Mr Moilwa then posed the question whether the low water temperatures and lack of water made aquaculture non-viable in the Southern part of the country.

Agribusiness: Malaki Bowane

Mr Bowane asked whether there were interventions to align policies to cater for aspirant farmers and whether they could be accommodated around the dams on small plots. If so, he suggested that the development of pilot projects should not only focus on government run initiatives but that farmers should create partnerships between one another and then apply to government for finance and subsidies.

Fisherman at Gaborone Dam: Isaac Sebekedi

Mr Sebekedi stated that there was a shortage of land in Gaborone and that it was hard to come by. He asked whether government could assist fishermen with equipment and land to start cage farming in the dam.

Director of Fisheries in the DWNP: Shaft Nengu

At this point Mr Nengu reminded the room that the purpose of the session was to provide inputs toward the development of policy, not a question and answer session.

Former Director of Fisheries: Trevor Mmopelwa

Mr Mmopelwa answered that cage farming was not easy, it required capital input and high operational costs. Feed was expensive and needed to be continuously supplied because caged fish could not forage. He added that water in the dams was used for municipal supply and that farming in the dam would increase the cost of processing the water for municipal supply.

He further commented that the strategy for aquaculture development needed to alter according to the scale at which it is undertaken, viz:

For small scale farming it would be preferable to promote very low intensity projects. These projects should be in backyard ponds which could be stocked with sex reversed fish from Mmadinare hatchery to support subsistence of families. The issue of temperature in small dams could be circumvented by using what the government had achieved at the Mmadinare hatchery. The facility should be able to grow sex reversed fish to 20-30g by April-July. By stocking these fish in July, they could be overwintered and when temperatures rose, farmers could get 8 months of growth until harvest in March-February.

The stocking of stock watering dams with mixed sex fish from Mmadinare, which could use the existing habitat and enable sport fishing.
Commercial scale projects should be developed (such as the Pandamatenga example)

TAHAL: Julian Van Der Nat

Mr Van Der Nat noted that the one thing that needed to be well understood was the market. If there was no market, an industry could not be started. People could be good farmers but if they couldn’t market their product they just couldn’t turn that into success.

Mr Van Der Nat then related his experience how the Fresh Goods Market helped tomato farmers to establish themselves in the Gaborone area. The history was that farmers would sometimes spend the whole day with a full bakkie load of tomatoes, driving around the city from supermarket to supermarket in an effort to sell their produce. By the end of the day the produce would be spoiled and they would have to sell their load at a much reduced price if they could sell it at all. Since the establishment of the fresh Goods market, farmers knew that they could drop their entire load in the morning and pick up their check in the afternoon after doing their business in town. This came at a cost (13%) of course but at least the farmer was guaranteed of selling and could turn their attention to what they did best: farming. Aquaculture policy should thus be market oriented before it was production oriented.

He then quoted the example in the USA where a successful marketing policy by government led to the popularisation of tilapia. Tilapia went from an unknown product to the 5th most consumed fish in the USA, thus spawning a very successful industry.

He further commented that aquaculture had a distinct advantage over wild caught fish in the marketplace for several reasons:

- Regularity of supply and price
- Sustainability
- Traceability

He told the gathering that in Europe, standards were set by supermarkets not governments and that quality and regular supply were what the lodge owners and supermarkets wanted.

He added that fish were not eaten here because people don’t know how to prepare it. And that assumptions about fish consumption could not be made because there was no regular supply.

He also supported cluster development and endorsed the establishment of outsourced satellite farmers. This could be done in conjunction with the development of processing facilities. He used the example of the three streams trout smoking facility which had very successfully created a market which had in turn supported many small growers. A similar initiative was required for catfish in Botswana. He suggested that there are markets everywhere but that government needed to sponsor their development.
<table>
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<tr>
<th><strong>DABP Agriculture: Malaki Bowane</strong></th>
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<tr>
<td>Mr Bowane supported the establishment of multiplication units in various areas of the country. He pointed out that there needed to be better transfer of technology.</td>
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<th><strong>Entrepreneur: Leatile Motshwane</strong></th>
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<tr>
<td>Mr Leatile made the suggestion that the sector should be grown in a multidimensional way and should include such things as catfish; soil farming; water farming, aquaponics and crocodiles.</td>
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<th><strong>Masunyama Investment: Dr Innocent Botshelo</strong></th>
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<tr>
<td>Dr Botshelo made the following comments:</td>
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<td>- Water management was important for aquaculture.</td>
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<td>- Fish feed should not be as expensive as it was because of the availability of agricultural byproducts.</td>
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<td>- Knowledge and skills training is needed and an information base was required.</td>
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<td>- Technical and scientific extension was needed.</td>
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<td>- The sector should be built on people with a diversity of skills: marketing, processing and growing for example</td>
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<td>- Possible by-products from fish should be considered</td>
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<td>- Fisheries policy did not mention anything about GM feeds or species</td>
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<th><strong>SOGES: Professor Peter Britz</strong></th>
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<tr>
<td>Prof Britz responded to the question of GM feeds by stating that GM was being supplied to the market on a massive scale, that GM products were a reality and were probably here to stay. He related that in his experience, it was almost impossible to find out whether feed ingredients were GM or not. In industry terms Southern Africa were very small players and did not have the clout to demand transparency from suppliers.</td>
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<td>He continued that it was much more important to focus on the genetics of the fish because that we could control. He warned that extreme care should be taken to prevent the uncontrolled introduction of <em>niloticus</em> despite its being a very good aquaculture species. He related that <em>niloticus</em> has destroyed the natural ecology of rivers and dams throughout Zimbabwe as a result of anglers transferring it. He urged that the Okavango in particular must be protected.</td>
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<tr>
<td>He did however agree that fish that grew quickly and that were genetically selected for growth were much needed. Local species such as the 3 spot bream (<em>Oreochromis andersonii</em>) as an aquaculture species had potential for improvement. With genetic selection programs it was possible to make 20% gains in growth per generation but species development required research and suggested that...</td>
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</table>
that must come from government. He told stakeholders about the possible *niloticus-andersonii-mossambicus* hybrid in Mmadinare dam. The hybrid was probably selected for survival but the hatchery facility could be used to improve the hybrid for growth.

**Discussion of Organisational Requirements For Sector Development**

**Entrepreneur Leatile Motshwane**

Mr Motshwane asked whether the DWNP were looking at aquaculture as farming fish only or as a whole industry.

**Madinonyane Fish & bird Farm: Richard Moloefe**

Mr Moloefe asked what the department was doing to support associations.

**Marketing and Acquisitions DEPT Agriculture: D Matoto**

Mr Matoto asked how M&A could get to know about fish so they could develop a market. He further related that the Ministry of Agriculture was introducing backyard gardening to try to eradicate poverty. Within this initiative, people were encouraged to establish fish ponds in their backyards. He believed that this would introduce people to fish eating. The water from the backyard ponds could be used for fish first and then gardening.

