SUB-REGIONAL OFFICE FOR THE PACIFIC ISLANDS

Study Report

THE POTENTIAL OF FARMING TILAPIA (OREOCHROMIS NILOTICUS) AND FRESHWATER PRAWN (MACROBRACHIUM ROSENBERGII) IN VANUATU

Prepared by

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My deep appreciation goes to Ben Ponia, Aquaculture Advisor of the Secretariat of the Pacific Community, for providing support and logistics required for this study.

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To all the above mentioned people, I extend my sincere thanks.
**ACRONYMS AND ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>CP</td>
<td>Crude Protein</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>MAQFF</td>
<td>Ministry of Agriculture, Quarantine, Forestry and Fisheries</td>
</tr>
<tr>
<td>NAS</td>
<td>Nadurulou Aquaculture Station</td>
</tr>
<tr>
<td>SAPA</td>
<td>Sub-Regional Office for the Pacific Islands</td>
</tr>
<tr>
<td>SPAPD</td>
<td>South Pacific Aquaculture Development Project</td>
</tr>
<tr>
<td>SPC</td>
<td>Secretariat of the Pacific Community</td>
</tr>
<tr>
<td>SPIFDA</td>
<td>South Pacific Islands Fisheries Development Agency</td>
</tr>
<tr>
<td>VFD</td>
<td>Vanuatu Fisheries Department</td>
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</table>
EXECUTIVE SUMMARY

Under the auspices of the Food and Agriculture Organization of the United Nations (FAO) Sub-Regional Office for the Pacific Islands (SAPA) in Samoa, a feasibility study on farming tilapia and prawns was undertaken by SPC Aquaculture Officer in November 2003. The objectives were to survey the potential to develop Tilapia (*Oreochromis niloticus*) and Prawn (*Macrobrachium rosenbergii*) farming in Vanuatu (further details are given in the Terms of References in Appendix 2).

A series of findings and recommendations were compiled from the interactions and discussions with the Vanuatu Fisheries Department (VFD) staff, contacts from various agencies, surveys and literature sources.

Physical parameters such as temperature, water quality and quantity, topography of the sites for ponds and soil type including feed and fertilizer resources, equipment supplies indicated that conditions were well suited for subsistence and semi-commercial level of production of tilapia and prawns. The abundance of land, labour and resources gives Vanuatu a comparative advantage in tilapia and prawn production.

However, there are some critical issues such as lack of aquaculture tradition, technical expertise and data on fish markets, inadequate capital and resources present that are impeding aquaculture development plans in Vanuatu. Nonetheless, given the opportunities in this sector as well as successes aquaculture in neighboring countries like Fiji, it is anticipated that farming of tilapia and prawns will be successful in Vanuatu.

Recommendations are provided in this report for specific actions that VFD can take to promote and enhance the culture of tilapia and prawns. In addition, a number of private sector initiatives, based on the fact that further development of aquaculture will require the active participation of both government and the private sector is recommended. Additional tasks (apart from those specified in the terms of reference) included the supervision and construction of two medium sized tilapia and prawn ponds.

It is essential to have at least a general knowledge of Vanuatu to understand and formulate workable solutions to some of the current problems in developing aquaculture in the country. The report therefore incorporates references to the general geography to place circumstances such as climate, fisheries and land tenure in the proper context.

The starting point for any attempt to develop aquaculture in Vanuatu is to recognize elements distinctive to the country. Vanuatu is an island nation with a relatively small land area and population. It however, possesses considerable potential for the generation of additional wealth from agriculture and fisheries. Only about a third of the total cultivable land is presently farmed. Transportation, both inter-island and intra-island, is a major constraint for marketing and thus to increasing productivity and volume of production of any commodity.
In order to attract funding and promote investment in tilapia and prawn culture in Vanuatu, the VFD and sponsoring agencies of this consultancy will have to provide all possible incentives, particularly since it is a new concept. Such incentives may include encouraging small vegetable and coconut farmers to expand into tilapia and prawn farming.

As mentioned in more detail in various sections of this report, there are a number of problems that government and private sector investor in tilapia and prawn culture may face. Besides solving these, to facilitate development of tilapia and prawn culture, Vanuatu government and other agencies, are urged to consider creating a favourable ‘climate’ supporting the development of either small or medium scale farms for ni-Vanuatu only. This is much needed because the nature of the aquaculture industry with regard to profitability has never been demonstrated to farmers/investors in Vanuatu before. Otherwise they may easily pursue other alternative investments that offer greater returns.

This report is not intended to address all the issues associated with the current situation of aquaculture in Vanuatu, as at present there are no farms and infrastructure in place. The contents of this report may only be used as a general guide and the suggestions or observations provided are intended to assist those interested in identifying their own criteria and options for actions, as well as for the partners collaborating in support of developing tilapia and prawn culture in Vanuatu.
1.0 INTRODUCTION

For the two decades following 1950, world marine and inland capture fisheries production increased on average by as much as 6 percent per year, trebling from 18 million tonnes in 1950 to 56 million tonnes in 1969. During the 1970s and 1980s, the average rate of increase declined to 2 percent per year, falling to almost zero in the 1990s. This leveling off of the total catch follows the general trend of most of the world’s fishing areas, which have apparently reached their maximum potential for capture fisheries production, with majority of stocks being fully exploited. It is therefore very unlikely that substantial increase in total catch will be obtained. In contrast, growth in aquaculture production has shown the opposite tendency. Starting from an insignificant total production, inland and marine aquaculture production grew by about 5 percent per year between 1950 and 1969 and by about 8 percent per year during the 1970s and 1980s, and it has increased further to 10 percent per year since 1990.

For the Pacific Islands region, interest in the development of aquaculture has led to many attempts to assess the potential of production programmes in many island countries. Some islands achieved moderate successes and thus have a tradition of aquaculture, while for others like Vanuatu, it is a new concept. The first Regional Initiative in Aquaculture was made by the South Pacific Commission (SPC) in the 1950s and early 1960s. Later a set of initiatives was made in early 1970s under the leadership of the Food and Agriculture Organization of the United Nations (FAO) - South Pacific Islands Fisheries Development Agency (SPIFDA). SPIFDA sponsored consultants and also initiated fisheries and aquaculture demonstration projects in the region. In the 1990s, the FAO South Pacific Aquaculture Development Project (SPADP) carried out similar projects and activities.

Majority of the projects initiated by these agencies did not achieve their objectives mainly because projects were implemented based on technical feasibility and a holistic approach, for example, viability studies especially marketing aspects were not incorporated or were always put at a later stage. Presently, a number of aid organizations are supporting several aquaculture projects in the region. The main agencies include Secretariat of the Pacific Community (SPC) with a Regional Aquaculture Initiative under its Coastal Fisheries Program and FAO under its Sub-Regional Office based in Apia, Samoa. In addition, some island governments are supporting their own efforts in developing aquaculture of various species and at various levels.

This report presents findings and recommendations of a consultancy on farming of Tilapia (*Oreochromis niloticus*) and Prawn (*Macrobrachium rosenbergii*) in Vanuatu based on visits to Efate Island and Santo Island and meetings with Vanuatu Fisheries Department (VDF) officials, other government agencies, non-governmental organizations, private sector organizations, hardware shops, supermarkets, hotels, feed suppliers, fish sellers, freight companies, earth moving companies and individuals.

Vanuatu possesses physical features and resources conducive to production of tilapia and prawns. The challenge is to capitalize on their inherent strengths while overcoming a number of weaknesses. In order to accomplish this, government and
donor support must be directed to this fishery. Such support should, however, be
carried out in a way that enhances and recognizes the participation of ni-Vanuatu as
the paramount factor for sustainable aquaculture.

2.0 SITE SURVEYS FOR POTENTIAL FARMS

Potential farming sites on the islands of Efate and Santo, pre-selected by VFD staff,
on the basis of availability of natural resources such as sources of water - springs,
creeks and clayey soil, were surveyed by the consultant. Recommendations given on
the suitability of these sites for farming tilapia and prawns were based upon on-site
testing of soil texture, water pH, water temperature, dissolved oxygen and assessment
of topography and infrastructure. The findings of the site surveys are given in the
following section.

2.1 Efate Island

A total of 6 sites were surveyed on Efate Island; their locations are shown in Figure 1
and the results of observations and other biophysical parameters tested are given in
Table 1. All the sites surveyed were generally good for tilapia and prawn culture. The
water required for filling of ponds, in most cases, comes from springs. Most of the
springs had enough water to fill the projected pond size completely within a few days.
The soil type at most sites was sandy clay and soil samples taken at various places
around each site indicated presence of adequate clay. The presence of clay would
prevent excessive seepage.

The topography or lay-of-the-land determines the amount of soil that has to be moved
during pond construction. The topography at all sites was generally flat and therefore
a lesser amount of soil would have to be moved during pond construction in
comparison to setting up ponds on rolling or hilly land. In addition, there is low-lying
land available adjacent to sites which could allow for ponds to be designed such that
during harvesting, the pond can be drained by gravity flow. This will prevent flooding
on neighbouring land.

Except for site at Undine Bay 2, all other sites surveyed may not be subject to
flooding. The site at Undine Bay 2 could be prone to flooding as it is at the same level
of the adjacent river flowing through the site. The six sites surveyed (see Plates 2-23)
have a total area of about 16 hectares suitable for construction of ponds suitable for
tilapia and prawn culture. A series of pond projects of small to medium size family
units can be set up in these areas.
2.2 Santo Island

According to Fisheries Officer based at Santo Island, over 100 requests had been received from individuals and groups interested in tilapia and prawn farming. In some places, for example, Sarete and Napauk, villagers had already dug small ponds of 5 - 10 m². The ponds were stocked with local prawns *Macrobrachium lar* (Plate 1) and tilapia *Oreochromis mossambicus* collected from the rivers and creeks. Local prawns are also sold in the local shops in very limited quantities for VT 800-1200 per kg.

After consultations with Fisheries staff, 5 sites (Figure 2) were chosen and surveyed. The details are provided in Table 1. The conditions required for tilapia and prawn culture seem to be more suitable and appropriate on Santo Island in comparison to Efate Island. There are sites with more abundant water supply, flat topography and better soil qualities (higher clay content) for pond construction. There is also an added advantage of having a copra mill and an abattoir at Luganville, by-products of which are very useful for making feeds for tilapia and prawns. The sites surveyed on Santo have a total area of approximately 6 hectares suitable for tilapia and prawn pond construction.

However, there are some immediate concerns: (1) the lack of hatchery and aquaculture facilities to produce tilapia fingerlings and prawn post-larvae, (2) lack of qualified personnel, i.e., trained personnel to carry out hatchery, pond development and general extension work, (3) VFD does not have any specific plans or policies on tilapia and prawn culture development and (4) lack of funding. Despite these constraints, the VFD may be able to promote and attract investments in tilapia and prawn culture in preference to other comparable investments through provision of incentives and government support services in the form of research, demonstration, and training and information services.
Figure 2. Map of Santo showing sites surveyed.

Table 1: Summary of sites surveyed on Efate and Santo Island.

