



## VALUE ADDING AND SUPPLY CHAIN DEVELOPMENT FOR FISHERIES AND AQUACULTURE PRODUCTS IN FIJI, SAMOA AND TONGA

### Scoping study for Tilapia (*Oreochromis sp.*)



Australian Government  
Australian Centre for  
International Agricultural Research

Institute of Marine Resources: Technical Report 04/2012



School of Marine Studies  
Institute of Marine Resources

**Value adding and supply chain development for fisheries and aquaculture products in Fiji,  
Samoa and Tonga: Scoping study for Tilapia (*Oreochromis sp.*)**

Institute of Marine Resources  
School of Marine Studies  
Faculty of Science, Technology and Environment  
University of the South Pacific

2011

Pacific Agribusiness Research and Development Initiative (PARDI) Project 2010/002:  
Value adding and supply chain development for fisheries  
and aquaculture products in Fiji, Samoa and Tonga

This publication should be cited as:

South, G.R., Morris, C., Bala, S. & Lober, M. 2012. *Value adding and supply chain development for fisheries and aquaculture products in Fiji, Samoa and Tonga: Scoping study for Tilapia (Oreochromis sp)*. Suva, Fiji: Institute of Marine Resources, School of Marine Studies, FSTE, USP. IMR Technical Report 04/2012. 18pp.

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Published by Institute of Marine Resources,  
School of Marine Studies, FSTE, USP,  
Private Mail Bag, Suva, Fiji.

ISBN: 978-982-9143-10-5

Cover photographs from left to right:

Lovell, E., 2008, *Porites cylindrical* coral off Suva waters, Fiji  
Morris, C., 2008, Prawn harvest at Navua Farm, Fiji.  
Morris, C., 2009, Tilapia harvest at Navua Farm, Fiji.  
Miller, C., 2010, Spinner dolphin off Moon Reef, Dawasamu, Fiji.  
Morris, C., 2011, *Caulerpa* at Tongan Market

Layout and Design: Dikoila A. Valemei

Printed by: University of the South Pacific

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## **INTRODUCTION**

Tilapia, named the 'food fish of the 21st century', is one of the most cultured freshwater fish in the world, farmed in more than 100 countries (Norman-Lopez & Bjorndal, 2009). A hardy and prolific, fast-growing tropical fish, it requires low input during grow-out periods and can be farmed successfully on any level, from extensive to intensive culture in ponds, tanks or raceways. It is disease resistant, tolerant of poor water quality, can eat a wide range of food types and be cultured in fresh or brackish water. Chemicals and antibiotics are not necessary for commercial farming (Fitzsimmons, 2006).

Integrated farming of crops (rice, poultry, sheep) with tilapia is a common practice in most parts of the world (El-Sayed, 2006). They are also used in aquaponics (integration of hydroponics and aquaculture), a system where fish and plants are grown together in a recirculation system. The plants (Rakocy *et al.*, 2004) directly use nutrients produced by the fish culture system.

Tilapia production continues to rise with global production figures predicted to reach 3.7 million tonnes by the end of 2011 (<http://www.globefish.org>). The growth in this field has doubled per decade with global tilapia landing (capture and culture) at 515,000 tons in 1984, over 1 million tons in 1995 (Fitzsimmons, 2000) doubling to over 2 million tons in 2006. Asia is the largest producer of farmed tilapia, contributing 75% of the world's tilapia production (SEAFISH, 2011) with China being the main supplier (<http://www.globefish.org>). The United States is the world's largest tilapia importer, with imports totaling over 215,000 metric tons in 2010, at a value of USD\$842 million (ERS, 2011).

Introduced into the Pacific Islands region in the 1950s, tilapia became a commodity for culture due to its low-cost and success in other regions. For Fiji and Samoa, tilapia was for human consumption and as potential pig feed (Costa- Pierce, 1998), although in Tonga it became an unsuccessful attempt to control mosquitoes. Fiji and Papua New Guinea both have policies of government support for tilapia farming in rural areas. Household-scale tilapia farming is common in the Pacific but medium-scale enterprises are now on the increase (Teri & Pickering, 2009).