**BOPA (Botswana Press Agency): Omphile Ntakhwana**

Mr Ntakhwana suggested that linking government departments was important. He also pointed out that whereas loans were available, land was a problem. He was very unhappy that the Land Board was not present.

**Unidentified contributor**

Ms X expressed her support for the commercial approach. She added that people would need to start with subsistence aquaculture until commercial structures came about. Only if land were identified close to water bodies where clusters could be established could there be some possibility for development beyond subsistence.

**Water Utilities: Mr Jonathan Baumake**

Mr Baumake suggested that BEDIA [The Botswana Export Development and Investment Authority] might be the organisation to promote a one stop shop as they were already doing this for other businesses. He suggested that DWNP approach BEDIA about this.

**Former director of DWNP: Trevor Mmopelwa**

Mr Mmopelwa questioned the assertion that Batswana were not a nation of fish eaters considering that Botswana imported 4-5 million Pula worth of fish per year. He suggested that if a product were
available, the community would consume it as happened with pane worm in the NE of the country. He endorsed backyard ponds and associations. He referred to the example of game farming; that it was very loose when it started but that farmers grouped together and thereby made progress; managing to achieve such advances as export waivers for their product. He further expressed support for an aquaculture association and gatherings such as the present workshop so that information could be exchanged.

**TAHAL: Julian Van Der Nat**

Mr Van der Nat commented that 2000 tons of fish per annum was not a small amount of fish. He further said that Botswana was lagging behind the rest of the world when it came to understanding the health benefits of fish but that this was changing. He supported the idea that availability would stimulate demand, especially if there was some value adding to the product. Mr Van Der Nat had witnessed tests done in Soweto [South Africa] where fish was also not traditionally eaten. When fish was offered by lunchtime street hawkers on a regular basis, local people started buying it. He also suggested looking at the Botswana Horticultural Council as an example of a farmers market that could be used to promote aquaculture products.

**Entrepreneur: Khruschen Sebolao**

Mr Sebolao suggested that fish feed needed to be produced locally or it would be too expensive for small producers to purchase.

**Madinonyane Fish & bird Farm: Richard Moloefe**

Mr Moloefe told the forum that he was working with National Food Technology Research Centre (NFTRC or NAFTEC) in Khanye to develop pet food production in Botswana and that by the end of 2011 they would have the necessary capacity to go into production. Mr Moloefe said that they had considered producing fish feed but decided to go for pet food instead because of the profit margin. He would however consider fish feed if there was a demand, although he would need more technical information as they had no idea how to go about its production.

**DABP Agriculture; Malaki Bowane**

Mr Bowane related that the department had registered two fishing associations and would like to expand this into establishing fish farming associations, but that they did not know enough about fish farming to do it. Mr Bowane committed his department to going the extra mile to provide capital or equipment in conjunction with banks or funding agencies for aquaculture associations.

**Director fisheries DWNP: Mr Shaft Nengu**

Mr Nengu stated that there was no point in discussing feed production or farmers associations without first having farmers. Farming needed to be established first. But even though the mandate of the department was to establish fish farming, entrepreneurs chose what they wanted to farm.
SOGES: Peter Britz

Prof Britz conceded that feed was indeed one of the many challenges facing aquaculture. Although there was an availability of byproducts in the country, a certain amount of fishmeal was always required in fish feed because of the essential amino acids that it contained. This made fish feed expensive. He therefore recommended that fish farmers in Botswana choose herbivorous species that required less than 5% fishmeal in their diet. He also suggested that whereas there was feed manufacturing capacity in the country, producing the necessary volumes could pose problems: the minimum quantity of feed required to make an investment in infrastructure was a minimum of 10 tons a year. It would thus be best, he continued, that feed factories continue producing a variety of feed until such time as there were a large enough market.

SOGES: Peter Britz

Prof Britz made the following summary points:

Government was well equipped to develop aquaculture
- There was a need for cooperative governance
- There was a need to link government and private sector
- BIDEA could be the contact point and provide information
- There was general agreement regarding the need for associations and that these associations could define the needs of their beneficiaries through successful lobbying.
- Consumption habits could change; there was scope for growth and there was no reason why fish eating could not increase, particularly amongst urban black communities.
- Aquaculture could produce a better quality product than fisheries.

He then handed back to the chair.

Madinonyane Fish & bird Farm: Richard Moloefe

Mr Moleofe related that the morning’s discussion played out over lunch: he (like many others) was looking for fish on the buffet table, but it didn’t look good – it was covered in too much batter and looked like “vetkoek”. He concluded that in Botswana, there was still much to learn in the preparation of fish. This was loudly echoed by the delegates and there were comments from the floor that people used a lot of batter with fish in order to make more profit.
Mmasenyetse Community Dam Committee Member: Lanki Kefetole

Ms Kefetole relayed her community’s experience at the dam where there were large fish kills. She wanted to know whether it was a disease that caused it and wanted to know more about fish diseases in general.

SOGES: Peter Britz

Prof Britz determined that the fish died over winter and suggested that the death was therefore probably not due to disease, but was rather a natural phenomenon as fish died in low temperatures because they got stressed and starved. He reassured Ms Kefetole that the fish population would bounce back in the summer. He suggested harvesting most of the fish at the end of summer to make best use of the resource before winter mortalities took their toll and to reduce competition during the colder months allowing the fish to recover quickly the next year.

Masunyama Investment: Mr Innocent Botshelo

Mr Botshelo Fish farmers in the country need a contact number for a vet that specialises in fish diseases.

SOGES: Professor Peter Britz

Prof. Britz advised that disease was prevented by good management. He also shared that World Organisation For Animal Health (OIE) were paying for vets to be internationally trained so capacity in the region would improve.

Entrepreneur: Mr Leatile Motshwane

Mr Motshwane suggested that it was advisable to know about the fish that are farmed before farming them.

Former Director of Fisheries: Trevor Mmopelwa

Mr Mopelwa advised that in order to prevent disease you need to limit stress and that there were no qualified fish vets in the country.

WUC: Mr Jonathan Baumake

Mr Baumake asked whether mercury could accumulate in small freshwater fish to the same extent that it could in large marine predators.

SOGES: Professor Peter Britz

Prof Britz answered that it could and suggested that government conduct a baseline study for heavy metals in fish in urban areas before they were allowed to be farmed.
LEA: Mr Moilwa

Mr Moilwa pointed out that there was a lot of sewage water around the town and that people were fishing from that water, especially where it entered the Motwane river. He asked whether the fish were safe to eat and whether it would be viable to develop farms along the river to take advantage of the nutrients.

Fisherman Gaborone Dam: Isaac Sebekedi

Mr Sebekedi asked whether it were healthy to eat fish caught from the sewage works.

Echo: Lenah Bogwasi

Mr Bogwasi echoed the question.

Madinonyane Fish & bird Farm: Richard Moloefe

Mr Moleofe asked the WUC to explain their policies in this regard. He said that people in Ramotswa were being allowed to use sewage contaminated well water, while dams were being fenced to prevent cattle from contaminating them. Why would WUC go to the huge expense of fencing dams against cattle when Batswana have been sharing water with cattle for generations he asked.