<table>
<thead>
<tr>
<th>EFATE</th>
<th>Topography</th>
<th>Water</th>
<th>Soil</th>
<th>Others</th>
<th>Skills of site owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erapo- 25 km from Port Vila</td>
<td>Flat. Total area suitable more then 10ha</td>
<td>Spring/creek-</td>
<td>Clay</td>
<td>pH 7.2 DO 6.97 mg/l Temp 22.1°C</td>
<td>Training in prawn hatchery</td>
</tr>
<tr>
<td>(Plate 2-9)</td>
<td>Flat base of a hill. Area 1.0ha</td>
<td>Spring: at a distance</td>
<td>Sandy and coral base</td>
<td>Water used for domestic use</td>
<td></td>
</tr>
<tr>
<td>Airport site (Plate10-11)</td>
<td>Flat base of a hill. Area available 1.0ha</td>
<td>Creek-good</td>
<td>Sandy/clay</td>
<td>pH 7.5 DO 6.6 mg/l Temp 22.0°C</td>
<td>Catches eels &amp; prawns- sells to Japanese</td>
</tr>
<tr>
<td>Undine Bay1 (Plate 12-13)</td>
<td>Flat, base of hill. Area over 2.0 ha</td>
<td>River</td>
<td>Sandy clay</td>
<td>Vegetable farm</td>
<td>Land owner not known</td>
</tr>
<tr>
<td>Undine Bay2 (14-15)</td>
<td>Flat. Area over 0.1 ha</td>
<td>Spring-good</td>
<td>Sandy clayish</td>
<td>Water also used for domestic use</td>
<td>Land owner very motivated</td>
</tr>
<tr>
<td>Ferori-1 (Plate 16-17)</td>
<td>Flat. Area over 3.0ha</td>
<td>Red soil/sandy</td>
<td>Inland old mining area</td>
<td></td>
<td>Land owner not known</td>
</tr>
<tr>
<td>SANTOS</td>
<td>Topography</td>
<td>Water</td>
<td>Soil</td>
<td>Others</td>
<td>Skills of site owner</td>
</tr>
<tr>
<td>Sarate, 0.75 km from village</td>
<td>Flat/ hilly, area 0.2 ha</td>
<td>Creek-very good water source</td>
<td>Sandy clayish and rocks</td>
<td>pH 7.6 DO 7.6 mg/l Temp 24.9°C</td>
<td>Aru - Experience in catching/raising prawns</td>
</tr>
<tr>
<td>1 pond 5m² for prawn culture</td>
<td>Flat-coconut farm, area 3 ha</td>
<td>Spring-300m away</td>
<td>Clayish</td>
<td>pH 7.8 DO 78.8mg/l Temp 24.9°C</td>
<td>Lidu - catching prawns</td>
</tr>
<tr>
<td>Nadango, close to village</td>
<td>Flat, area 0.2 ha</td>
<td>Creek-very good</td>
<td>Clay/sandy</td>
<td>pH 7.5 DO 7.6 mg/l</td>
<td>Land owner-very keen</td>
</tr>
</tbody>
</table>
and mainroad

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Water Quality</th>
<th>Clay/sandy</th>
<th>Temp. 24.2°C</th>
<th>OTHERS</th>
</tr>
</thead>
</table>
| Napauk, base of hill, 5 small ponds, 2 completed and 3 half complete | Flat and hilly, area 0.2 ha | Spring adequate supply | Clay/sandy | pH 7.7  
DO 4.72 mg/l  
Temp 26.4°C | Clan farm: 2 ponds (10m² each) and 3 ponds (15-20m²) |
| Turtle Bay        | Flat, beside main road, area over 2.0 ha | Creek-very good | Sandy clayish  | pH 8.8  
DO 7.7 mg/l  
Temp 25.0°C | Land owner not known. |

2.3 Summary

Vanuatu (based on survey of Efate and Santo Islands) has good natural resources for farming of tilapia and prawns. The VFD should undertake dialogue with appropriate government agencies and regional organizations in formulating a national short and long-term tilapia and prawn culture development plans specifically focusing on procuring resources necessary to initiate tilapia and prawn farming. These plans or models must address the needs of subsistence and semi-commercial farmers including support for hatcheries and essential material supplies, feed, quarantine service, subsidy and extension information services. The plans or models should be based on a holistic approach for economically viable and efficient tilapia and prawn production under different culture conditions. Short-term plans should include the seed and feed supply, pond development, training workshops, and extension service while long-term plans should include training and education, development of infrastructure and domestic market.

3.0 DEMONSTRATION FARMS

3.1 Erapo site

After assessing all the sites surveyed and discussions with VFD staff, Erapo site was recommended for tilapia hatchery as well as for pilot demonstration farming of tilapia and prawns.

Erapo is located at the mouth of the Rantabau River, at the top of Teouma Plateau. Foreign companies had logged the land for prime whitewood about 20 years ago and since then it has been left undeveloped. It is 25 km from Port Vila. The road condition (about 4 km of the 25 km) towards the end of Erapo is very poor and accessible only by four-wheel drive vehicles in rainy conditions. The tilapia hatchery and tilapia/prawn demonstration pilot farm will become part of a multi-development project model called Erapo Inland Development Project. The total area available for development is 300 hectares. The Erapo community led to the formulation of this project after having consultations and assessments of the land with relevant departments. About 200 families reside in the vicinity of the project which involves the development of:

- Agriculture crops
- Livestock (cattle and goats)
- Reforestation and
• Aquaculture

The Erapo site has the best potential for demonstrating tilapia and prawn farming based on the following:

a. Water supply - the water source originates from a spring at the base of a nearby mountain (Plates 3 & 4) and flows into a stream that spreads out towards the low-lying areas at the site. Farmers residing in the vicinity of the area stated that the water source does not dry out, even during severe droughts. There is sufficient flow of water (rate) to supply the 2 existing ponds as well as other ponds if constructed. The water quality parameters taken on 15/9/03 at 1150 hours were: water temperature - 22.1°C, pH - 7.2 and DO - 7.2 mg/l. The water can be diverted to the ponds at minimal cost using PVC pipes or vinyl pipes.

b. Topography - flat to low-lying area with small hills (Plates 2 & 7). Levee-type ponds can be built. Some big trees and marshes have been cleared. The area is not subject to flooding. Two ponds (Plates 8 & 9) have already been built.

c. Soil type - the soil is clayey (10-15% clay) as shown in Plates 5 & 6. At the time of survey due to prevailing dry conditions, the soil was very dry. If the ponds leak, clay soils and cattle manure should be spread and compacted on the bottom of the pond.

d. The site has added advantage of having the landowner's farmhouse at the site. Feed storage shed and other amenities will also be built including the grading and improvement of the present feeder road leading to the farm. The farmer also raises cattle on his land and there are several other farmers raising cattle (Plate 39), chickens on adjacent land. A sketch plan for the proposed pilot tilapia/prawn farm cum tilapia hatchery is given in Figure 3.

The area designated for tilapia hatchery and demonstration for Tilapia and Prawn grow-out farm has the following features:

• Water: A good water source (pH 7.3). A pH close to 7 indicates neutrality of the water and excellent for freshwater culture species. The water flows continuously throughout the year. Measurement on the rate of the water flow shows that the water source can sustain and support tilapia hatchery operation including development of 2-3 hectares of tilapia and prawn farms.

• Topography: Flat plains and small hills. There is ample space available for construction of over 10 hectares of ponds.

• Soil: Soil is alluvium clay with good water retention properties. Several meter-deep pits were dug to ascertain the soil profiles. There are no rocks and boulders thus suitable for pond construction.

• Progress so far: A total of 5 hectares has been cleared for various purposes, including construction of two ponds each of which is: 42 m x 20 m and 42 m x
15 m with a depth of 1.5 m. Refer to Figure 3 for sketch plans of the ponds. The total construction cost was VT 100,000 provided by VFD.

The following preparatory tasks at Erapo were carried out prior to pond excavation works for demonstration farm.

a. Site was surveyed
b. Met with landowner and VFD staff regarding funding for excavation of ponds at the site, which resulted in VFD contributing VT 100,000 towards pond construction and drainage works. The land-owner hired a backhoe (Plate 2) and cleared part of the site at his own expense prior to pond construction.
c. A drain, depth of 0.6 m was made to allow for incoming water (from the source) to drain away from the pond site. This enabled the pond excavation work to be easier and faster.
d. Excavation was carried out on a ‘cut and fill’ basis using a large excavator - model UH120 Hitachi (Plate 8) - the only digger available in Port Vila for pond excavation works at that time.

3.2 Pond construction

The landowner in collaboration with VFD and assistance from SPC has already constructed 2 ponds with a total surface area is 1430 m². In addition, about 3 hectares of land has been cleared to build more ponds (Plate 7). Other points worth considering are:

- PVC or polyethylene flexible 50 mm pipe of approximately 300 meters length is required to supply sufficient water for a year round production of fish and prawns.
- There is a need to import quality tilapia fry and prawn post-larvae based on quarantine protocols given in other section of this report. The seeds would also become the future broodstock for VFD to use for its hatchery operation. In addition, quality feed should be imported and fed daily at recommended rates.
- There is option of formulating feeds (powder and crumble form) with locally available ingredients such as copra mill, meat bone meal, commercial poultry feed and hog feed.
- Though the farmer has undergone one-month training in prawn hatchery operation at Naduruloulo Aquaculture Station (NAS), Fiji, he still lacks skills in tilapia and prawn grow-out operational aspects. Therefore, he needs further training in grow-out aspects and continued technical support from VFD.
- A set of tilapia and prawn broodstock should be imported and hatchery facilities established for breeding.

A sketch plan for the construction of ponds is given in Figure 3 with details as follows:

a. Pond sizes: Two rectangular ponds measuring (i) 42 m x 20 m and (ii) 42 m x 15 m - were constructed during the time of the consultancy. Location and
topography of the site are such that there is land available to make a series of 20-30 ponds of similar sizes or even bigger. Total area available and suitable for pond construction is over 10 ha. However, the local population (approximately 200 families) is not large enough to absorb the annual production and the land owner has to find options of marketing the fish and prawns in Port Vila and other outlets.

b. Pond depth: 1.3 - 1.4 m, use of 100 mm PVC for outlets is recommended (down-pipe can adjust the water depth as per requirement).

c. Free board: - 0.2 m above water level to be adjusted with down-pipe.

d. Pond dike: - 5.0 to 6.0 m. The dikes will allow free movement of vehicles and machinery and avoid excessive erosion. Though the pond walls are well constructed, there was hardly any rain at that time therefore there was no moisture in the soil to allow for compaction. The optimum soil moisture for compaction for the type of soils at Erapo is 20-30%.

e. Dike slope: 2:1 to 3:1 (internal and external slope). At the time of the pond excavation the soil was very dry due to prevailing dry conditions thus allowing for this type of dike slope. The internal slope of 3:1 will facilitate seine harvesting and avoid erosion.

f. Pond base: slightly sloped towards the outlet drain to allow for the pond to be completely emptied by gravity (during harvesting).

g. Water inlet - use of 40 mm polyethylene with gates valves is recommended.

h. Water outlet - 100 mm PVC pipe is installed for complete gravity drain out and elbow to adjust water depth.
Figure 3. Sketch plan of the ponds constructed at Erapo demonstration farm.

4.0 TILAPIA HATCHERY

A hapa and pond system of tilapia seed production system is recommended. This hatchery is to be based at Erapo and would also include as sites for both prawn and tilapia grow-out.

Several methods of tilapia hatchery operations have been developed and applied that simplify work and increase the efficiency and quality of various operations related to management. The hapa system would allow for an intensified management of breeding fish in order to reduce contamination and match seed output to demand. This is possible if spawning fish are held in tanks or hapas at higher densities than is normal for pond-based seed production.