Pond culture is the main culture method used in the Pacific although cage culture in a lake is practiced in Vanuatu. Integrated farming of tilapia with sheep, ducks and chicken is also practiced in Fiji, whereby the animal pen is built on top of the tilapia ponds, allowing waste to drop in the water and induce growth of primary producers (algae) which in turn are eaten by the fish. In addition, a few farmers practice poly-culture of tilapia with carp and/or prawns.

## **VALUE-ADDING OF TILAPIA**

The increasing demand for tilapia has also seen an increased number of value added products. In the 1980s, the only tilapia product in the international market was whole frozen forms, but with increasing demands, exporting countries started producing and exporting in increased quantity and quality (processed). The major tilapia producing countries produce tilapia as whole frozen, IQF fillets, fresh fillets and sashimi.

### Case study 1: Tilapia by-products in the global market

By-products from tilapia are available on the global market. **Tilapia skin** is used for a variety of leather goods like purses, clothing and accessories (Fitzsimmons, 2006; Fitzsimmons, 2004). Several companies in Brazil use treated and dry tilapia skin to produce dresses, skirts, vests, wallets, purses and briefcases. Another possible market for tilapia skin is as a pharmaceutical product. Several European firms are purchasing frozen or salted skins which are processed for gelatin and used to make time-released medicines, substituting material from tilapia skins for mammalian products (Fitzsimmons, 2004). Another by-product is its **trimmings and heads** as heads are used for soups in some countries. Fillet trimmings and throat meat can be recovered and used for ceviche and other preparations using small amounts of fish. Equipment also exists to facilitate the recovery of flesh through **de-boning of skeletons**. The flesh recovered provides a base for fish sticks, fish sausage, fish balls, fish sauce or other highly-processed forms. Carcasses, heads, and trimmings are also used for animal feeds. A cottage industry in Brazil is using **dry and curled tilapia scales** to make ornaments, such as flowers (Fitzsimmons, 2004) and a study by Dale *et al.*, (2004) looked at the possibility of using **tilapia meal** as a feed ingredient for animals such as poultry. Tilapia meal has been shown to have as high as 57.8% crude protein level.

The United States is one of the major importers of tilapia products and the product range includes fillet of different sizes (3-5 oz, 4-6oz, 5-7oz, 6-8oz etc) and packages; with skin off or on; deep skinned; ozone-dipped; carbon monoxide treated; individually quick frozen; smoked; liquid smoked and in sashimi grade (Fitzsimmons, 2004; Lim & Webster, 2006). Individually frozen whole fish can be either marketed in individual plastic bags or individual Styrofoam trays with plastic wrap for retail sales. Similar options are available for fresh or frozen fillets.

Most fillets now also go through hand trimming with the dorsal and ventral margins trimmed off leaving nicely rounded edges and a smooth appearance. Fitzsimmons (2004) noted that many processing plants ran their trimmed fillets through a water bath after trimming and whereas in the past, some plants used a mild chlorine solution to reduce bacteria and lengthen shelf life, nowadays, most plants use ozone gas, which is bubbled into the tank. Ozone treated fillets are not subject to the disinfection byproducts that chlorine can form with organic molecules nor does it leave any disagreeable taste that can be discerned by some consumers. "Most plants use an on-site ozone generation system that supplies the small amounts of ozone needed to effectively disinfect fillets. Studies conducted at the University of Arizona demonstrated that bacterial counts could be lowered by several degrees of magnitude and shelf life could be extended by several days when fillets were rinsed with ozonated water compared to untreated fillets" (Fitzsimmons, 2004).

Tilapia skin is also sold on the international market as frozen or in salted and deep fried forms. In Thailand and the Philippines, skins are scaled, cut into thin strips and deep-fried, served with onion and lime as appetizers (Fitzsimmons, 2004).