WUC: Mr Baumake

Mr Baumake explained that the only dam totally fenced was the Gaborone Dam. He explained that fences were a preventative measure to reduce treating the water against algal contamination. The cost of treatment was much higher than the cost of fencing. He added that there was a lot of pressure on local water resources and water utilities were looking at all sources to satisfy demand, including the Ramotswa wellfields. He added that there were human health issues regarding fish grown in sewage water and that it was too much of a risk to eat them.

Former Director of Fisheries: Trevor Mmopelwa

Mr Mmopelwa related that in the East, people used night soil to fertilise fish ponds and that raw sewage was used for feeding fish directly.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu wished to address the issue of research and that his department had very limited manpower to conduct what was needed. He asked for help from academic institutions like UBOTS. He suggested that issues like species selection be left to the academics.

SOGES: Professor Peter Britz

Prof Britz stated that research was one of the things needed to promote aquaculture in Botswana, and that a good development pathway would facilitate government funding. He suggested that inputs be matched with outcomes.
Mmasengetse: Lankie Kefetole

Ms. Kefetole expressed her wish to link up with others in the business so she could start farming.

Fisherman on Gaborone Dam: Mr Keodirets Bamotoga

Mr Bamotoga told the workshop that medium sized bream sold at P10. He said that the main problem was access to water at the dam and asked whether there was a possibility that cage farming be allowed in the dam.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu said that Water Utilities was currently assessing water the usage of all the dams in Botswana and suggested that the question of using Gaborone Dam for fish farming be addressed by the consultants working on the project.

Former Director of Fisheries: Trevor Mmopelwa

Mr Mmapulwa suggested that focus should not be limited to the cities where issues of water were complicated. The priority of Water Utilities was to provide clean water for municipal use and alternatives would be preferable. He went on to say that there was plenty of water sitting for many months of the year in stock watering reservoirs and should be used for farming fish. He also warned that the pumping of underground water for fish farming was expensive.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu said that it was a myth that fish could not be farmed in a desert. He related his experience of Israel where he saw very successful aquaculture being done in similar conditions to those found in Botswana. It was merely a question of having the right technology and of piping water from where it was available to where it was needed.

Madinonyane Fish & bird Farm: Richard Moloefe

Mr Moleoefe suggested that aquaculture in Botswana needed a country to benchmark against in the same way that the beef industry in the country benchmarked with Argentina’s.

Former Director of Fisheries: Trevor Mmopelwa

Mr Mmopelwa suggested that all existing water infrastructure needed to be investigated and used if appropriate, even such things as the 6-7m3 watering holes at cattle posts.

SOGES: Prof Peter Britz

Prof Britz summarised the days discussion as follows:
He sincerely thanked everyone for their attendance and input. He felt it was truly representative and reflected well on the country's will to develop the new enterprise. He encouragingly added that if everyone carries on like this that they were bound to succeed.

He pointed to opportunities for the utilising of waste heat from industry. That it was possible when designing water cooling systems to incorporate aquaculture facilities.

That the water shortage in the country actually represented an opportunity because water was being stored and moved around and this created opportunities for aquaculture.

That research was required, particularly into market opportunities.

That the meeting showed the strength of the institutions in Botswana and that these institutions created growth opportunities.

And that public-private cooperation was essential.

He finally reassured the stakeholders that the experts representing SOGES and the ACP Fish II program would take the inputs offered in this workshop and formulate it into a workable plan.

He then handed the conclusion of the workshop over to Mr Nengu, who in turn requested Mr Mmopelwa to make the concluding remarks.

Former Director of Fisheries: Trevor Mmopelwa

Mr Mmopelwa started his conclusion of the workshop by relating his experience of being involved in aquaculture in Botswana over many years: government’s involvement in aquaculture started in 1984. Since then there had been significant interest but none of that interest had resulted in production. The challenge to the ACP Fish II project was to address this. He said that if just one entrepreneur could start production, it would act as an example that others could follow.

He continued by reminding us that fish and fishing was done by the poorest people in the world so what we were talking about could make a real impact on people’s lives – people who really needed it.

The technology for diversification was abundant but the question was how to convert this into reality. He related that he is a firm believer that there was room and potential for fish and that we could turn things around. Batswana were not a fish eating nation because they did not have the water natural water bodies. However fish eating was common in those areas where these water bodies existed – around the Okavango and the Chobe. He added that fish eating was developing around the world.

He reinforced that effort must be made where it was applicable, that all institutions should cooperate and that partnerships were vital. That the link to agriculture must not be lost and that efforts must be integrated with tourism.

Finally he thanked the consultants, wished them good travel further and expressed the hope that they produce a good document that could take aquaculture to its full potential in Botswana.
Appendix 2. Consultative workshop: Francistown 29th March 2011: Programme; Attendance Register; Discussion

Department of Wildlife and National Parks - ACP FISH II Programme

AQUACULTURE DEVELOPMENT STRATEGY for BOTSWANA (ADSB)

CONSULTATIVE WORKSHOP

PROGRAMME

Cresta Thapama Hotel, Francistown, 29 March 2011

08h30 Registration

09h00 Opening prayer

09h05 Introduction of Delegates/ Participants

09h15 Welcome Remarks – MEWT/DWNP representative

09h20 EU ACP 2 programme and workshop objectives – Mr Shaft Nengu DWNP

09h30 Botswana Aquaculture Potential and Constraints – Prof. Peter Britz SOGES

10h15 Issues of clarity, general comments

10h30 Tea

11h00 Institutional/ Organisational Requirements for Sector Development – presentation by Peter Britz

11h30 General Discussion

13h00 Lunch

14h00 Further discussion

15h00 Summary and way forward

15h15 Closing remarks, vote of thanks
# Attendance register Francistown Stakeholder workshop

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<td>Self</td>
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<td>Tamajasi</td>
<td>CTO</td>
<td><a href="mailto:ptamajazi@gov.bw">ptamajazi@gov.bw</a></td>
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ACP Fish II Aquaculture Development Strategy For Botswana

Consultative workshop Francistown 29th March 2011

Discussion of Botswana Aquaculture Potential and Constraints

DWNP Stephen Sekhutu

Mr Sekhite welcomed us all to the discussion and reminded delegates of the potential that aquaculture holds for poverty alleviation in Botswana. Despite shortages of water, fish could be farmed in small ponds and tanks. He expressed his hope that the workshop would enable delegates to share their experiences so that farming could be promoted. He further called on all to use our resourcefulness to achieve results. He wished us a pleasant and fruitful discussion.

CTO: Palalani Tamajasi

Mr Tamajasi shared that he wanted to go into small scale fish farming. He asked how much land was needed and how that could be calculated using stocking density.

SOGES: Professor Peter Britz

Prof Britz replied that 1ton of fish could be produced from a 1ha pond per year. In tanks, annual fish production in 1m³ could be 20-30kg.

Fishnet Botswana: Nshomali Malapeng

Mr. Malapeng asked how big a medium sized farm was. He also asked about tank farming, ponds and ways to increase the capacity of a pond and increase stocking density. He asked this because there were constraints on land.