A process diagram of Oreochromis niloticus hatchery system: hapa-in-pond is given in Figure 4 below.
Figure 4. A process diagram of *Oreochromis niloticus* hatchery system: hapa-in-pond.

### 5.0 PRAWN HATCHERY

#### 5.1 Site selection and evaluation

The VFD has constraints in providing a suitable site for prawn hatchery as it does not have any other sites available. The existing government trochus / green snail hatchery facility located adjacent to the VFD complex however, can be used for setting up a backyard type prawn hatchery. The space available is 670 m². The approval for use of site has been given by VFD.

The trochus / green snail hatchery site has the following facilities:

- Open shed space, length 10 m, width 6.7 m and height 2.5 m (Plates 26-28).
- The shed has a cement tank measuring 5.2 m x 1.65 m and 0.70 m deep. This tank will be used as mixing and holding tank for rearing water (Plate 29).
- A series of 8 similar sized cement tanks.
- Power supply-single phase with 1 power point. Three phase power can be connected from the mechanical workshop building (about 10 m away).
• Aeration system from existing aerator and fittings (Plate 30).
• Four tanks—flat bottom, 500 L capacity.
• Water pump-fitted with filter.
• Other basic hatchery facilities.
• A set of equipment for the hatchery has been purchased (as of 22 November).

Other facilities include air-conditioned laboratory complex containing desks, fridge, shelves, chairs, old microscopes and other accessories.

a) Climatic conditions

The water temperature in tanks at the present site is 24-30°C. This is suitable for establishing a prawn hatchery in order to have a number of seed production cycles over an extended period almost through out the year without involving excessive use of temperature control devices.

b) Saltwater and freshwater supply

The site is on the edge of seawall where some natural freshwater springs exist. The salinity ranges from 30-35 ppt which is suitable for prawn hatchery. There is a good tidal flow and it seems the water is free from pollutants. The seawater will be pumped during the high tide through an in situ filter and stored in a concrete tank. Freshwater will be taken from the municipal water supply and stored in small cement tanks for 2-3 days after which it will be pumped through an in situ filter to dilute/mix with seawater in the concrete tanks.

c) Water quality

Good quality seawater is available at all times at this site. However, there is a problem relating to the non-availability of clean untreated freshwater although groundwater (spring water) can be seen seeping from the base of the seawall into the sea. Water supply charge rates range from 52 VT per cubic meter for up to 50 cubic meters to 61.75 VT for more than 200 cubic meters. The water supply in the rural areas is not fixed and varies for each community.

As the site is located near the government wharf where the maintenance of ships and vessels and other activities are carried out by various agencies, an accidental spillage of diesel oil including discharge of bilge water by vessels could potentially affect the water quality at the hatchery site.

d) Availability of broodstock

Availability of berried prawns in the vicinity of the proposed site is extremely essential for a continuous seed production programme. One or two 0.1 to 0.2 ha freshwater ponds are required but this is not available at the present site. Arrangements have been made to use grow-out ponds at Erapo to hold berried prawns which will be transported to the hatchery site when required.
e) Pumps and tanks

There are two submersible pumps with fittings available for use and a third pump will be required for preparing water for larval rearing tanks. The existing rectangular concrete tank with the dimensions - 5.2 m x 1.65 m x 0.7 m deep (approximately 6 tonne capacity) is adequate for holding water for the larval rearing tanks. There is also a series of 8 cement tanks (Plate 11 - length 2.3 m, width 1.2 m and depth 0.65 m) capacity of 1.7 tonnes, which can be used for holding freshwater. The water in the tank has to be aerated to allow all the chlorine to evaporate before mixing with seawater.

There are 3 circular tanks with a capacity 500 L each, which is adequate for holding and conditioning of the breeders. It is recommended that four 500 L conical bottom (for larval rearing) tanks and three 150 L artemia hatching tanks be bought for the hatchery. Refer to figure 5.

f) Seawater intake system

Information from staff members indicate that the seawater intake line is a 100 mm PVC pipe and it extends about 30 m into the sea. The outer end is attached with a strainer (size and type of material used not known) preventing the intake of large particles and other foreign matter. The intake is 3-5 m below the surface and about 0.5 m above the bottom. The present flow rate is not known. The PVC pipe is joined by galvanized metal pipes and has gates valves of various types. It is important that all pipes and fitting including gate valves to be changed to non-metallic material as the current materials are very old and rusted and can be a source of contamination. Additional plumbing will be required for the freshwater to be diverted to the concrete mixing tanks.

g) Air blower comparison

There are two aerators installed at the site (Plate 30). One of the aerators is too old to be repaired while the other one is in use but needs servicing. The capacity is 40 m³/hour, which is ample for the proposed prawn hatchery. A standby aerator is recommended for the hatchery including a 12V blower for transportation of breeders or for emergency use.

h) Personnel

Two senior staff of VFD has attended training in prawn hatchery operations as part of their plans to establish and operate a prawn hatchery in Vanuatu. Both staff completed the training successfully, producing post-larvae within 30 days of larval rearing.

The success of the prawn hatchery at VFD will to some extent depend on the quality of the personnel responsible for the daily operations. Since two staff have acquired skills and knowledge in operating a Prawn Hatchery, it is imperative that these staff be given the opportunity to manage and operate the hatchery. If it is decided that the proposed prawn hatchery operate in conjunction with a grow-out farm, it is essential that one of the two trained staff be in charge of the grow-out facility.
5.2 Proposed hatchery design

It is proposed that the prawn hatchery be established at the current trochus/green snail hatchery, designated as a multi-species hatchery whereby resources (including human resources) can be utilized to the maximum. Refer to Figure 5 for sketch plan for proposed hatchery design.

This hatchery would thus provide focal point and stimuli for ni-Vanuatu aquaculture development. Furthermore, it will be used for demonstrating tilapia and prawn hatchery technology as well as providing training opportunities for the staff in hatchery procedures under commercial conditions. It may also serve to stimulate local investor confidence in prawn culture as well as provide resources for research, development and training at practical level.

Figure 5: Sketch plan of proposed prawn hatchery.

5.3 Set up of prawn hatchery

This section is limited to basic aspects as other details can be found in appropriate literature sources.

A prawn hatchery is a self-contained life supporting system in which all the essential components are to be functional for smooth seed production. The success of hatchery operation depends on a suitable design with requisite facilities. The design of hatchery
is mostly site-specific and depends on availability of freshwater, salt water, post-larvae production target, level of financial input and future expansion plans. The information below provides basic information on the design, construction and facilities required for establishment of a makeshift (or backyard) prawn hatchery at the VFD complex. The suggested hatchery layout and design is given in Figure 6.

![Diagram of prawn hatchery](image)

**Figure 6. Diagrammatic representation of prawn hatchery.**

### 5.4 Guidelines for installation of hatchery facilities

The first step is to arrange and procure the estimated materials for the construction of the hatchery. The aeration system, filter system, power supply and drainage pipes need special attention and proper skills while working. The hatchery should have the following components.

1. Storage tanks: Four rectangular cement each with 1.7 tonne capacity and a 6-tonne tank capacity will be required for storing freshwater, saltwater and mixed water (salinity 12 ppt). It is appropriate for these tanks to be placed at a higher level than the larval rearing tanks to facilitate gravitational flow of the water.
2. Larva rearing tanks: Two types of larval rearing tanks are recommended (based on Fiji experience).
   a. Cylindro-conical tanks (500 L capacity): they are made of fibre-glass for rearing larvae from Zoec I to Zoec VI (1-10 days) or the complete cycle to post-larvae. The interior surface should be smooth and dark (green or blue or black) in colour. A gate valve controlling the flow of water should be fitted at the center of the bottom.
   b. Rectangular fiberglass tanks (200-500L capacity): These types of tanks can be used if the cylindro-conical tanks are not available. Cement tanks, circular cement tanks, hume pipes of ferro cement pipes with an effective water volume (500L) can also be used.

3. Post larval holding tanks: The circular fibreglass tanks of 500-1000 L (presently available at the site) should be provided to hold post-larvae till disposal.

4. Artemia hatching tanks: Three, cylindro-conical tanks made of fibreglass (150-250 L) are suitable for hatching the artemia cysts. All the tanks of artemia hatching unit should be fixed on a wooden platform and be near to sunlight.

5. Miscellaneous items: Plastic ware, PVC tubing for siphons, sieves, chemicals (formalin and KMnO₄), refractometer, thermometer, beakers, blenders etc are required for smooth functioning of the hatchery. Refer to Appendix 4 for recommended list of equipment required to operation of the hatchery.

6. Aerator and generator: These are required as standby for aerating the culture medium, lighting, pumping and heating purpose.

7. Aeration and water supply system: The aeration distribution should be provided with a suitable PVC pipe running throughout the hatchery connected or hooked to the present blower. Reducers can be used to connect the main PVC pipe to supply aeration to all the tanks including the mixing tank. A spare blower in working condition is recommended and to be used on rotational basis. The air stones used should be round and of good quality. Each air stone can aerate 1 m³ of water but two air stones are recommended to be placed in each of the tanks to have an effective aeration and to create considerable agitation and movement of water to keep the prawn larvae and food particles in motion.

8. Electricity: A dependable power source with a standby generator is essential to run the life supporting systems in the hatchery.

9. Water analysis kit: It is necessary to analyze water quality parameters of larval rearing medium on a daily basis using simple stick thermometers and refractometers but not an essential since two staff have gained very good hands-on training in hatchery operation.
10. Broodstock ponds: the ponds at Erapo site are recommended to be used for holding breeders.

5.5 Cost estimates for setting up prawn hatchery

The items for operating a backyard type prawn hatchery are mentioned in the preceding sections. The costs for the hatchery items available in Vanuatu, as obtained by VFD is AUS $2302.00. The additional items essential for operating the hatchery will cost approximately Vatu 2 million - details are given to VFD officials.

6.0 COSTS ESTIMATES FOR FARMS

Development of tilapia and prawn farms in Vanuatu, either on small or large scale, would involve the use of a number of items which are currently not available in the country. Examples of the items are: tilapia and prawn seed and feed supplies, specialized equipment like hatchery tanks, heaters, rearing facilities, harvesting facilities, transportation and marketing equipment.

If the culture of tilapia and prawns is to be developed (and is large enough), hatcheries for production of seed and small-scale unit for production of feed has to be developed. If not then alternative arrangement for importing these items should be considered. However, it would be extremely difficult to establish a tilapia and prawn industry in Vanuatu on regular import of all such supplies and equipment. In the interest of present study, a cost estimation model has been prepared (see Tables 2 & 3 below) for the two ponds that have been built at Erapo site. The model is based on the assumption that seed and feed supplies are imported from the NAS in Fiji, while equipment are bought from Port Vila.

6.1 Cost estimation model for Tilapia

The estimated costs for the project i.e., cost and returns of two (2) ponds with total surface are 1,470 m² for tilapia culture is shown in Table 2.

Assumptions for tilapia pond culture are:-

- Spring water gravity flow into ponds by 50 mm polyethylene pipes
- Tilapia fry and feed imported from NAS – Fiji
- Other details -
  - Water area 1,470 m²
  - Stocking density 4/m²
  - Total stocked 11,760
  - Survival rate 95%
  - Harvest weight 200g
  - Total yield 2,230 kg
  - Price/kg- VT 300/kg
  - Revenue/crop VT 334,500
  - Crops/year 2
  - Annual revenue VT 669,000
  - FCR 1.5 : 1
Feed requirement per crop 1,700kg
Feed cost @ VT 52/kg VT 88,400
Annual cost VT 176,800
Freight cost of feed VT 64,380
Seedstock cost to Nadi VT 47,400
Freight Nadi-Port Vila VT 65,000
Labour: family labour VT 96,000

Table 2. Cost and returns of two ponds (total area 1,470 sq. m) for Tilapia culture. All prices are in Vatu (F$1.00 equivalent to VT 60).