Efforts in value adding of tilapia have been minimal in the Pacific ([www.spc.int](http://www.spc.int)). Tilapia is mostly sold live or fresh in bundles, but interestingly in Papua New Guinea, cooked tilapia (fried) is sold on the roadsides (Ponia & Mobiha, 2002). Simple village level post-harvest processing, such as smoking may exist in some countries ([www.spc.int](http://www.spc.int)) but proper documentation is absent.

### TILAPIA FISHERY STATUS IN FIJI

In Fiji, Tilapia (*Oreochromis mossambicus*) was introduced in the early 1940s, and again in mid 1950s as pig feed and potential human food (Costa- Pierce, 1998). Initially the fish were kept in Nacocolevu Agriculture Station in Sigatoka (Nandlal & Foscarini, 1990; [www.spc.int](http://www.spc.int)), but these fish were later released in the natural river systems of Fiji, while at the same time some earthen ponds were also stocked with Tilapia. Over the years Tilapia became quite popular amongst the inland people of Fiji (Nandlal & Foscarini, 1990) and so did the potential for aquaculture.

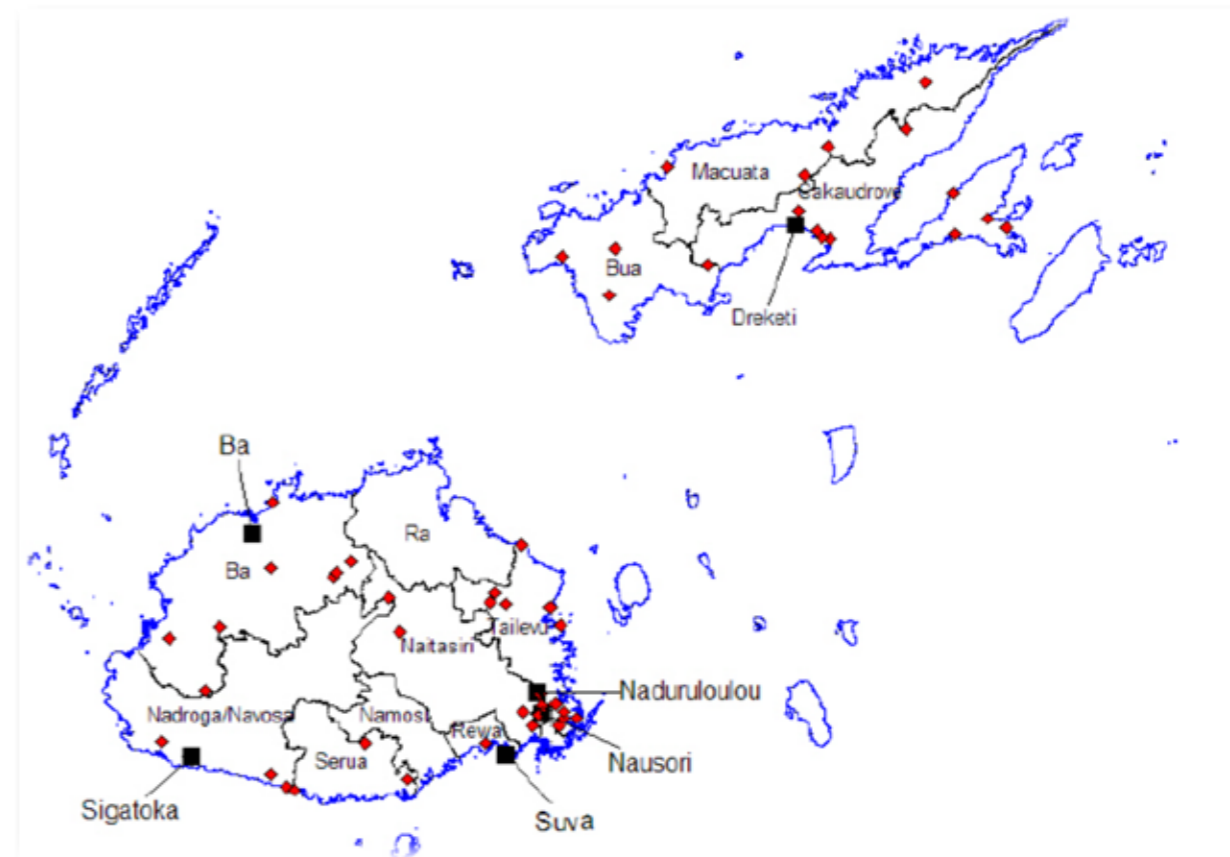


FIGURE 1: DISTRIBUTION OF TILAPIA FARMS (RED ) AND MAJOR MARKETS (BLACK) IN FIJI, (SOURCE: TERI & PICKERING, 2009).