SOGES: Professor Peter Britz

Prof Britz replied that for a standalone medium sized enterprise to be successful, it must be able to market 200-300 tons.

Small scale enterprise at the local village level must keep costs down in order to be economical, pond capacity can be enhanced by adding manure as fertilizer.
Oxygen is the major factor limiting stocking density. Paddlewheels used to oxygenate water can increase stocking densities 3 fold. There was of course extra cost involved and an electrical supply was required. These extra costs would need to be covered in the business plan. Catfish can breathe air and can be stocked at 500kg in 1m3 tanks. The problem with catfish is market.

Osenotse Stampana

Ms Stampana suggested the establishment of syndicates or clubs to boost aquaculture like those that have worked for cattle farmers. She also asked whether the College of Agriculture trained people in aquaculture?

SOGES: Professor Peter Britz

Prof Britz agreed that syndicates are a very good idea. If government could facilitate land, feed and seed in one place, it would give a boost to small farmers. He gave the example of satellite farmers producing trout and mussels in South Africa where commercial farmers could produce enough product. the original commercial farmer has evolved into the processor and helps the satellite farmer to produce. Satellite farmers now own their own mussel rafts. Small farmers don’t have the resources to put together all these things by themselves. He also mentioned that unless there was existing water aquaculture was a non starter so clustering in suitable areas was the answer.

He further said that the College of Agriculture offered a 4 months course in aquaculture but that the staff there did not have enough experience and needed an internship at a commercial farm.

Jackalas No2 VDC: Maolosi Letsogile

Mr Letsogile asked how long a fish lasted once it has been frozen.

SOGES: Professor Peter Britz

Prof Britz answered that fish can be frozen for about 3 months; thereafter product quality goes down. He went on to say that fresh fish is better quality than frozen and that restaurants preferred to cook fresh product. Locally produced fresh fish would outcompete an imported frozen product, even in SA where the market usually prefers marine fish. He added that this needed to be considered when planning aquaculture strategies.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu agreed that freezing is an important element to fish farming and that water quality in ponds was vital.

DWNP: Stephen Sekhutu

Mr Sekhutu asked about the cost of paddlewheels. Prof Britz replied: about P1000 each.

Entrepreneur: Masego Rantsudu
Mr Rantsudu mentioned that funding agencies such as CEDA should always be present at forums such as this.

Montshwari Molefe, DWNP

Mr Molefe confirmed that they had been invited to the workshop and Prof Britz confirmed that they had been invited to the workshop in Gaborone.

Entrepreneur: Ramatlotlo Keoagile

Mr Ramatlotlo asked what could be done as far as feeds were concerned to minimise costs. What were the failures were with aquaculture in Botswana and whether it were viable to farm fish in the country if people didn't eat them. He also asked about disposal of waste products and commented that education was key to aquaculture development.

SOGES: Professor Peter Britz

Prof Britz replied that fish feeds were expensive because they required fishmeal and the international demand for fishmeal was high. Feeds sold for P8-9/kg which was at least half of running cost. This cost could be reduced by reducing fishmeal in the diet. Vegetarian fish were therefore better to farm as they could grow on diets containing less than 5% fishmeal. High protein crops like soya needed to be grown and industry would need to set aside land for this. He added that feed was a volume business and that a production unit of at least 10 tons was needed to be economically viable. Aquaculture in Botswana would depend on imported feed in the beginning and the cost of this would need to be allowed for in the business plan.

Prof Britz said that there were a lot of reasons causing failure in aquaculture. This was primarily because the first commercial farm would need to do it all. In order to start a successful operation, industry would need to work with government.

He answered the question regarding market by saying that the problem with the local market for fish was one of availability; that with a regular supply, the market could be grown.

Aquaculture wastes could be buried, fed to pigs or reprocessed into feed for chickens or could be fed back to the fish.

Regarding education, Prof Britz recommended that fish should be sent to working commercial farms by government because real learning happened in reality.

Entrepreneur: Samson Manyathelo

Mr Manyathelo asked where he could get duckweed. He also asked about RAS (Recirculating Aquaculture Systems) because there was no water where he lived in Palapye.

SOGES: Professor Peter Britz
Pete Britz replied that duckweed could become a problem but that it was a high protein feed that fish could eat directly without requiring processing.

Oxygen levels required for RAS systems was 5mg/l but that bream were tough. Although RAS systems were a good idea in dry areas, but that a 10% exchange was still needed per day. RAS could also be used to control temperature, especially in covered ponds. He warned that implementing RAS implied extra cost and required management skills. He advised that one needed to ask the question whether the price would accommodate the investment.

**Entrepreneur: Rosemary Mukwewa**

Ms Mukwewa asked whether there were laws regarding disposal of fish waste?

**Director of Fisheries in the DWNP: Shaft Nengu**

Mr Nengu commented that in the Okavango, the FD taught people to bury fish byproducts in Okavango. He further commented that commercial scale waste could be fed to pigs but that it was not allowed to feed chicken waste to chickens and that it was therefore unlikely that fish would be allowed to be fed back to fish.

**Dept. Veterinary Services: Bernard Mbetha**

Mr Mbetha addressed the issue of disease: that not all diseases of fish will affect pigs. He said that disease was an important component of aquaculture and that it should be considered in any business plan, mainly to certify that the product was healthy. The OIE code existed for this purpose and that every farm needed a disease control and surveillance program.

**SOGES: Professor Peter Britz**

Prof Britz agreed that health management and disease control was vital, especially with high density farming. Veterinary services were required when operations became commercial. He warned that Government would not support individual farmers because it was a large commitment. Veterinary services did not mean just curing sick animals but was a commitment to ensuring fish health from “farm to fork”. He told the delegates about OIE in Gaborone and that Rhodes University was collaborating with OIE to train vets from the region. He explained that OIE was an organisation based in France where all listed diseases were registered in a central database. OIE was empowering African countries to export products to Europe.

**Entrepreneur: Rosemary Mukwewa**

Ms Mukwewa asked who paid for this?

**SOGES: Professor Peter Britz**

Prof Britz replied that this was a policy decision and varied between countries. In some countries, government would contract a private vet and his services would be shared between industry and
government. The OIE database was paid for internationally but certification would need to happen locally.

Entrepreneur: Alex Boxhall-Smith

Mr Boxhall-Smith expressed his appreciation for the forum and the opportunity to be heard. He then shared his experience of trying to start a pilot aquaculture project in Selebi Phikwe. Despite working with SPIDU (Selebi Phikwe) for the last 18 months with no result and no light at end of tunnel. He was finding the process extremely frustrating and an enormous waste of time. His primary frustration was with the amount of red tape that was needed and that it was a nightmare to get through.