COSTS

Development Cost

a. Excavation of 1,470 m³ earth for the pond system.
   Type-dugout, hire of Excavator at 8,000 VT/hr (quote by Fletcher Construction) - will take approx. 12 hrs (includes drainage and water ways) 96,000 VT
b. Structures, piping and fittings (4 X 100 mm, 2 L-bow, 1 coil x 25 mm hose, 2 m screen 31,500 VT
c. Pump and accessories: ONGA pump 2" (90,400 VT) --
d. Seine net, buckets etc 30,000 VT
e. Miscellaneous expenses 10,000 VT

TOTAL 167,500 VT

Operational Cost (2 croppings/year)

a. Purchase of 11,760 pcs of tilapia fry (SD 4 pcs/m³)
   @ 2 VT/pc = 23,520 VT
   packing-48 plastic bags @ 30VT/each = 1,440 VT
   styloform boxes 12 @ 720 VT each = 8,640 VT
   rubber bands, tape, oxygen, handling charges
   - 300 VT/2000fry~ = 1,800 VT
   transportation from NAS to Nadi airport
   - road/air freight ~12,000 VT
   47,400 VT
b. Freight charges Nadi-Port Vila (2000 fry will require
   30kg baggage - cost $180.38. Thus for approx. 12,000
   fry weight 180 kg cost - F$1,082.28 ~ 65,000 VT.
   Air Pacific freight charges ex-Nadi 65,000 VT
c. 200 kg of chicken fertilizer (free from Vanuatu Poultry
   farms: cartage charge 5,000 VT
d. Approx. 67 bag of feed at F$43.00/bag = F$2,881~
   172,860 VT (Shipment by Sea - Port Services -Vanuatu
   - Limited) cost F$1,073.50 ~ 64,380 VT i.e., F$536.75 for
   each m³ of feed (note each m³ will take 32 bags) 237,240 VT
e. Miscellaneous expenses (harvesting, transport, marketing) 40,000 VT
f. Labour for routines activities 240 days @ 400 VT/day 96,000 VT

TOTAL 490,640 VT
SALES

At 95% survival, there will be 11,172 pcs of marketable size tilapia at 5 pcs/kg. Therefore 2,230kg at 300 VT/kg 669,000 VT

Less operational cost 490,640 VT

TOTAL 178,360 VT

GROSS INCOME

ROI = (178,360 VT/167,500 VT) x 100 = 106%
PP = (167,500 VT/178,360) = 0.93 years

TOTAL PROJECT COSTS 658,140 VT

6.2 Cost estimation model for Prawns

The estimated costs for the project- Cost and Returns of two (2) ponds (total surface are 1,470 m²) for prawn culture are shown in Table 3.

Assumption for prawn culture:

- Spring water gravity flow into ponds by 40 mm polyethylene pipes
- Prawn post-larvae: Imported from NAS-Fiji
- Other details -

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water area</td>
<td>1,470 m²</td>
</tr>
<tr>
<td>Stocking density</td>
<td>5/m²</td>
</tr>
<tr>
<td>Total stocked</td>
<td>14,700</td>
</tr>
<tr>
<td>Survival rate</td>
<td>80%</td>
</tr>
<tr>
<td>Harvest weight</td>
<td>30g</td>
</tr>
<tr>
<td>Total yield</td>
<td>352 kg</td>
</tr>
<tr>
<td>Price/kg-</td>
<td>VT 1,000/kg</td>
</tr>
<tr>
<td>Revenue/crop</td>
<td>VT 176,000</td>
</tr>
<tr>
<td>Crops/year</td>
<td>2</td>
</tr>
<tr>
<td>Annual revenue</td>
<td>VT 352,000</td>
</tr>
<tr>
<td>FCR</td>
<td>2 : 1</td>
</tr>
<tr>
<td>Feed requirement per crop</td>
<td>352 kg</td>
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<tr>
<td>Feed cost @ VT 52/kg</td>
<td>VT 18,300</td>
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<tr>
<td>Annual cost</td>
<td>VT 36,120</td>
</tr>
<tr>
<td>Freight cost of feed</td>
<td>VT 16,100</td>
</tr>
<tr>
<td>Seedstock cost to Nadi</td>
<td>VT 71,700</td>
</tr>
<tr>
<td>Freight Nadi-Port Vila</td>
<td>VT 81,171</td>
</tr>
<tr>
<td>Labour: family labour</td>
<td>VT 96,000</td>
</tr>
</tbody>
</table>
Table 3. Cost and returns of two ponds (total area 1,470 m²) for prawn culture. All prices are in Vatu.

<table>
<thead>
<tr>
<th>COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Cost</td>
</tr>
<tr>
<td>a. Excavation of 1,470 m³ earth for the pond system. Type-dugout, hire of Excavator at 8,000 VT/hour (quote by Fletcher Construction) - will take approximately 12 hours (includes preparation of drainage and water ways)</td>
</tr>
<tr>
<td>b. Structures, piping and fittings (4x 100 mm, 2 L-bow, 1 coil x 25 mm hose, 2 m screen)</td>
</tr>
<tr>
<td>c. Pump and accessories: ONGA pump 2&quot; (90,400 VT)</td>
</tr>
<tr>
<td>d. Seine net, buckets etc</td>
</tr>
<tr>
<td>e. Miscellaneous expenses</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

| Operational Costs (2 cropping/year) |
| a. Purchase of 14,700 prawn post-larvae (SD 5 pcs/sq. m) @3 VT/each =44,100 VT, packing 1,000 pls / (2) bag-30 plastic bags @ 60VT/each = 1,800 VT styloform boxes 15 @ 720 VT each = 10,800 VT rubber bands, tape, oxygen, handling charges-200 VT/1000fry = 3,000 VT, transportation from NAS-Nadi airport road or air freight=12,000 VT | 71,700 VT |
| b. Freight charges Nadi-Port Vila- (2000 pls total weight 30kg cost $180.38. The 14,700 fry weight 225 kg - cost - $F1,352.85~ 81,171 VT. Air Vanuatu freight charges ex-Nadi | 81,171 VT |
| c. 200 kg chicken fertilizer (free Vanuatu Poultry farms) cartage | 5,000 VT |
| d. Approx. 14 bag of feed at F$43.00/bag = F$602 = 36,120 VT (Shipment by Sea –Port Services –Vanuatu- Limited) cost F$268.36 = 16,100 VT i.e., F$536.75 for every cubic meter of feed (note one cubic meter will take 32 bags) | 52,220 VT |
| e. Miscellaneous expenses (harvesting, transport, marketing) | 40,000 VT |
| f. Labour 240 days @ 400 VT/day | 96,000 VT |
| TOTAL | 346,091 VT |

<table>
<thead>
<tr>
<th>SALES</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 80 % survival, there will be 11,760 pcs of marketable size prawns average wt. 30 g. Therefore 352 kg at 1,000 VT/kg</td>
</tr>
</tbody>
</table>

Less operational cost

TOTAL 5,909 VT
GROSS INCOME

ROI = (5909 VT/ 167,500 VT) x 100 = 3.5%
PP = (167,500 VT/5909) = 0.035 years

TOTAL PROJECT COSTS

546,000 VT

6.3 Recommendations

The costs and revenue projected in the above tables indicate that seed and feed including their freight charges are the most expensive items, accounting about 71% and 59% of the total operating cost for tilapia and prawns respectively, followed by other costs.

The projected cost of importing 11,760 tilapia fry to Port Vila is VT 47,400. This is based on: cost of fry VT 23,520 (@ 2Vatu/fry), packing and handling charges is estimated to be VT 11,880. A total of 500 fry will be packed into each of the plastic bags (double layer) filled with 5 litres of water and oxygenated. Two plastic bags of fry will be packed into one styloform box. A total of 12 boxes will be required for carrying the 24 plastic bags of fry. The transportation of fry from NAS to Nadi either by air or road is estimated to cost about VT 12,000. The best option for transport from NAS to Nadi is by air as it takes less time minimizing the handling of the boxes. It will take 30 minutes for the fry to be packed at NAS and thereafter 30 minutes for it to be transported to Nausori airport and then loaded on to a domestic flight to Nadi. The flight time from Nausori to Nadi is approximately 45 minutes.

Fiji’s Airport Terminal Services requires that any items to be sent overseas by airfreight have to be checked-in 2 hours prior to departure of the flight. The flight from Nadi to Port Vila is about 2 hours. Considering it will take a further 2 hours for Customs and Quarantine staff to certify clearance at Port Vila, and also 30 minutes for transportation to VFD, approximately 9-10 hours will be required from the time the fry are packed at NAS to the time the fry are released into quarantine tanks at VFD at Port Vila.

A total of 500 tilapia fry will easily survive for 10 hours in 5 liters of oxygenated water. There should be negligible mortality if proper packing and handling procedures are followed.

The transportation of prawn post-larvae would take same route as for tilapia fry and thus same number of hours (9-10 hours) for transportation. The differences are: the cost of post larvae is VT 3 for each and that 1,000 prawn post larvae will be packed into each of the plastic bags.

The simple cost evaluation and transportation arrangements given above lead to the conclusion that shipment of tilapia fry and prawn post-larvae from Fiji by air is the best arrangement available. There are no other hatcheries within the region that could supply post-larvae and tilapia fry. The NAS has the capacity to provide certification of the health status of the stocks as well. The option of either using locally available feed or importing feed from Fiji is given in another section.
Despite the fact that the annual production cost is projected for 2 small ponds and based on the assumption that the seed and feed supplies are imported from Fiji, there is still modest amount of profit to be made indicating good prospects for tilapia and prawn farming if these resources are produced or made in the country.

7.0 FEED AND INPUT SOURCES

7.1 Feed quality and feeding rates

Poor quality feed results in poor growth. Feeding pellets reduces selective feeding on individual ingredients and the loss of micro-ingredients such as vitamins and minerals. Feeding pelleted floating feed to tilapia will result in a higher feed conversion ration and similarly feeding a water stable pelleted feed to prawns will also result in higher feed conversion. In addition, health and well being of the fish can be assessed from the pond bank by observing the feeding vigor and also during the sampling times.

Studies indicate that maximum growth of tilapia is achieved while feeding them at crude protein (CP) dietary levels of 35-50% for adults. However, economically optimum levels of commercial diets are usually 25-35%. A minimum of 35% CP level is recommended for juvenile diet and 25% CP for adult. Feeding rates for tilapia is a function of size, water temperature, fish biomass, density and the natural feed in the water. The optimum feeding rate using quality feed (CP 28-32%) at 25-29°C is presented in Table 4 below.

Table 4: Recommended daily feeding rates for tilapia at 25-29°C using high quality feed.

<table>
<thead>
<tr>
<th>Average weight (g)</th>
<th>Feeding rate (% body weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–5</td>
<td>8.0</td>
</tr>
<tr>
<td>5–20</td>
<td>5.0</td>
</tr>
<tr>
<td>20–100</td>
<td>4.0</td>
</tr>
<tr>
<td>100–200</td>
<td>3.0 (3.0–3.5%)</td>
</tr>
<tr>
<td>200–400</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Although it was not possible to undertake a complete survey of all the feed ingredients available in Vanuatu, the information given in Table 5 was collected during field visits.