The freshwater aquaculture station at Naduruloulou was established in 1975 which primarily focused on research and farming assistance. Research and development work on tilapia was carried out during 1993 to 2000 through ACIAR funding and as a result, a better performing species (*Oreochromis niloticus*) and strains was obtained to improve the productivity and profitability of tilapia farming.

Currently tilapia is found in most major rivers systems of Fiji as well as some outer islands. There are approximately 300 tilapia farmers around Fiji (Fig. 1), out of which 50 are commercial farmers, the rest semi-commercial (100) and subsistence (150); (Source:

## Case Study 2: Nadala women learn new skills in fish farming

Women in rural areas are known for their skills and talents in making use of natural resources to earn a living for their families. An inspiring story is unveiled in Driti Village in the Tikina of Dama where women have taken the lead role in managing six fish ponds that is a source of income and most importantly supplements the protein intake villagers desperately lack in their daily diet. Established in 2002 by the Department of Fisheries, Ministry of Women, Secretariat of the Pacific Community and University of the South Pacific Marine Studies the project was handed over to Driti women. Known as the Seatura Women's Club Aquaculture project, the two main objectives met by the initiative are: create source of income for the women and sustain their nutrition level.

According to Seatura Women's Club leader Narieta Leba, about 40 women benefit from the project and the revenue earned is deposited into a fixed savings account while portion of the money is used to meet miscellaneous expenses. "Most of the money is kept in the bank for education purposes of the children in the village and in total from the fish project. During harvest we are able to earn \$1000 to \$2000 a month," said Leba. She said the fish was supplied to the nearby villages and Bua School at a reasonable price and there were plans to expand the market to Labasa Town."

(<http://www.connectme.com.fj/news/national/Womenthrive-in-Fish-Pond-business>) on: 16/03/11

*Presentation by Principle Aquaculture officer, Commodity Task Force meeting, 2010*). Estimated annual tilapia production recorded was 284.9 tonnes in 2007 and 182.3 tonnes in 2008, valued at FJ\$1.4 million and FJ\$0.9 million respectively (Fisheries Annual Report, 2007 & 2008). Tilapia currently sells for FJ\$5-7 per kilogram.

Fish processing and quality standards in Fiji are in place and the same protocols can be adopted for future tilapia processing/value adding. The Fiji Fisheries Department has a Product Development and Utilization (PDU) unit, which assists fish processors (such as Fiji Fish, Golden Ocean Fish, Tosa Bussan Fiji, Solander Pacific, Tripacific Marine, Celtrack Holdings) achieve quality products of international standards for local and export markets. These standards include, the European Union Food Safety, United States Food and Drug Administration, and Hazard Analysis and Critical Control Points (Fisheries Annual Report, 2008). Processing companies process deep sea fish such as tuna (yellowfin, bigeye and albacore), marlin, sword fish etc. Fish are exported fresh or frozen, whole gilled & gutted, headed gilled & gutted. These companies also vacuum pack fresh and/or frozen loins and steaks. High quality chilled and processed tuna are also exported to Japan, Europe and United States. Two companies, PAFCO and Voko Industries are involved in canning (FTIB, 2009).

In a case study by Prasad (2006), fishing contributed about 2.4% to Fiji's GDP in 2001 however, this does not provide the whole picture as fish processing and post-harvest activities are incorporated within other sectors of Fiji's economy. Summarized data from the Fiji Bureau of Statistics indicates that export of fishery products account for approximately 9% of the total domestic export from Fiji.