He had already completed a business plan already, his funding was approved by BDC but the project was “hitting a brick wall”. The project needed water and land and both belonged to WUC who would not allow access to the dams. He claimed that the relevant government departments were not communicating with one another.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu replied that what Mr Boxhall-Smith was saying was true; that government policies were insufficient and that the departments were operating as independent entities and that too much red tape was hindering the vision of aquaculture. It took DWNP 10 years to get access to the dam for the hatchery and he was in Government! DWNP had to fight with WUC for the pipeline as well. He hoped that the strategy would highlight this and hopefully inform government.

LEA: Kabelo Nkwane

Mr Nkwane commented that this was not the correct forum for these issues and that a separate forum was needed to deal with institutional bottlenecks. He also said that the dissemination of information was very slow in Botswana. He said government needs to work hand in hand with an investor and be instrumental in establishing a [commercial] farm.

SOGES: Professor Peter Britz

Prof Britz responded that this was a common problem in Africa and that an appropriate forum was required that was driven by policy. In South Africa, aquaculture development zones have been established after many years of problems. He agreed that DWNP does not have political clout when working isolation.

DWNP: Choto Choto

Choto asked how cage farming operated.

SOGES: Professor Peter Britz
Prof Britz explained cage farming and said that there was a lot of it in China where it was being done very cheaply. The problem with cage farming in Botswana was temperature and the fact that pelleted feeds were required.

He described farming in 1m deep fertilised dams which in Botswana would have low production in winter. Tunnels could be used to warm the water.

DWNP: Choto Choto

Mr Choto asked about breeding fish in cages.

Prof Britz replied that fish are bred in a hatchery and stocked into the cages.

CTO: Palalani Tamajasi

Mr Tamajasi commented that the presentation was being pitched too high. He wanted technical information on smaller systems.

SOGES: Professor Peter Britz

Professor Britz replied that we were not yet ready for small farmers until the value chain was established and small farmers would be set up to fail if advised to go farming now. If farmers had existing water there was some possibility to make money but even building ponds was going to outweigh profit. He said that SME farmers were ahead of government. He said that a business plan had to be designed for at least 200 tons or it wouldn’t be viable and that government needed to back one project that would work. Until then he advised farmers to bring their expectations down and focus what can work because development finance would only put money into something viable.

Development finance and government will only put money into something viable. DWNP should model an incubator model whereby it was calculated how much it would cost to host 10 entrepreneurs in areas with water. If this feasibility showed the correct numbers it might be a model which government may be willing to adopt. In order for this to happen, an MOU with relevant departments was needed to break down bottlenecks. Mr Shaft Nengu agreed with this.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu commented that a 2 fish/m2 model was misleading as that was for very small scale. Commercial scale was more than 50 fish/m2 and that the water quality was more important than stocking density. He was convinced that Botswana could consume 15 tons a month of farmed fish or maybe even 25-40 tons. That the market was “there” but that the costs were enormous and needed a funded pilot project.

SOGES: Professor Peter Britz

Professor Britz agreed and said the fundamentals were there but asked how the small farmer could be accommodated. He again quoted the satellite farmer model and cited examples where it was working.
Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu said that the most commonly asked question was: “how much land do I need?” He answered that it depended on the culture systems and that most applicants had misconception about their expectations; that they expected it to be easy and expected to make money instantly.

Director of Fisheries in the DWNP: Shaft Nengu

Mr Nengu explained about Niloticus distribution and where it is possible to stock.

SOGES: Professor Peter Britz

Professor Britz thanked everyone for their input and their time. Stated that we had a responsibility to put a draft strategy together. That we would present and discuss with stakeholders. He reminded all that this was a Botswana based project and hopefully that the strategy could be sold to politicians at the validation workshop. He thanked the DWNP for facilitating the project and the meeting and that we needed partnerships to succeed.

Dr Mbetha closed the Workshop.
Appendix 3. Key informants that were consulted during the stakeholder consultation process

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<th>Consult. Date</th>
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<tr>
<td>25-Jan-11</td>
<td>Shaft Nnengu</td>
<td>Director Division Of Fisheries, Ministry Of Environment, Wildlife And Tourism</td>
<td>Gaborone</td>
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<tr>
<td>25-Jan-11</td>
<td>Nelson Nagasela</td>
<td>Deputy Director of Research and strategy, Ministry of Environment, Wildlife and Tourism</td>
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<tr>
<td>26-Jan-11</td>
<td>Vincent Vire</td>
<td>Economic attache, European delegation</td>
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<td>26-Jan-11</td>
<td>H. Nnyambe</td>
<td>Program Officer, Natural Resource Management, SADC</td>
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<td>26-Jan-11</td>
<td>Julian Van der Nat</td>
<td>Consultant, TAHAL Group Consulting Engineers,</td>
<td>Gaborone</td>
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<tr>
<td>27-Jan-11</td>
<td>Ulf Newmark</td>
<td>Managing director, Water Farming Botswana</td>
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<tr>
<td>28-Jan-11</td>
<td>Neil Fitt</td>
<td>Coordinator Agricultural Hub</td>
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<tr>
<td>31-Jan-11</td>
<td>Syria Molepo</td>
<td>Principle Technical Officer, Mmadinare Hatchery</td>
<td>Letsibogo Dam</td>
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<td>01-Feb-11</td>
<td>Various individuals</td>
<td>Dam Committee and Village Development Committee</td>
<td>Jackalas II Village, outside Francistown</td>
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<tr>
<td>02-Feb-11</td>
<td>Kaelo Nkile</td>
<td>Wildlife Biologist, Dept Wildlife and parks</td>
<td>Maun</td>
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<td>02-Feb-11</td>
<td>M.B. Othomile</td>
<td>Regional Wildlife Officer - Ngamiland</td>
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<td>02-Feb-11</td>
<td>Ketthatlogile Mosepele</td>
<td>Senior Research Scholar, Harry Oppenheimer Okavango Research Centre, University of Botswana</td>
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<td>03-Feb-11</td>
<td>O. Modiaemang</td>
<td>Technical Assistant, Ministry of Environment, Wildlife and Tourism</td>
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<td>03-Feb-11</td>
<td>Babontsheng Mokoba</td>
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<td>22-Mar-11</td>
<td>Edmond Moabe</td>
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<td>25-Mar-11</td>
<td>Neo Bagwase</td>
<td>Lecturer, Botswana College of Agriculture, Animal Science and Production</td>
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<td>29-Mar-11</td>
<td>Phin Mackenzie</td>
<td>Manager, Senn Foods</td>
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<td>04-Apr-11</td>
<td>Gordon O Brian</td>
<td>Researcher, University of Johannesburg</td>
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<td>26-Apr-11</td>
<td>Trevor Moelwa</td>
<td>Former Head of Fisheries Division, DWNP</td>
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<td>26-Apr-11</td>
<td>Goitseone Patrick Ramaloto</td>
<td>Selebi Phikwe Economic Diversification Unit</td>
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## AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA

Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

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<td>Other tunas, skipjack &amp; bonito n.e.s.</td>
<td>3,386,185</td>
<td>156,717</td>
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<tr>
<td></td>
<td>Mackerel in airtight containers, not frozen</td>
<td>1,287</td>
<td>73</td>
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<tr>
<td></td>
<td>Other mackerel not elsewhere specified</td>
<td>22,471</td>
<td>676</td>
</tr>
<tr>
<td></td>
<td>Prepared or preserved anchovies (excl. minced)</td>
<td>169,313</td>
<td>5,299</td>
</tr>
<tr>
<td></td>
<td>Prepared or preserved fish---other, frozen</td>
<td>1,268,357</td>
<td>53,951</td>
</tr>
<tr>
<td></td>
<td>Horse-mackerel (trachurus trachurus) in airtight metal containers not frozen</td>
<td>16,091</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td>Other anchovies n.e.s.</td>
<td>2,155,523</td>
<td>1,223</td>
</tr>
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<td></td>
<td>Fish paste</td>
<td>636,700</td>
<td>17,595</td>
</tr>
<tr>
<td>Product Description</td>
<td>Quantity 1</td>
<td>Quantity 2</td>
<td>Quantity 3</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Other sardines, mackerel and horse-mackerel, in airtight metal containers</td>
<td>9,321</td>
<td>929</td>
<td>194,733</td>
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<tr>
<td>Other prepared or preserved fish--- other, frozen</td>
<td>2,041,625</td>
<td>69,487</td>
<td>671,983</td>
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<tr>
<td>Other prepared or preserved fish--- other</td>
<td>3,504,653</td>
<td>187,339</td>
<td>3,737,694</td>
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<tr>
<td><strong>TOTALS</strong></td>
<td><strong>43,245,102</strong></td>
<td><strong>2,382,086</strong></td>
<td><strong>57,473,837</strong></td>
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Appendix 5. Observed shortcomings of Mmadinare Hatchery

An interview with the chief technical officer at Mmadinare on 31 January 2011 revealed a list of shortcomings that was affecting the hatchery’s efficiency:

- There was no accommodation at the facility for staff. Staff needed to commute from the nearest town. There was a single vehicle available which was used for both aquaculture and all other DWNP duties in the area. At the time of the visit, the vehicle was “boarded” (functionally obsolete) and staff were borrowing a vehicle from another department. Staff therefore often walked to work.
- There was a shortage of basic hatchery equipment such as scoop nets or a dissolved oxygen meter.
- A proper transportation tank was required for fingerlings. High mortalities were encountered when the current tank was used because of the long distances that needed to be covered.
- Staff were inadequately trained. They had undergone some training at the facility from a consultant but none had worked on a commercial fish farm or hatchery.
- Maintenance was inadequate: there seemed to be insufficient budget for maintenance and basic maintenance skills were unavailable. Maintenance has been attempted by the Department of Building and Engineering Services but had apparently been ineffectual.
- The fingerlings being produced were not being effectively sex reversed. Staff suspect that the feed did not contain the required hormone. The feed that was originally used (successfully) was bought from Aqua Nutro in South Africa. Subsequent payments to Aqua Nutro could not be affected because the company would not accept an order number in payment and government procedure dictated that purchases could only be made on order numbers. This forced DWNP to go through a local agent who would not reveal his source nor confirm the ingredients of the feed.
- Staff were unclear as to what the objective and strategy for the hatchery were.

Observations of the expert regarding the facility and its operations:

- The facility had been solidly built and was equipped with highly sophisticated systems. However, it was precisely the sophistication of these systems that contributed to the difficulties of keeping the infrastructure in good repair. Much of the technology employed was overdesigned and overspecified.
- Non-standard and oversized plumbing pipes and fittings had been used. It is generally good practice to design aquaculture systems in remote areas using standard sized construction grade plumbing which is readily available off the shelf (e.g. 50mm and 110mm piping where possible). Repairs to the plumbing were thus not being done because the fittings required were simply not available or prohibitively expensive. Many of the systems that had been installed were thus bypassed and there was a significant amount of water running to waste. As water for the hatchery was being purchased from the dam, leaks were contributing to running costs.
- The hatchery was fitted with super sophisticated equipment for filtration, heating, cooling and reticulation. All this equipment and all the systems installed were being bypassed at the time of the visit and the overwhelming majority of it was in poor repair due to lack of parts or technical skills to repair it.
- The systems had been designed to work automatically via electronic solenoid valves. None of these valves were working.
- The plastic on the agricultural tunnels was broken. The plastic was not replaced because staff on site did not have the technical skill or materials to repair it.
- There was no workshop or tools on the site and none of the staff had been trained in basic mechanical repair.
- The tilapia species being produced were a stunted hybrid of Niloticus x Mossambicus X Andersonii captured from the Lestibogo dam. The Nile tilapia had been stocked into the dam from Zimbabwe by naïve anglers (Ulf Nermark, Pers. Comm. April 2011). Although the strain is probably well adapted to surviving in the dam, it offers poor growth characteristics. The strain is also ecologically undesirable as it contains genetic material foreign to Botswana’s indigenous tilapia species (Tomschi et al 2009).
Appendix 6. Botswana College Of Agriculture, Department Of Animal Science And Production Aquaculture Course. Asb 429, Aquaculture- 2 Credits

Course Outline

The course is intended to enable students to be able to:

- Plan and set up fishponds
- Manage ponds and fish in ponds
- Harvest fish
- Preserve fish using different methods
- Describe fish diseases and plan for their prevention

Outline

Week 1  Introduction to aquaculture
Week 2  Fish anatomy and physiology
Week 3  Fish production systems
Week 4  Principles of pond construction
Weeks 5 - 6  Fish species for farming (Tilapia, Catfish & Carp)
Week 7  Test I
Week 8  Semester break / Visit to Fish hatchery (Mmadinare)
Week 9  Water quality in aquaculture
Week 10  Pond maintenance
Weeks 11-12  Fish health
Week 13  Harvesting and preservation of fish

Practical

Week 1  Gross anatomy of fish and Handling of fish
Week 2  Water quality assessment
AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA

Support for Devising of the Aquaculture Development Strategy for Botswana and the development of outlines for the Fisheries Management Plan of the Okavango Delta

Week 3  Cleaning BCA Aquaculture unit & counting fish
Weeks 4 - 5  Site planning and preparation
Week 6  Feeding fish, pond fertilization & weighing
Week 8  Semester break / Visit to Fish hatchery (Mmadinare)
Week 9  Visit- Fish Preservation and storage- Sea foods company, Gaborone
Week 10  Lab Test

Modes of assessment

- One theory test 20%, two unannounced quizzes 20%
- Lab test 20%, Term Paper 20%, Lab assignment & quiz 20%
- Examination at the end of the semester

Prescribed text

Appendix 7. Twenty Common Questions On Aquaculture. DWNP Fisheries Division Booklet

1. WHAT IS AQUACULTURE?

Aquaculture is the growing of aquatic organisms under controlled conditions. These aquatic organisms can either be plants or animals (that include fish).

Fish culture is the rational cultivation of fish in a confined water area where the practices of both crop and animal husbandry are applicable. Fish culture is therefore a branch of aquaculture.