Vanuatu Abattoir Limited located at Port Vila and Santo Meat Packers Limited at Santo have been processing beef meat and producing quality meat meal (Plate 32). Meat meal is derived mainly from processed bone, skin and rejected parts. It is usually packed into 50 kg and 18 kg bags and sold at VT 990 and VT 440 per bag respectively. Santo Meat Packers Limited packs in 35 kg bags and exports to Europe at VT 788 per bag. But lately the exports have been stopped due to a disease (BSC) found in meat meal in Europe. The company is pursuing to analyze crude protein levels on a regular basis to maintain quality standards and sells in other international markets as recommended by SPC aquaculture consultant.
The reported prices of the commercial poultry feeds given by companies in Port Vila are: Chicken starter (CP 15%) - unit price VT 91/kg; Red label pellet (CP 15%) - unit price VT 75/kg; Chicken grower - unit price VT 85/kg and Chicken layer - unit price VT 85/kg. The Toa Poultry Farm sells at following prices: Chicken starter - unit price VT 62.5/kg; Chicken layer - unit price VT 57.5/kg. This company provides chicken manure free of charge to the farmers.

The Santo Copra Mill located on Santo Island purchases copra (Plate 33) and produces oil and its by-product a very high quality copra meal. It has machinery to grind the copra meal particle size according to requirements of the customers. It also maintains a very high standard in quality control. All the copra meal produced is exported to Australia and there is nothing left to be sold locally. The current selling price is Vatu 12,500 per tonne.

In addition to the above products, there are other companies that produce agricultural by-products that could be used as aquaculture feeds. Discussions with some companies and agencies indicate that they will import feed products from Fiji, Australia and even Asia if sufficient quantities (volumes) are required i.e., container loads.

Crest Feed Mill Limited based at Nausori, Fiji presently produces tilapia mesh (CP 23%) - unit price F$0.50/kg and tilapia pellet (CP 29%) - unit price F$0.86/kg and sells to government farms and all the tilapia and prawn farmers throughout the country. It also exports tilapia pellets to American Samoa and other countries in Asia. It has laboratory facilities for monitoring quality (CP level etc.) and also supplies the samples from the same batches to The University of the South Pacific to do parallel analysis in order to maintain international quality standards.

In Fiji, tilapia pellet is also used as prawn feed as there are no specific feeds for prawns developed as yet. Growth rate of 30-50 g in 4 months is easily achieved provided farmers feed their prawn regularly. The company is keen on exporting tilapia mesh and tilapia pellet into Vanuatu provided sufficient volume is ordered.

### 7.2 Recommendations

One of the major constraints to tilapia and prawn culture development in Vanuatu will be the availability of feeds and fertilizers. It is recommended therefore that a detailed survey be conducted of the agricultural feed and fertilizer resources of Vanuatu. This survey should include where the individual resources are geographically located, how much is available, seasonality of availability, the composition and cost of this resource at sources, transportation costs to point of use and its shelf life. This information would assist farmers to develop their own feeding strategies, maximize the utilization of local agricultural by-products and thus minimize the use of imported feeds.

It is also recommended that proper analysis of crude protein level of all agricultural by-products and other commercial feeds (poultry, hog etc) be carried out at a certified (ISO 9001) laboratory. The data generated should be used for formulating diets (mesh and pellets) that will be suitable for feeding the various sizes of tilapia and also prawns by the farmers. The data should also be published in a report form for
distribution within Vanuatu and the region for the benefit of the aquaculture sector and the feed milling companies.

Table 5. List of feed ingredients that can be utilized for feeding tilapia and prawns.

<table>
<thead>
<tr>
<th>Source: complete address in Appendix 3.</th>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanuatu Abattoirs Limited Port Vila</td>
<td>Meat bone meal</td>
<td>50kg/bag = 990 VT/bag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18kg/bag = 440 VT/bag</td>
</tr>
<tr>
<td>Santo Copra</td>
<td>Copra mill—several grades</td>
<td>12 VT/kg</td>
</tr>
<tr>
<td>Toa farm (Poultry farm) Port Vila</td>
<td>Chicken starter feed</td>
<td>2,500 VT/40kg</td>
</tr>
<tr>
<td></td>
<td>Chicken layer feed</td>
<td>2,300 VT/40kg</td>
</tr>
<tr>
<td></td>
<td>Chicken manure</td>
<td>free</td>
</tr>
<tr>
<td>Vanuatu Agriculture Supplies, Port Vila</td>
<td>Chicken grower -CP 15%</td>
<td>3,640 VT/40kg</td>
</tr>
<tr>
<td></td>
<td>Red label pellet-CP 15%</td>
<td>3,000 VT/40k</td>
</tr>
<tr>
<td></td>
<td>Cracked corn-CP 7%</td>
<td>3,850 VT/40kg</td>
</tr>
<tr>
<td></td>
<td>Sulphate of Potash-fertilizer</td>
<td>4,280 VT/40kg</td>
</tr>
<tr>
<td>Riverina Stock Feeds, Westend, Queensland</td>
<td>Suppliers of feed to Vanuatu Agriculture supplies</td>
<td>Can provide feed on demand</td>
</tr>
<tr>
<td>Crest Mills —Fiji</td>
<td>Tilapia pellet-CP 29%</td>
<td>2,580 VT/50kg</td>
</tr>
<tr>
<td></td>
<td>Tilapia mesh-CP23%</td>
<td>1,500 VT/50 kg</td>
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<tr>
<td></td>
<td>Others available too</td>
<td></td>
</tr>
<tr>
<td>Port Services (Vanuatu) Limited: shipment: Suva to Port Vila</td>
<td>1 x cubic meter fish in F$</td>
<td>1 x cubic meter in VT</td>
</tr>
<tr>
<td></td>
<td>Freight F$375</td>
<td>Freight: 22,500 VT</td>
</tr>
<tr>
<td></td>
<td>Documents F$90/set</td>
<td>Doc: 5,400 VT/set</td>
</tr>
<tr>
<td></td>
<td>Processing fee F$65.75</td>
<td>Processing: 405 VT</td>
</tr>
<tr>
<td></td>
<td>Cartage F$65/RT</td>
<td>Cartage: 3,900 VT</td>
</tr>
<tr>
<td>Air Vanuatu: freight Nadi-Vila-for 30 kg</td>
<td>Freight F$4.10/kg</td>
<td>Freight 246 VT/kg</td>
</tr>
<tr>
<td></td>
<td>ATS fee F$11.25</td>
<td>ATS fee 675 VT</td>
</tr>
<tr>
<td></td>
<td>DOXS F$46.13</td>
<td>DOXS 2,767 VT</td>
</tr>
<tr>
<td></td>
<td>Total: F$180.38</td>
<td>Total: 10,822 VT</td>
</tr>
</tbody>
</table>

Since feed generally represents the largest single operating cost item of finfish and crustacean farming operations, particular attention must be focused on the development of research strategies aimed at reducing feed costs and improving on-farm feed and fertilizer management techniques. A logical step to achieve this would be to study feeding and fertilizer strategies currently employed in countries like Fiji followed by a detailed appraisal of its application in Vanuatu. Only by taking such initiatives can feeding and fertilizer deficiencies and constraints of farmers be identified in advance, which can then also be incorporated into future research activities of VFD.

It is essential that research activities in feeding be aimed at finding local solutions by supporting applied on-farm based research rather than conducting pure or fundamental research. To start this process, it is also recommended that VFD purchase some basic feed processing equipment namely, mixers, hammer mill
(grinders), sieves, small pelletizing machines and storage facilities. Although some of these equipment, for example, grinders, may not be required for the production of simple feed mash, it is essential for the production of pellets that all ingredients be first ground so as to pass through a 1 mm sieve (for grower feed) and a 0.5 mm sieve (for starter feed), so that the pellets or crumbles produced have good water stability and a low content of fines.

8.0 QUARANTINE PROTOCOLS

8.1 Existing provisions

Extracts from Chapter 201 ANIMAL IMPORTATION AND QUARANTINE from Laws of The Republic of Vanuatu (REVISED EDITION 1988) state the following:

An Act to make provisions for the regulation and control of the importation of animals, animal products and biological products into Vanuatu, and for matters connected therewith.

In the Act “animal” means any living stage of any member of the animal kingdom except human beings and includes arachnids, birds, crustacean, fish, insects and reptiles and also any fertilized egg or ovum;

The definition of ‘animal’ as given above gives us the understanding that tilapia and prawn importation and its quarantine is part of the Act. Other usual terminologies like ‘disease’, ‘carcass’ ‘quarantine area’ are also given with its definitions as found in the Act of the countries as in this Act too. Also included are other conditions and regulations like, restrictions on importation, provisional import permits, declaration on arrival in Vanuatu, enforcement of quarantine measures, power to inspect etc. But there are no specifics given in the Act on the actual procedures and protocols to be followed or implemented including which facilities and sites are available for quarantine of fishes and crustacea. For example, it is stated in the Act [page 5, number 9 (e)] that a veterinary officer may order the treatment, disinfection, fumigation or sterilization, as the case may be, of any animal, animal product, biological product or related article.

Director of Quarantine Department and Senior Officer, Robert Jimmy of VFD were helpful in providing the information on quarantine and are keen in developing procedures and protocols for importation of live fish and crustacea into Vanuatu. As such, an example of protocols based generally on international codes of practice is given as recommendation.

8.2 Recommendations

The following protocols based on international codes of practice and which may have included one or more of the existing protocols of Vanuatu are included to serve as general guidelines for the staff of the VFD and Quarantine Department. These are in addition to any other national requirements that are in the Act.
Vanuatu (Receiving Country)

- Stocks to be imported as eggs or as other early life history stages.
- Qualified personnel should examine shipments for freedom from prescribed pathogen/parasites and other biota. If diseases are identified, destroy shipment and dispose off in appropriate manner unless effective treatment can be guaranteed.
- Quarantine the imported fish for at least 30 days.
- Disinfect introductions upon arrival at quarantine unit if possible. If young fish are imported, give prophylactic bath.
- Upon arrival at quarantine unit, destroy or sterilize all water, packing materials, containers or other associated shipping materials.
- Quarantine sites must be secure against escapes and discharges of water. Water must be safely disposed of.
- If the quarantine unit suffers a disease outbreak that cannot be controlled, destroy diseased stocks and dispose of after sterilization in approved manner. Monitor quality of water at the quarantine unit, at regular intervals.
- Continue periodic checks for introducible parasites and diseases.
- Original imports should not be transferred to natural environments.
- Compile a list and periodically update known parasites and diseases and pathogens.
- Advise exported in case of unexpected occurrence of parasites or pathogens

VFD in collaboration with Vanuatu Quarantine and Inspection Services should ensure the exporting country/agency:

- provide information on:
  - Numbers
  - Origin and nomenclature (scientific, common and local names) of stocks [Specify geographical location where stock is collected. If stock originally came from another locality, it would be useful if name of that locality is provided. Specify breeding history, if known.]
  - Growth stage at time of export (eggs, yolk-sac larvae, post-larvae, fry, fingerlings)
  - Disease history
  - Parasite/predator history
  - Competition with other species [Include all possible aspects of competition such as food, habitat and reproduction, if available. If not, state as unknown.]
  - Feeding habit
  - Reproductive characteristics (e.g., at first maturity, spawning in stagnant or running waters)

- Certify from prescribed parasites/pathogen/other biota
- If possible, disinfect stock prior to shipment. This will take several days to implement as follows:

**DAY 1**

Harvesting of fry/fingerlings and grading/sorting into different sizes (to be done early in the morning with appropriate equipment).
Pathological/parasitological examination (visual and microscopic; to be done after several hours has lapsed, i.e., in the afternoon).