### Marketing and Value Adding

Tilapia is commonly marketed live (Fig. 2) in Fiji from some municipal markets, while fresh bundles and farm gate sales are also practiced. Frozen tilapia is also being sold by Tebara Meats Limited (previously known as Dairy Farms Fiji Limited).

Value-adding has been conducted on an experimental basis by some University of the South Pacific (USP) staff and students and a businessman does small-scale tilapia smoking but village-level smoking also exists. Terry Mandam runs a small family business and has been selling smoked fish including tilapia since 1985. He buys live tilapia from the Nausori market (FJD5.00 for 4 fish), smokes, vacuum packs and sells them for FJD12.00. Mandam cold smokes (30-40 °C) tilapia on order or for research purpose. The smoker used is homemade (made using a 44 gallon drum) and

the design can be adopted by farmers at minimal cost. Fish are gilled, gutted, scaled and brined; followed by a quick freshwater dip and fan drying (Fig. 3). Prior to fan drying, a small stick is used to open the stomach of each fish. Once dried, the fish are hung on metal rods and placed vertically in the smoker. The whole process from brining to the smoked product takes approximately 8 hours. The smoked fish are then cooled, vacuum packed and stored in a freezer until it is ready to be cooked. Mandam believes that value adding of tilapia has great potential in Fiji and needs to be taken to a commercial level.



FIGURE 2 : SOLD LIVE AT NAUSORI MARKET. TOP LEFT AND RIGHT: TEMPORARY HOLDING TANKS FOR LIVE SALES OF TILAPIA AT NAUSORI MARKET. BOTTOM LEFT AND RIGHT: SCOOPING AND CHOOSING FISH AS PER CUSTOMER PREFERENCE

## Consumption

In Fiji, the major consumers of tilapia are indigenous Fijians while Chinese and Indo-Fijians purchase tilapia at a smaller scale from the municipal markets. These prefer to buy live, plate size tilapia, that is, 4-6 fish per kilogram. Indigenous Fijians do not prefer larger-sized fish (2-3 per kg) as smaller fish allows each member in the family to have one whole fish per plate. There are no hotels or restaurants that are known to purchase tilapia however, consumer/market testing can be done once value-added tilapia products are available and introduced into the local markets.

### Case Study 3: MSc research on "Value-addition of *Oreochromis niloticus* (Tilapia)"

While a great deal is known of the socio-economic aspects of Tilapia, little has been done on product enhancement. A current MSc research at University of the South Pacific by Janice Natasha is looking at the value-adding of Tilapia, a fisheries commodity in Fiji. The demand is extensive but it is being sold live only in the local markets. However, most consumers do not prefer Tilapia because of its characteristic tasteless meat. This project proposes to investigate possible product enhancement methods that can be used at the community level and for potential commercialization such as the salting of Tilapia as a pre-treatment to further product enhancement such as drying, smoking, freezing and canning.



FIGURE 3: PROCESS OF COLD SMOKING TILAPIA: A) BRINING; B) OPENING THE INSIDE; C) DRYING PRIOR TO SMOKING; D) SMOKING AND E) VACUUM PACKED FINISHED PRODUCT (PHOTOS: TERRY MANDAM)

## TILAPIA FISHERY STATUS IN SAMOA

In Samoa, Tilapia (*O. mossambicus*) was introduced in 1955 (Bell *et al.*, 1997; [www.spc.int](http://www.spc.int)), after its potential as a candidate for pond culture was investigated by SPC ([www.spc.int](http://www.spc.int)). Following this, the Fisheries Division of Samoa introduced a better performing *O. niloticus* for aquaculture, under its South Pacific Aquaculture Development Project (SPADP), in 1991. Tilapia has been a subsistence fishery in a few villages, but utilized at a larger scale in Savaii (Bell *et al.*, 1997). They have been released in main freshwater river systems in Savaii for subsistence ([www.spc.int](http://www.spc.int)). In 1996, several demonstration ponds were constructed under the SPADP and Fisheries Division (Nandlal, 1996). By late 2000, Samoa had 19 tilapia farms in total, 11 on Upolu and 8 on Savaii (Su'a *et al.*, 2009).