Aquaculture and fish culture are different from capture fisheries. Aquatic organisms that are exploitable by the public are the harvests of “hunting and gathering” or fishing which is different from fish farming.

2. WHAT ADVANTAGES DOES FISH FARMING OFFER OVER OTHER AGRICULTURAL PRACTICES?

Fish culture can be practiced in land not suitable for other forms of agriculture e.g. marshy or swampy areas.

Fish convert feed consumed into their flesh better than any other land animal. For example the Food Conversion Ratio (FCR) for fish can be as low as 1.0 (i.e. one gram weight gain per gram of practical diet) while that of chicken, the most efficient warm blooded food animal would be twice as much.

One hectare of land can easily produce from 0.5 to 7 tons of fish. Crop or livestock production rarely reach these yield levels.

3. WHAT DO I NEED TO GROW FISH?

Basically a suitable site that would offer the following features;

- land that has a gentle slope (to fill and drain pond by gravity).
- adequate water of good quality.
- soils with adequate water holding capacity.
- near to the farm owner, close to social services (roads, electricity etc) and in proximity of sources of inputs.

4. HOW MUCH LAND AND WATER DO I NEED TO START A FISH FARM?

LAND. Most people ask for a 40m x 40m piece of land from the land boards and think it will be enough for a fish farm. This will only do for a family fishpond. For a semi intensive fish farm one
needs at least 3 hectares of pond area. Thus a larger area is required to accommodate other structures such as feed stores and market buildings.

WATER. It is generally believed that 20,000 m$^3$ of water per hectare per year is required to meet all evaporation and seepage losses, in order to raise a crop of fish.

5. HOW DO I KNOW IF WATER IS GOOD FOR FISH CULTURE?

The following parameters should be within the ranges indicated below:

- **Salinity**: average 2000 mg/l
- **pH**: 6.5 to 9
- **Alkalinity**: above 20 mg/l
- **Dissolved Oxygen (varies with temperature)**: at least 5 mg/l
- **Plankton turbidity (secchi disk reading)**: 0 to 45 cm

6. HOW DO I CONSTRUCT A FISH POND?

A pond is not just a hole dug in the ground. It is a carefully constructed structure for raising fish. The first crucial step in pond construction is selection of a suitable site, as outlined in “3” above. A pond should have the following features:

Dykes (banks or walls) built above ground for retaining water. Pond banks should be designed to have:

- A slope, gentler inside and steeper outside.
- An inlet to let the water into the pond.
- An outlet to let the water flow out of the pond.
- An overflow to let some of the water flow away in order to avoid it flowing over the banks.

The general procedure of constructing an earthen pond involves;

- clearing all vegetation and rocks from the area.
- removing the upper 20cm humus reach top soil and saving it somewhere.
- marking the outer and inner limits of the pond dykes.
- digging from the inner limits and using the soil to build the banks layer by layer and compacting tightly.
- shaping the slopes and adding the saved topsoil on the outer slopes to guard against erosion.

The average depth of a pond is 1 to 1.5 m on the deeper end (drain end) and 0.7 to 0.8 m at the shallow end (inlet side).

Pond sizes vary with the purpose for their use. Family ponds are usually 200 m² in area. For semicommercial ventures ponds need not be larger than 500 to 1000 m². It is advisable to construct a number of smaller ponds than a few large ones.

7. WHY SHOULD I FERTILIZE A FISH POND?

Soil fertilization is a practice intended to improve nutrient availability to plants in agricultural crop production. Similarly, pond fertilization is intended to stimulate plankton (microscopic plants and animals) growth, which is primary production supporting fish life. The importance of pond fertilization depends on the feeding regime. It may not be necessary to fertilize ponds when complete fish feed is provided, but natural food production usually supplements artificial feed provided by the farmer.

Both organic and inorganic fertilizers can be applied to a fish pond. Earthen ponds are best fertilized after draining or before pond filling. However, fertilization is often applied to filled ponds, including concrete ones which have the advantage of not having some nutrients (phosphates) locked up in pond mud. A compost crib is usually built at one shallow corner of a pond to continuously release nutrients to the water. Fertilized water should be retained long enough in a pond to reap the benefits of fertilization. A good measure of how much fertilizer to apply is the secchi disc reading.

8. WHAT FISH ARE SUITABLE FOR FARMING IN BOTSWANA

A good aquaculture species has the following characteristics:

- grows within the temperature range of the chosen location/site
- feeds low on the food chain. Primary production is the cheapest manufacture of “wild feed”
- tolerates water of poor quality, particularly low dissolved oxygen
- ability to reproduce in captivity
- resistance to handling stress
- fast growth rate
- accepted widely by consumers as food

Examples of fish fitting the above are: Bream (tilapias), Barbel (Catfishes) and Common Carp.

9. HOW MANY FISH SHOULD I STOCK IN A POND?
As in livestock farming, stocking density is a function of management. Stocking densities of up to 100 fish per m² are possible in raceway systems. In semi intensive pond systems 2 fish per m² is the usual recommended density.

10. **HOW DO I TELL MALES FROM FEMALES?**

No easy answer for this one. It varies with the fish species as differentiating males from females is easier with certain species than others. As expected the older the fish the easier it is to tell its sex.

Ability to tell males from females is important when it comes to breeding, but in the tilapias it is also important not to stock the two sexes together because the fish tends to reach sexual maturity much earlier than they reach market size.

The practice therefore is to stock only one sex, preferably males since they have been proven to grow faster.

Within the tilapias males can be distinguished from females because males have a single urogenital pore. Females have a reddish slit (oviduct) just behind the anus but in front of the urinary orifice.

In the catfishes males have a distinct sexual papilla, which is absent in females.

11. **WHEN SHOULD I EXPECT GETTING BABY FISH AFTER STOCKING?**

Some people get excited by the thought of being able to have baby fish in a pond. Having baby fish can be a problem if facilities are not adequate. The time to expect fish fry depends on the fish cultured. Catfish and common carp can grow up to one year without reaching sexual maturity. Even if sexual maturity is reached certain specific environmental conditions have to be met before fish can start breeding.

The story is quite different with mouth brooding tilapia (bream). This fish can breed at the age of four months (although there are slight differences between species). Once sexual maturity is reached and both the temperature and food are not limiting one can be sure that breeding will certainly take place. The fish can spawn (lay eggs) anywhere, even in a glass aquarium.

12. **HOW DO I CONTROL FISH BREEDING AND WHY?**

A fish like tilapia that breeds early in its life history and can have up to six spawning cycles in a year poses a challenge to recommended stocking densities. Subsequent to breeding the stocking density is unknown (and surely exceeded). Due to overcrowding the fish get stunted as they compete for space, food and oxygen. Water quality deteriorates quite rapidly because of increased excretory products and the build up of toxic metabolites. Consequently, few fish reach market size, and may do so after an extended growth period. All these factors are the basis for the need to control unwanted breeding in ponds. The following techniques are commonly applied:

Introduction of predator (one predator to 5-10 tilapia)

Monosex male culture:- Hand selection, Sex reversal
13. WHAT DO FISH EAT?