Conditioning of selected fish in continuous flow of water.

**DAY 2**

Prophylactic treatment; dip or bath (suggest prophylaxis be given early in the morning with continuous aeration and water flow).

Feeding (fry mesh at 2-3% of fish body weight, 2 times a day, continuous aeration and flow of water must be provided).

Parasitological examination (verify presence of parasites, in the afternoon or at any appropriate time).

**DAY 3**

Preparations and issuance of Fish health certificate (sample certificate used by NAS in Fiji can be used as sample for making one for VDF).

Packing and ready to transport late in the afternoon (especially for local trips).

In case the fish transportation is cancelled for the following day, feeding of treated fish with 2-3% body weight will be continued for the whole day. Continuous flow of the water must be provided.

**DAY 4**

Suggest that fish transportation to take place early in the morning or late in the afternoon. If fish are to be transported late in the afternoon, fish should be starved.

Any of the following alternatives may be applied:

1. Dipping the fish at 5% Sodium Chloride (50 ppt NaCl, ordinary table salt) for 5 minutes will help kill to ectoparasites.

2. Dipping the fish at 20-40 ppm potassium permanganate (0.02 –0.04 KMnO₄) will be beneficial in controlling and killing ectoparasites. For procedures refer to Appendix 4 and 5.
9.0 PRAWN AND FISH MARKET

Several types of imported prawn and shrimp products were observed at the main supermarket and a few small outlets in Port Vila (Plates 34-37). These are available under the following labels - Go-Go, Sea Breeze, Paradise prawn etc. The most common brand is the New Caledonia shrimp. Hoteliers and other consumers buy prawns from these sources and there appears to be no competition for the price for all the forms of the product.

1. Go-Go Raw Head-on shell-on (16/20) 800 g 3995 VT
2. Cooked Shrimp Sea Breeze (60/90) Pink Tiger shrimp 1 kg 3,800 VT
3. New Caledonia shrimp (31/40) 500g 2250 VT
4. French Pacific Paradise Prawn (31/40) 1 kg 6,200 VT
5. Black tiger shrimp 1 kg 5,200 VT
6. New Caledonia Prawn (whole) 500g 2,300 VT
7. New Caledonia Prawn (whole) 1.5 kg 6,500 VT
8. Shrimp peeled 1 kg 3,800 VT
9. Monodon type half cooked 1 kg 4,800 VT
10. Freshwater prawn 1 kg 1,200 VT

Seafood products sold at La Tuque a poisson, a small fish market outlet in Port Vila are:

Poulet and bream 800 VT/kg
Fillet of bream 1500 VT/kg
Mahimahi fillet 1400 VT/kg
Cut pieces 800 VT/kg

Large quantities of these prawn products are imported from New Zealand, Australia and Asian countries. Discussions with wholesalers and retailers indicate a willingness to purchase locally produced prawns as they assume it will be cheaper and fresher. One of the retailers is willing to market live tilapia and prawns provided there are sufficient quantities produced and available regularly.
10.0 DEVELOPMENT CONSTRAINTS AND OVERALL RECOMMENDATIONS

Considerable thought and planning are required when selecting sites for production ponds. Construction costs, provision of security, ease and cost of operation and productivity can be greatly affected by the site selected. Selection of pond sites on flat land would seem to be a simple matter but many factors are involved and these should be given careful consideration while carrying out the site survey. Otherwise one may find that the costs and problems associated with production are prohibitive with respect to profits. For example, some sites surveyed did not have adequate supply of suitable quality water for prawn culture (hence marginal), however, the topography and soil types were generally good for pond construction and thus suitable for tilapia culture.

i) Observed development constraints

On the basis of the survey, literature sources and meetings with VFD staff, the following development constraints were identified:

- Lack of training and knowledge of VFD staff in aspects of tilapia and prawn farming
- Lack of up-to-date information concerning tilapia and prawn culture plans and policies
- Lack of information concerning the available feed and fertilizer resources within the different regions of Vanuatu
- Lack of information regarding transportation links and costs involved in importing items into Vanuatu
- Lack of published technical information concerning tilapia and prawn farming technology for application by extension officers and farmers
- Lack of published market information on fish and fish products and other aspects.

The constraints mentioned above are similar to those experienced by the private sector. Given below are general recommendations and views for developing tilapia and prawn farming in Vanuatu. These are based on observations, surveys, literature sources and discussions with staff of VFD and other agencies in Vanuatu.

ii) Tilapia/prawn culture development

Vanuatu does not have any tilapia or prawn farms. However, since 1960s tilapia culture and in early 1980s, prawn culture has been the focus for technical development and attention. The majority of these projects were designed to provide a means of economic development for the islands to provide food, employment and income. The VFD acknowledges that they are empowered and have a leading role in promoting, supporting and regulating the development of aquaculture. However, there is no policy or plans for aquaculture.

Therefore, there is a need to establish a ‘aquaculture specialist unit’ within the Research Division of VFD, with skills and experience to undertake aquaculture development planning within the context of planning for the overall economic
development of Vanuatu. This should include specific policies or master plan for the development of tilapia and prawn aquaculture including a legal framework. The 'unit' will also need to interact and develop linkages with other Government authorities and agencies concerned such as Agriculture, Rural Development, Public Works Department, Education, Health etc. in formulating the plans.

iii) Marketing issues

There seems to be good market for locally grown prawns and fish in Vanuatu. It is therefore recommended that ni-Vanuatu should attempt to farm prawns and fish and sell in the domestic market and thereby compete with imported products. In addition, a step-by-step approach should be taken to developing the domestic markets and the VFD to provide support in all the stages of development.

iv) Consultation with stakeholders

Effective consultation by government departments and agencies with the ni-Vanuatu people and their participation in all stages of the planning process are essential prerequisites for successful tilapia and prawn culture development. It should be noted that ni-Vanuatu own almost all the land and hence there is a need for their participation in developing the plans. There is a need to explore options that exist to integrate development-planning strategies for tilapia and prawn culture planning for other complimentary activities of the islands.

v) Resource inputs

The resource inputs for tilapia and prawn culture are limited in Vanuatu. Given the high-risk nature of these culture systems and the difficulties inherent in establishing viable farms, proponents should be made fully aware of the need for a long-term commitment to any proposed project. It is recommended that VFD establish tilapia and prawn demonstration farms in selected sites and carry out on-farm trials and demonstration including result demonstrations etc.

vi) Pond construction and equipment purchases

Pond construction has been carried out at several sites without any proper planning, causing a lot of difficulties to the farmers and villagers, for example at Saret village on Santo. Fishpond design and construction have a basic influence on the efficiency and economy of pond fish production. Although technical standards and design criteria have been elaborated in many countries, their collection and systematic evaluation, together with the preparation of guidelines (applicable to Vanuatu conditions), would be most useful for VFD staff and farmers.

Different equipment and methods have been designed and used for tilapia and prawn hatchery and grow-out technology. The equipment that proves to be most efficient, durable and spare parts available needs to be considered for purchases. This has the advantage of reducing the costs and the long-term viability of the projects.

Since tilapia and prawn culture has yet to commence in Vanuatu, it is proposed that before any work is initiated, ensure a thorough assessment is carried out of the
selected site to assess its physical, biological and ecological features including relevant economic and social factors. Ensure that the farmer/villagers are aware of the methods to be employed to construct ponds, equipment required to eliminate any adverse effects or waste unnecessary time and labour.

vii) Government subsidy

The establishment of a government sponsored subsidy scheme is considered an important component of any aquaculture development strategy in a developing country and there is a need for one for ni-Vanuatu. The ‘aquaculture specialist unit’ recommended in earlier section should be entrusted of developing such a subsidy scheme for tilapia and prawn farmers. An important component of this scheme will be the identification of industry parties interested in becoming involved in the scheme. A register of potential companies willing to assist Vanuatu or forming joint venture schemes with ni-Vanuatu should be made by the ‘unit’.

The ‘aquaculture specialist unit’ should make proposals to relevant government authorities for a scheme or plan for development of tilapia and prawn culture in Vanuatu. It should also develop a database of all the potential farmers and maintain links between farmers, communities and industries including - excavator companies, hardware suppliers, feed processors, poultry farms, shipping companies and other service suppliers etc. The ‘unit’ should promote establishment of working groups to unite and represent ni-Vanuatu with a common interest in developing tilapia and prawn aquaculture i.e., peak bodies or associations.

viii) Information on services

To allow for ni-Vanuatu to take advantage of the various services, funding schemes and programs for tilapia and prawn culture development initiatives (the government may like to provide), an information leaflet should be developed that provides all relevant details. In addition, the range of services, loans, grants that may be available through ‘aquaculture specialist unit’ and other agencies, the processes the agencies uses to assess applications and the time it takes to do so, need to be clearly documented to enable applicants to have a clear understanding of the processes.

As mentioned, the ‘aquaculture specialist unit’ should develop a detailed document that identifies all organizations that might provide services, programmes and funding guidelines for tilapia and prawn development projects.

ix) Networking and technical information

One of the requirements for ni-Vanuatu tilapia and prawn farming development will be the availability of culture technologies that suit the conditions under which the farmers and villagers will be operating. VFD should be encouraged to focus efforts on and accommodate the requirements of the farmers in relation to their development needs. The Department should look at opportunities to collaborate with agencies (SPC, USP, FAO, ACIAR and Worldfish Centre) and develop linkages as they advance in the development of aquaculture. There are a lot of experiences that these agencies have acquired in the region and will be useful for the VFD in their efforts to promote and develop their tilapia and prawn farms.
Ni-Vanuatu are hardworking people and will succeed provided proper guidance is given in lieu of starting their tilapia and prawn farms. The existing technology for tilapia and prawn culture needs to be adapted to suit conditions under which the ni-Vanuatu practice raising freshwater prawn _Macrobrachium lar_ in taro patches and also tilapia in small pools. Effective means of transferring suitable technologies need to be derived and practiced by VFD with its links with a regional agency like SPC.

There is need for focusing and giving special attention to ni-Vanuatu for development of their tilapia and prawn farms. For example, it is necessary to translate the outcomes of tilapia and prawn culture development at NAS in Fiji into practices that can be transferred and realistically applied by the ni-Vanuatu in their farms. There is a need for a regular communication link with the various agencies in the region involved with aquaculture and fisheries development and participation in all the technical meetings etc.

x) Education and training

As there are no tilapia and prawn farms currently in operation, ni-Vanuatu who have undergone some form of education or attachment training often cannot practice their skills in Vanuatu. To allow them to gain experience, these trained people should be placed in a working environment where they can practice what they have learnt.

Furthermore, ni-Vanuatu staff seeking to become involved and develop a career in aquaculture is uncertain about the education and training requirements. It would be helpful to have access to information that clearly outlines the possible career path and opportunities that may arise as well as providing details of education and training requirements.

To cater for specific needs of ni-Vanuatu people, there is a need to consider providing training courses based on currently available and accredited aquaculture modules. The training course should include trainings offered by Fiji Fisheries Department as well as the more formal training offered by The University of the South Pacific (USP) and the short-term, on-farm traineeship and work experience.