FIGURE 4 : MAP OF SAMOA SHOWING THE SEMI-COMMERCIAL FARM SITES ON UPOLU (SOURCE: [WWW.LIB.UTEXAS.EDU/MAPS/SAMOA.HTML](http://WWW.LIB.UTEXAS.EDU/MAPS/SAMOA.HTML))

## Marketing

Currently, there are approximately 29 farmers out of which 5 are semi-commercial and 24 are subsistence. Annual production from 4 semi-commercial farms located at Vailele, Falese'ela and Falelauniu on Upolu Island (Fig. 4) is approximately 0.8 tonnes.

In addition to these farms, 3 communities harvest tilapia from natural water bodies. These are communities of Faleapuna and Saoluafa-ta on Upolu and Satoa-lepai on Savaii Island. These fishermen use nets and spears for tilapia, crabs and eels for the family meal. On a good fishing trip, there can be 20 tilapia caught but on average 4 - 5 tilapia are caught per week ranging from 0.8 to 2 kg in size.

## Consumption

A taste study of smoked tilapia in Samoa showed that some people (33%) preferred smoked tilapia over smoked reef fish (Bell *et al.*, 1997), which suggests that fish smoking (tilapia and other species) is being practiced. Generally, there is no value adding of tilapia in Samoa.

The major consumers of tilapia are the locals while expatriate Asians and Africans have also been reported buying tilapia from one of the farms. Chinese restaurant owners in Samoa usually bought for restaurant menus and for their own consumption. The communities of Saoluafata and Faleapuna on Upolu Island and Satoalepai in Savaii Island who are involved in the tilapia fishery consider tilapia as a staple protein source especially in the latter where tilapia strings were sold along the roadside.



FIGURE 5: TILAPIA CEMENT TANK IN SAMOA (PHOTO: FALESE'ELA LEFAGA)



## TILAPIA FISHERY STATUS IN TONGA

In Tonga, the aquaculture of tilapia is nonexistent. Initially in the 1950s, tilapia (*Oreochromis mossambicus*) was introduced in an unsuccessful attempt to control mosquitoes. The culture of tilapia, integrated with piggery was later trialed at Sopo with unsuccessful results. Tilapia is believed to have spread to neighboring areas and also introduced to several outer islands in Tonga during this time ([www.spc.int](http://www.spc.int)) but there are no records of tilapia fishery. The “Tonga Aquaculture Commodity Development Plan 2010-2014” has identified commodities but Tilapia is not on the priority list, being considered as having medium importance and impact.

According to the Fisheries Aquaculture Officer, there has been some interest in the subsistence production of tilapia and farming tilapia for pig food. Tilapia exists in estuarine waters in the lagoons and lakes in Tongatapu, Vavau, ‘Eua and Ha’apai and grow to a large size (individuals are likely to be in the range of 800g to 1kg). On the island of ‘Eua, there is no intertidal area and tilapia is a major protein source for the residents who harvest it from the lake. However, tilapia may be given higher priority in the future given the decline in inshore fisheries and the high cost of living (*Personnel Communication, Poasi Ngaluafe, April, 2011*).

## PRELIMINARY ANALYSIS OF THE SUPPLY CHAIN

In **Fiji**, the market/supply chain occurs over a 4 - 6 month cycle as such:

1. Farm-based harvesting (partial or complete) with assistance from Fisheries Department
2. Transport to the market live in tanks or alternately sold live to consumers from the farm
3. Sale of live fish in municipal markets on Fridays and Saturdays
4. Consumption mainly by non-commercial users

The cash flow steps for Fiji are:

1. Operational cost during cycle (feed, maintenance)
2. Percentage loss of product due to handling (mortality)
3. Transportation and related costs to the market
4. Income to farmers

In **Samoa**, the Savaii and Upolu market/supply chain occurs over a 6 - 12 month cycle as follows:

1. Farm-based harvesting (partial or complete) with assistance from Fisheries Department
2. a. Product sold live (and occasionally gutted and scaled) to consumers from the farm or  
b. transported to restaurants for sale or  
c. transported to municipal markets and sold live to consumers on Saturdays
3. Consumption by non-commercial and commercial users

### Case Study 4: The cost structure of tilapia farming in Samoa based on an average pond size of 5 x 10 (m)

Capital involves machinery to clear land if it's new land for the pond(s). Construction of ponds and plumbing are the other two main factors required for tilapia farming.