A potential fish farmer came to our headquarters office and wanted to make a lot of money by growing fish because “each female can produce over a thousand young ones and they will all grow from feeling on mud”. Ga kere tlhapi e ja seretse?

We should not forget that a fish is an animal. Therefore the nutrients required by fish for growth, reproduction and other normal physiological functions are similar to those of land animals. They need proteins, vitamins, and energy sources (carbohydrates and fats). This is why in addition to pond fertilization some form of supplemental feeding is recommended. In intensive fish culture systems a complete (balanced) formulated fish feed must be made available. Feeding rates and frequencies vary with fish species. In the tilapias feeding rates vary from 4 to 30% feed as a fraction of total fish biomass (weight) for fish less than 100g. For fish larger than 100g the feeding rate is usually constant at 3% of total fish biomass.

14. HOW DO I MONITOR CHANGES IN WATER QUALITY?

Some water quality parameters are fairly constant and need to be checked less frequently such as only once a month. These include;

- Salinity
- pH (if alkalinity is moderate at a minimum of 20 mg/l)
- alkalinity
- plankton density (Turbidity)

However, the following need close monitoring and should be checked daily:

- temperature
- dissolved oxygen (DO)
- toxic metabolites - total ammonia (ammonia plus ammonium)
  - nitrites
  - methane

Of all the above dissolved oxygen is the most critical and any measure of water quality monitoring should start with DO. In fact DO should be checked at least three times daily, once early morning (before sunrise) and twice in the evenings (around 22:00 hours and 23:00 hours). Water quality field
15. **WHY SHOULD I WEED A FISH POND?**

In a few school ponds managed by CJSS’s students have imported wild aquatic weeds and introduced them into their ponds. It does simulate the natural environment yes, but is it necessary?

Competition between plankton and rooted weeds in a pond is that of “first come first served”. If plankton density in a pond is low (secchi reading of over 45 cm) then sunlight penetrates through to the pond bottom and encourages growth of rooted weeds. These take up the limited nutrients available in the pond and would never allow for a plankton build up. On the other hand, if a pond is adequately fertilized just after filling, there is a rapid establishment of a plankton bloom that should appropriately give acceptable secchi disc readings. A good plankton density shades the pond bottom and consequently suppresses the growth of rooted aquatic weeds.

16. **DO FISH GET SICK?**

Yes all animals have some disorder sometime in their life span, and do get sick!

Fish culture results in a higher fish population density in a small area than would normally be the case in the wild. Under such conditions there is an increased likelihood of parasitic and communicable diseases. Fish get infections, infestations, attacks and disorders from:

- Bacteria
- Parasites
- Fungi
- Viruses, and
- Nutritional deficiencies

17. **HOW LONG DO FISH TAKE TO GROW TO MARKET SIZE?**

Fish growth is affected by temperature, feed quality and feeding rate, fish species and age of fish at stocking. In most literature on aquaculture in Africa it is common to state that fish can be harvested within 6 months and thus have two fish crops per year. Unfortunately most work has been done in “pure tropical” Africa. We in Botswana do not fall completely within the tropics. Although we do experience very hot summers, the cool winter temperatures of late April to mind August (roughly 4 months) would not offer much in terms of fish weight gain. So on the basis of temperature the growth period would seem to be limited to a maximum of eight months. To exploit this period of ideal environmental conditions, pond stocking should be done by September of any calendar year.

Within this growth period, what size will the fish grow to? This is where quality of feed and age at stocking come in. With good quality feed (at least 30% protein) one should be targeting at an FCR of 3.0 at the worst (i.e. 1 gram weight gain from consuming 3 gram feed). The bigger the fish at
stocking the better. An average individual weight of 50g stock of fingerlings gives the whole crop a better chance of survival than those at 15 g. In this case, total individual fish weight gain from initial stocking weight to a market size of 300 to 350 g seems easily achievable in 8 months growth duration. It is obviously more economical if the target market size is reached within as short a period as possible.

18. HOW DO I HARVEST MY FISH CROP?

Fish can be harvested by non-draining or by draining of ponds.

Non-Draining of Ponds:

The practice of harvesting some fish during the production cycle is called partial harvesting or intermittent cropping. Partial harvests are carried out to occasionally have enough fish for household consumption or target the periods when fish prices are at their best. Where partial harvests are common it is not often necessary to drain a pond. The seine net is the most efficient gear for partial harvests. But other methods are occasionally used such as; baited fish traps, hook and line and cast net.

Draining of Ponds:

When a pond is drained a complete harvest is possible. Pond draining also allows maintenance time on the pond and an opportunity to improve on the pond soil (liming, fertilization, disease treatments etc.) To effect pond drainage the pond bottom must be sloped to the drainage end. To be able to drain the pond by gravity the pond bottom must be at least 10 cm above ground level. Two methods of pond draining are possible, namely:

Cutting the dyke – common with small scale farmers. The dyke has to be rebuilt after harvesting.

Using a drain pipe - can be a stand pipe connected by an elbow to act as both an overflow and a drainage pipe.

19. IS THERE A MARKET FOR FISH?

Nearly all of freshwater fish landed in the country is consumed in the north-western region. Maun and Gumare are the two main centres where locally produced fish from the natural systems gets marketed. Hardly does the fish reach the eastern and southern parts of the country. Botswana’s urban centres predominantly sell marine fish from either South Africa or Namibia. Fish from these countries gets frozen onboard fishing vessels in the sea and by the time it reaches places like Botswana it is a few months old.

Fish culture has the potential to produce freshwater fish that can be marketed live. When a hotel or restaurant wants 500kg, partial harvesting can provide only the required quantity. With the change in eating habits of most town dwellers fish has become an important substitute for red meat. The good performance of the Botswana economy has over the past few years attracted a lot of
foreigners who complain about lack of fish and too much nama (red meat) in this country. Market trials by an enthusiastic private entrepreneur have shown that fresh bream would not sell for anything less than P12 – 15.00 a kg.

20. WHAT IS INTEGRATED AQUACULTURE PRODUCTION SYSTEM?

Integrated fish farming system makes use of the waste and by-products from the farming of livestock or growing of crops. Their use as fish inputs to enhance fish production is often the most efficient and versatile way to utilize them. In these techniques expenses on feed inputs is only on the agricultural crop, while fish do not have to be fed. Examples of integration include:

Duck-cum-fish – the ducks are stocked at a density of 750 to 1500 per ha in a fish pond. Ducks also feed on tadpoles, snails, frogs, insect larvae and regularly fertilize the pond by directly defecating in the water. Excess or waste duck feed benefits fish in the pond.

Pig-cum-fish – 100 pigs per ha is recommended. Fish feed directly on pig excreta which is also an excellent organic fertilizer that stimulates growth of dense natural fish food organisms.

Chicken-cum-fish – To be of any use the chickens should be housed. Chicken house can be built directly over the pond so that the excreta may fall in the pond water underneath. A stocking density of 400-600 chickens/ha of pond water surface is used.
Appendix 8. Dams stocked with fish from Mmadinare Hatchery