To provide guidance for ni-Vanuatu who wish to follow a career path in aquaculture (tilapia and prawn culture), VFD should prepare documents that clearly explains the training and education that exist, as well as some details about education and training requirement and opportunities (government and donor scholarships) for its staff.

VFD should consider running training courses for ni-Vanuatu based on regional experiences. In addition, VFD should develop links with Fiji Fisheries Department and other relevant agencies (e.g. USP) that can provide skills-based training courses for ni-Vanuatu and where appropriate, provide traineeships to the people to attend the course. It should also seek and develop a job-placement programme to place trained ni-Vanuatu in commercial aquaculture farms to gain relevant experiences.
xi) Social and cultural factors

Foreign companies who wish to operate joint ventures with ni-Vanuatu in commercial aquaculture, have very limited or no experience of the relevant social and cultural issues in Vanuatu. To facilitate the development of joint ventures in tilapia and prawn culture, an information paper needs to be developed that identifies social and cultural issues and provides a set of guidelines for doing business with ni-Vanuatu. This document should be specifically related to aquaculture and could be based on similar existing documents that deal with other industries in Vanuatu.

Therefore it is recommended that VDF prepares a paper that provides guidelines of how to do business including development of joint venture projects with ni-Vanuatu with the specific requirements for tilapia and prawn culture.

11.0 REFERENCES


Climate Summary for Winter. 2003 (May to October, 2003).


Vanuatu Fisheries Division 2000 Annual report.

Vanuatu Fisheries Division 2001 Annual report.


12.0 LIST OF PLATES

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Plate 7  Plate 8  Plate 9
Plate 10 Plate 11 Plate 12
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APPENDIX 1

Background on Vanuatu

Vanuatu is an archipelago of approximately 83 islands is situated in the South-western Pacific Ocean, about 1,750 kilometers east of Australia and 500 kilometers northeast of New Caledonia. It lies between latitude 13° south and 23° south and longitude 166° east and 172° east.

Vanuatu is an independent republic with a population of 195,000 in 1999. The main towns are: Port Vila, capital on Efate, population 32,000; Luganville on Santo, population 10,000. The land area is 12,195 km² (12 main islands and 58 inhabited islets: Santo, Malekula, Erromango and Efate making up about half the total land area. Next in size are Ambrym, Tanna, Epi, Vanua Lava, Gaua, Ambae, Maewo and Pentecost. Sea area EEZ is 680,000 km².

![Figure 7. Map of Vanuatu.](image)

Land and sea

The total land area is 12,190 km². The land tenure system before the colonial and commercial impacts of the 20th century are varied and complex in Vanuatu. The land tenure systems are still important as most of the land remains under some form of customary tenure. The present land tenure systems are frequently referred to as
‘traditional’ or ‘customary’. These terms are used although most systems have been modified to meet the requirements of new forms of economy, technology and social organization.

Vanuatu’s 200-nautical mile Economic Exclusive Zone (EEZ) encompasses 680,000 km² with ownership of a further 230,000 km² surrounding the Hunter and Mathew islands near New Caledonia yet to be resolved. The reef area comprises 448 km². There are no records of total coastal shoreline and area of freshwater lakes and rivers.

Physical environment

The islands are mountainous, of volcanic origin with a narrow coastal plain. The young volcanic islands, some of which are still active, form a central chain extending south from the Banks Islands, broadly located to the west of Fiji and north of New Caledonia, between latitude 12-21° south and longitude 166-171° east. While several islands (the Torres islands, Santo, Malekula, Maewo and Pentecost) are formed from belts of older sedimentary rock, repeatedly uplifted and tilted, the eruptions, which split a large island into the present Shepherd group in the east, occurred only about 600 years ago. Santo has several high peaks, rising to a height of 1875 m above sea level (Mt Tabwemasana), with Mt Lairiri at 1650 m. Yasur on Tanna is an active volcano, as are Lopevi and Mt Garet, on Santa Maria and Suretimeat on Vanua Lava. The last serious eruption of Yasur was in 1978 when the southeastern end of the island was uplifted, reducing the depth of the harbour at Port resolution. The volcano has remained active but not dangerous, and the ease of visitor access to the crater’s rim is now promoted.

The predominant vegetation is dense rainforest, broken on some of the southern islands by patches of grassland, and there is some mangrove swamp. Coconuts grow widely as do introduced flora such as flamboyant, hibiscus and frangipani. Subsistence crops include yams, sweet potato, cassava, taro, breadfruit and bananas. These starchy staples make up most of Vanuatu’s indigenous crop plants and are grown in wide variety of cultivation systems, ranging from classic polycultural system to highly intensive, monocultural plots of yams, taro etc. Many fruit and nut species are used as food throughout Vanuatu. Most are ‘indigenous’ plants which have been domesticated in the region or were domesticated elsewhere and introduced in pre-European times. Some are rich in carbohydrate, such as breadfruit and are dietary substitutes for root crops and bananas. Others are rich in oil, and valuable where the oil of fat content of diets is low. Some fruit and nuts provide useful amounts of vitamins. A variety of fruits and nuts grow in most of the islands and also sold in the local markets, for example peanuts.

The climate is hot and wet, with southeast trade winds blowing most of the year and occasional hurricanes from January to April. Average humidity at Vila is 83%. Rainfall distributions through Vanuatu are mostly controlled by the two major ENSO events, El Nino and La Nina. For example during a La Nina year rainfall are expected to be above average while that of El Nino should be below average. During La Nina year of 1999 and 2000, rainfall were above average for Bauerfield (E fate) and Pekoa (Santo) Stations. Bauerfield – 4104.4 mm (1999) and 3229.0 mm (2000), Pekoa – 2705.4 mm (1999) and 3467.8 mm (2000); The annual long-term average (30 years) rainfalls for Bauerfield and Pekoa are: Bauerfield – 2181.2 mm and Pekoa –
2366.3 mm. Temperatures and rainfall are lower in the southern islands. Rainfall analysis for Bauerfield and Pekoa for the last 10 years is available on request. (Vanuatu Meteorological Service, 2003).

**Fisheries**

Subsistence fishing is significant and is an important source of protein for most island communities. The coastal dwellers fish regularly for home consumption, selling the surplus (either cooked or fresh) locally for cash.

The fisheries resources of Vanuatu are comprised of three main components. These are: the various species of tuna, the deepwater bottom fish (referred to as ‘poulet’) made up of snappers and related species, and the reef fish. Indications are that the population of all three types of fishery resource is limited and in some cases are not being properly exploited. The tuna resource is most likely near to being fully exploited by long line and purse seine vessels operating under permit in Vanuatu waters. The reef fisheries are over-fished in some areas, notably nearby the more heavily populated areas of Efate, Tanna and Santo but are generally under-exploited near the other outer islands. The deepwater snapper resource has the potential for some further exploitation but there appears to be definite limits.

The fisheries sector contributes about 1.0% to overall GDP and makes up only 5.5% of the primary production sector. In recent years marine exports valued at about VT 125 million per annum, mainly made up of trochus shell exports, have accounted for about 3.5% of total commodity exports. Licensing and access fees paid by tuna fishing vessels for access to Vanuatu waters amounted to some VT 82 million in 2000.

The importance of the domestic fisheries industry goes far beyond its contribution to the formal economy as it plays a significant role in supplementing protein supplies and providing income-earning opportunities for rural families.

**History of aquaculture**

Pacific oysters (*Crassostrea gigas*) were introduced from California for farming by a private farmer in 1971 (Autrant, 1973). Farming method used was the Philippine rack culture, the first farm being established at Mounparap Bay in Santo. This farm was set up with a long-term credit from New Hebrides Condominium. The second farm was established at Port Sandwich on the island of Malekula with the assistance from Local French Administration to provide an alternative to the declining prices of copra at the time. A third farm was set up at Efate, near Port Vila.

Spats were imported for all the farms, the first being 20,000 from the hatchery of W. Budge, Mariculture farm, Pescadero, California via New Caledonia. Other imports included batches of 100,000 spats every six weeks.

Collection of oyster spats was also carried at the sites of the farms using various materials. Trochus, giant clams and oysters shells gave satisfactory results with 30-50 oysters per shell. The results of collection tests using bamboo, fibro-cement, coral,
mangrove wood etc were poor and hence led to farmers loosing interest and thus discontinue farming of oysters.

In 1987, a black pearl farming operator from Tahiti conducted trials at Malakula on the indigenous species of black-lip pearl oyster (*Pinctada margaritifera*) but the trials had to be suspended due to conflict with the reef owners.

The success rate of aquaculture ventures in the Pacific Islands has been poor. In the final report of SPIFDA, it was recommended that feasibility studies be initiated on *Macrobrachium* farming (SPIFDA 1975). Local conditions and the availability of cheap feed were conducive to the establishment of prawn culture. Granperrin (1977) cautioned that prawn culture should not be attempted until the Centre National pour l'Exploitation des Oceans (CNEXO) in Tahiti prove the reliability of such farms.

In 1979, two trainees from New Hebrides spent six months studying *Macrobrachium rosenbergii* culture at the New Caledonia Aquaculture Center and at CNEXO, Tahiti (Crossland and Grandperrin 1979 b). The SPC supported the education of the two students at CNEXO (SPC 1978).

Experimental culture of freshwater prawn was being carried out on Efate (Crossland and Grandperrin 1979 b). In Vanuatu freshwater prawns (*Macrobrachium lar*) are known as Naura and tilapia (*Oreochromis mossambicus*) as tilapia.

In March 2003, two trainees from VFD spent 4 weeks studying hatchery operation of *Macrobrachium rosenbergii* at NAS, Fiji. The two trainees completed their training successfully, rearing post-larvae within 25 days of operation.

*Macrobrachium rosenbergii* qualifies as a suitable candidate for freshwater culture in the Vanuatu. Nevertheless, the current knowledge of prawn culture and farming is not fully known in Vanuatu. What is known is the following:

- It is a tropical species widely distributed in the Indo-Pacific region ranging from Australia to New Guinea to the Indus river delta.
- The distribution of the species is limited to the estuarine and freshwater zones of river mouths and backwaters with a temperature usually ranging from 25-24 deg. C and salinity (0-20 ppt)
- The larval biology is well understood and very good survival rates are achievable;
- The species is a bottom feeder and omnivore and accepts a variety of food items ranging from grains, worms etc.
- Growth is not continuous because of the hard exoskeleton covering the body and appendages. Visible growth takes place only at the time of immediately after molting.
- Growth rates of *Macrobrachium* are well documented from places throughout their range
APPENDIX 2

Terms of Reference

In cooperation with the Government authority concerned (Fisheries Department), other relevant government authorities and private sector in Vanuatu, the subscriber will:

Conduct a survey on development of Tilapia (*Oreochromis niloticus*) and Prawn (*Macrobrachium rosenbergii*) farming in Vanuatu with reference to:
- Tilapia and Prawn culture system appropriate to market conditions of Vanuatu,
- The numbers and status of likely beneficiaries (farmers, consumers etc.) of tilapia and prawn culture development, and assessment of impact of Tilapia and Prawn culture on them,
- Sources of certified post-larvae (including the claimed health status),
- Identification of the best option of transport arrangements for larvae and its cost estimation to Vanuatu,
- Identification of feed and input sources and likely costs at point of use,
- Cost estimate of setting up hatchery facilities for Vanuatu
- Quarantine protocols for trans-boundary movement of Tilapia and Prawn into the country, and
- Economic description of Tilapia and Prawn culture based on likely domestic and other markets, and indicate maximum scale of Tilapia and Prawn culture sector.