#### 1. Labour:

Worker wages are not counted since tilapia farm management is usually a family activity. However when there is harvesting, depending on the catch, this is distributed to neighbors, relatives and to those who assisted in the farming or harvesting.

#### 2. Operating Expenses:

For subsistence farmers, the main operational cost is feed. The main use of fuel on the farm is mowing grass, transporting of feed to the farm or cutting down nearby trees threatening pond stability and shading over the ponds.

#### 3. Purchase of Fingerlings:

Ministry of Agriculture and Fisheries- Fisheries Division (FD) is the main supplier of tilapia fingerlings to the local tilapia farmers. Currently the fingerlings are free of charge for initial stocking. If the industry expands, there will be a need for the FD hatchery to expand to meet the demand and set prices to sell fingerlings.

#### 4. Feeds:

The feed currently used by the FD is a combination of fish meal, coconut meal and brewery waste from Vailima Brewery Company. The pellet machine has enabled the production of pellets for feed now sold at \$3/kg. Fisheries had assisted Farmtech Company Limited in producing the same feed using the FD's formulation. The formulation has been modified by the company replacing the brewery waste with the mashed cassava. Most of the tilapia farmers in Samoa farm for food security and are advised to utilize peles and cassava leaves that are readily available.

#### 5. Marketing

Tilapia in Samoa is mainly consumed by the subsistence market. However past trials of tilapia sales at the Apia Fish Market has been successful at \$5/kg. Future opportunities lie in the potential export of tilapia. In 2009 a tilapia farm was established at Vailele by business man, Sala Vaimili. The pond is fed with water diverted from the river adjacent to the farmer's land. The pond size is estimated at 96 m<sup>2</sup>. The pond was initially stocked with 3000 fingerlings with total weight of 39kg. After 8 months of culture, 1980 fish (600 kg) were harvested. As it was Vaimili's first tilapia harvest, it was distributed to his relatives and friends.

#### 6. Risk Analysis

Using the model developed by AusAID project in 2005, we can assume that the risks (natural disasters, theft, disease, lack of fry supply) for a typical tilapia farm range between a probability of 10-40%.

Source: Fisheries Division, Ministry of Agriculture and Fisheries, Apia, Samoa. March 2011

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### **INSTITUTE OF MARINE RESOURCES (IMR)**

IMR provides scientific and technical skills, capacity-building, marine resource assessments, coral reef monitoring/ database maintenance and socio-economic analysis for fisheries and aquaculture. IMR aims to increase the regional capacity to sustainably develop its marine resources through applied research, training and teaching. Research and development projects focus on marine ecology, aquaculture and biodiversity issues.

Much of IMR's work is externally-funded research and consultancies on the region's marine environment and its resources. Current activities centre on coral reef monitoring, marine biodiversity assessment, aquaculture management and cetacean research. The Institute also coordinates the South-West Pacific node of the Global Coral Reef Monitoring Network ([www.GCRMN.org](http://www.GCRMN.org)).

### **CONTACT DETAILS**

Phone: 323 2930/ 323 2988

Fax: 323 1526

Website: [www.usp.ac.fj/imr](http://www.usp.ac.fj/imr)

Email: [joeli.veitayaki@usp.ac.fj](mailto:joeli.veitayaki@usp.ac.fj) OR [cherie.morris@usp.ac.fj](mailto:cherie.morris@usp.ac.fj)



School of Marine Studies  
Institute of Marine Resources