Assess the possibility of establishing freshwater hatchery using the existing Fisheries Department facilities.

Prepare recommendations for necessary Government and private sector actions required for sustainable Tilapia and prawn development in Vanuatu, with providing a written plan of ponds, directions of establishing pilot farm and trials

Work closely with local counterpart selected by the Government and provide him with technical advice on the knowledge and understandings of Tilapia and Prawn farming and management.

Report preliminary findings to the Government prior to departure from Vanuatu, and submit to SAPA a full report formatted in accordance with FAO style in MS WORD upon completion of study, for formal submission to the Government of Vanuatu.

Duration: 15 days (one week in Vanuatu and one week for work preparation and report writing)
APPENDIX 3

Travel Itinerary

16 November  Suva-Nadi- Port Vila.

17 November  Discuss terms of references and logistics of work with VFD staff. Survey tilapia hatchery site at Erapo with VFD staff.

18 November  Survey shops and feed companies, shipping agents

19th November  Survey Meat meal factory, quarantine department, Fletcher Construction

20th November  Survey prawn hatchery facility and meeting with VFD staff (Robert, Sompert and Felix). Site Survey at Ferori and several other sites.

21st November  AM meeting and gathering information, PM Tilapia hatchery pond construction supervision-Erapo site

22nd November  Tilapia Hatchery Pond construction supervision-Erapo. Completed 2 ponds

23rd November  Port Vila- Nadi
APPENDIX 4

Persons and organization contacted during the consultancy

1. Mr Robert Jimmy, Senior Biologist, Private Mail Bag 9045, Port Vila Vanuatu, Phone 678 23119, Fax 678 23641.

2. Moses Amos, Director of Fisheries, Private Mail Bag 9045, Port Vila Vanuatu, Phone 678 23119, Fax 678 23641.

3. Mr Felix Nguyen, Assistant Biologist Private mail bag 9045, Port Vila Vanuatu, Phone 678 23119, Fax 678 23641

4. Mr Sompet Gereva,: Biologist Private mail bag 9045, Port Vila Vanuatu, Phone 678 23119, Fax 678 23641.

5. Mr Glen, Fisheries Extension Officer, Fisheries Department, P.O. Box 211, Luganville, Santo, Vanuatu. Phone 678 36218, Fax 678 36155.

6. Mr Aru Ase, Prawn- M. lar Farmer, Sarete C/- P.O. Box 211, Luganville, Santo, Vanuatu. Phone 678 36218, Fax 678 36155.

7. Mr Alsen F.Obed, Senior Fisheries Officer, Fisheries Department, P.O. Box 211, Luganville, Santo, Vanuatu, Phone 678 36218, Fax 678 36155, Email alsenobed@yahoo.com

8. Sinko, JOCV Private mail bag 9045, Port Vila Vanuatu, Phone 678 23119, Fax 678 23641.

9. Masao, JOCV Private mail bag 9045, Port Vila Vanuatu, Phone 678 23119, Fax 678 23641.

10. Mr. Benuel Tarilongi, Director, Vanuatu Quarantine Inspection Services, PMB095, Port Vila, Vanuatu. Email: vqisvila@vanuatu.com.vu

11. David Challenger, manager, Teouma Prawns, P.O.Box 1123, Vanuatu. Phone 678 27590, Fax 678 27590. Email: teoumaprawns@vanuatu.com.vu

Supermarket/Hardware

1. Au Bon Marce, Down Town Market Place, Port Vila, Vanuatu.

2. Andrew Hobbs, Director, Wilco Hardware, P.O. Box 201, Port Vila-Vanuatu, Phone 678 22385, fax: 678 25371. Email: wilco@vanuatu.com.vu> Also refer Feed supplier from Australia

3. Warrick Sands, Accountant, Spare parts Controller, Vanuatu Agricultural Supplies Limited, P. O. Box 819, Port Vila, Vanuatu. Phone 678 22376, Fax: 678 23402. Email: vasvila@vanuatu.com.vu
4. Pacific Polytanks Limited, Vanuatu (Part of Wilco)

5. Asia Pacific Marketing Group, P.O. Box 314, Port Vila, Vanuatu. Phone 678 25555, Fax 678 25888

Hotels

1. Helter Olena, Crown Plaza Vanuatu Resort, P. O. Box 86, Phone 678 22313

2. Seafoods, P. O. Box 201, Port Vila, Vanuatu. Phone 678 24761, Fax 678 25761

Feed Suppliers

1. Hugh V. Langdale, Farm Manager, Toa Farm, P. O. Box 321, Port Vila, Vanuatu. Phone 678 23711, Fax 678 24334. Email: tofa@vanuatu.com.vu

2. Vanuatu Abattoirs Limited, P. O. Box 47, Vila, Vanuatu. Phone 678 22961/27439, Fax 678 26184. Email: valpac@vanuatu.com.vu


4. Vanuatu Poultry Farm-Free chicken fertilizer

Fish Sellers

1. Mr Augustin Pheu, La Touque a Poisson, Phone 678 25734

2. Felix Store

3. Road side Fish sales - 400-550vt/kg (low grade reef fish)

Freight Companies

1. Port Services (Vanuatu) LTD, Vate Electric Building, Lini Highway, Port Vila, Phone 678 22387, Fax: 678 23529: Shipment charges for 1 cubic meter fish feed Suva to Port Vila- freight F$375/RT, documents F$90.00/set, processing fee F$6.75, cartage F$65.00.

2. Copra importer from Santos-5000vt/tone or 1000vt/50kg bag

3. Williams & Gosling LTD, Suva. Shipment of Live fish ex-Nadi F$4.10/kg, ATS fee $11.25, DOXS $46.13, total $180.38 for 30 kg.

Earth Moving Companies

1. Mr Andre van Heerden, Project Manager, Fletcher Construction, New Zealand & South Pacific, The Fletcher Organization (Vanuatu) Limited, P O Box 167-
2. Entreprise Dinh Dominique Thu, P.O. Box 870, Phone 678 22125, Fax 678 24650.

3. S.M.E.T, P.O Box 70, Port Vila. Phone 678 22735, Fax 678 24677.

4. Mr Kuvu Noel, S.R & Const, Santo Roading & Construction, P.O. Box 310, Luganville, Santo Vanuatu. Phone 678 36 158, Fax 678 36 681. Email mws@vanuatu.com.vu

Others

1. Asian Development Bank, P. O. Box 127, Port Vila, Vanuatu, Phone 678 2330 Fax 678 23183.

2. Robson S. Tigona, Vanuatu Meteorological Service, Private Mail bag 9054, Port Vila-Vanuatu Phone 678 23866/24686 fax: 678 22310 Email: robsontigona999@hotmail.com
APPENDIX 5

Procedure for Prophylactic treatment using sodium chloride (ordinary table salt).

1. Preparation of all materials to be used: fish to be treated, sodium chloride, aerators, scoop nets, pales, alarm clock, measuring pitcher, plastic tubs/buckets.

2. Starve the fish for 24 hours prior to treatment. Ensure that detritus materials are not present and these materials can absorb chemicals and reduce effectiveness of the drug.

3. Filling-in of water into the plastic tubs/buckets until the desired level. Do not use galvanized containers as they tend to react with chemicals.

4. Dilution/mixing of chemical into the water. Ensure that any calculations of dosage are based on usable volumes of container.

5. Scooping of conditioned fish to undergo treatment. Make sure that fish density is not too large or excessive to create handling stress.

6. Always perform a preliminary treatment of a few fish before embarking in a large-scale treatment. Observe for at least 6 hours to see if the trial is successful.

7. Treatment proper
   
   Note:
   
   - Apply treatment during the coolest time of the day. Avoid temperature fluctuations from normal i.e., treat fish at the temperature where it was at.
   
   - Dissolved oxygen is the most important factor. It must be maintained at adequate levels. Use aerators. Monitor D.O. levels during and after treatment. Low D.O. levels lead to increased respiration thus, increased uptake of drug. Fish are stressed during treatment and have higher need for oxygen.
   
   - Watch the fish during treatment and be ready to interrupt proceedings and restore the environment to its original condition as rapidly as possible (by flushing with new water and forcing oxygen into the water) should the fish become distressed.

8. Only repeat the treatment of absolutely necessary to avoid stress. Repeated treatments are, however, necessary to kill parasites developing after the first treatment.

9. Keep record of all treatments, their purpose and the results for future reference.
   
   Note: 50,000 to 75,000 pcs of fingerlings is effective per treatment.
Example:

1. Calculate the rate of sodium chloride (salt) if:
   Volume of water  = 30 L
   Concentration  = 5%

   = 5 g/100 ml x 1000ml/1L
   = 50 g/L
   = 50 g/L x 30 L
   = 1,500 g in every 30 L water

2. Calculate the rate of sodium chloride (salt) if:
   Volume of water  = 30 L
   Concentration  = 50 ppt

   = 50g/1000 ml x 1000 ml/1L
   = 50g/L x 30 L
   = 1,500 g in every 30 L

*Note: 50,000 to 75,000 fingerlings is effective per treatment*
APPENDIX 6

Procedure for Prophylactic treatment using Potassium Permanganate (KMnO₄)

1. Preparation of all materials to be used: fish to be treated, potassium permanganate, aerators, scoop nets, pales, alarm clock, measuring pitcher, plastic tubs/buckets.

2. Starve the fish for 24 hours prior to treatment. Ensure that detritus materials are not present and these materials can absorb chemicals and reduce effectiveness of the drug.

3. Filling-in of water into the plastic tubs/buckets until the desired level. Do not use galvanized containers as they tend to react with chemicals.

4. Dilution/mixing of chemical into the water. Ensure that any calculations of dosage are based on usable volumes of container.

5. Scooping of conditioned fish to undergo treatment. Make sure that fish density is not too large or excessive to create handling stress.

6. Always perform a preliminary treatment of a few fish before embarking in a large-scale treatment. Observe for at least 6 hours to see if the trial is successful.

7. Treatment proper

   Note:

   - Apply treatment during the coolest time of the day. Avoid temperature fluctuations from normal i.e., treat fish at the temperature where it was at.

   - Dissolved oxygen is the most important factor. It must be maintained at adequate levels. Use aerators. Monitor D.O. levels during and after treatment. Low D.O. levels lead to increased respiration thus, increased uptake of drug. Fish are stressed during treatment and have higher need for oxygen.

   - Watch the fish during treatment and be ready to interrupt proceedings and restore the environment to its original condition as rapidly as possible (by flushing with new water and forcing oxygen into the water) should the fish become distressed.

8. Only repeat the treatment of absolutely necessary to avoid stress. Repeated treatments are, however, necessary to kill parasites developing after the first treatment.

9. Keep record of all treatments, their purpose and the results for future reference.

   Note: 50,000 to 75,000 pcs of fingerlings is effective per treatment.
Example of calculation of chemical:

1. Calculate the rate of potassium permanganate (KMnO₄) if:

   Volume of water = 30 L
   Concentration = 20 ppm

   \[ \frac{20}{1,000,000} = \frac{x}{30} \]
   \[ x = \frac{20 \times 30}{1,000,000} \]
   \[ x = 0.0006 \text{ L} \]
   \[ x = (0.0006 \text{ L}) \times 1000\text{ml/L} \]
   \[ x = 0.6 \text{ ml} \]

*Note: 50,000 to 75,000 fingerlings is effective per treatment.*