

Editorialⁱ

Developing Sustainable Fish Farming in the Western Pacific: A Viewpoint on Potential Reasons for Why Many Attempts Failed



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Capture fisheries and aquaculture have been a major source of food and providers of economic benefits to many communities around the world for a very long time. While the history of aquaculture or fish farming can be traced back for more than 2000 years in some corners of the globe, notably in China, Japan and the Mediterranean, this is not true everywhere, where in general, fish farming is a relatively new industry. Rapid human population growth and increasing urbanisation over the last 20 to 40 years has meant that while fish consumption has doubled globally, returns from capture fisheries have remained static or have declined due to overexploitation and rising pollution levels, with some fisheries either closing or becoming economically unviable. Data from studies suggest that this trend is unlikely to be reversed unless appropriate fisheries management allows depleted wild stocks to rebuild. This has occurred during a time when demand for fish products has grown, in part due to improved purchasing power in some developing countries and changing dietary habits where fish are now considered to have a positive impact on health. Based on the projected population growth over the next two decades, Food and Agricultural Organization (FAO) estimates that at least an additional 40 million tonnes of aquatic food will be required to maintain the current per capita consumption (FAO 2006). Thus, many nations have attempted to address the need to increase fish supply by promoting development of aquaculture as it is perceived as having the greatest potential to meet the growing demand for aquatic foods. For some countries, this change has resulted in development of large, highly competitive aquaculture industries, an outcome driven by market pressure, such as salmonids in Norway, channel catfish in the USA, penaeid prawns and tilapia in Asia and more recently, 'tra' catfish in Vietnam. In contrast, development of productive fish culture industries in other regions has been uneven, notably in Africa and the western Pacific, and has been very slow and experienced many failures after significant effort had been directed at encouraging their growth. While many reasons are likely to have contributed to these failures, the social context, traditional lifestyle and the social systems of indigenous people are not often considered to be the factors that could have contributed to the success or failure of new aquaculture ventures.

Here, we argue that many of the aquaculture failures experienced in the western Pacific may have potentially resulted from a failure to develop fish culture systems that are designed for, and well-adapted to, the traditional lifestyles and social systems present in the region.

The western Pacific is a vast marine ecosystem that contains large numbers of mostly small islands and atolls divided into isolated island chain states (referred to as the Pacific Island Countries and Territories or PICTs). Most island human populations are relatively small and have traditionally relied on sustainable agriculture and fishing to meet their food security needs because terrestrial animal food resources are limited or absent. In reality, fisheries are the principal natural resource available across the region, providing almost 50% of the total animal protein supply on average and in some PICTs, the importance of fish to food security is even greater. According to the Secretariat of the Pacific Community (SPC 2008), up to 50% of daily protein intake in the region, as recommended by World Health Organization (WHO) for good nutrition, will need to come from fish. Until recent times, traditional social and cultural systems and practices, while varying among PICTs, essentially controlled access to most resources and by doing so, contributed to their long-term sustainability ensuring ongoing supply of natural foods for local people. Over the last 10 to 15 years, however, many culture systems and associated land/water tenure and resource access traditions have faced increasing challenges from rising human populations, urbanization, coupled with more pollution and increased rates of harvesting of inshore and offshore marine resources (e.g. tuna) by large industrial scale fishing enterprises from outside of the region. Another major concern is that chronic over fishing has occurred in coastal areas to an extent that they may not have the capacity to support for future fish food security requirements (SPC, 2008; Bell *et al.*, 2009a &b). Most PICTs now import a significant amount of food, most noticeably cereals, including flour and rice. In addition, PICTs have experienced increasing food and fuel prices, unstable economic conditions and climate change impacts that together affect the availability of food and also the access to it. In particular, increased local food prices have exacerbated an already high reliance on imported and processed foods. Together, these factors contribute to a general decline in the local food production, and island populations are at increasing risk of malnutrition and related disease impacts. These challenges demand a coordinated response and require an understanding of the factors leading to declining food security and most importantly actions that are acceptable to locals to address the problems.

Following from the above, in recent times, the net result has been that in many PICTs, inshore marine resources have declined to a point where they cannot now meet the animal protein needs of the local indigenous populations. Alternative indigenous animal protein sources are limited in most PICTs because native freshwater aquatic faunas are de-pauperate and terrestrial livestock

are limited in supply and very expensive, so some indigenous populations have been forced to change their diets to include increasing quantities of imported, canned or frozen substitutes (e.g. canned fish, frozen low grade meat) to address this problem. This change, as stated above, is linked to growing human health problems (rapid increases in the rates of Type 1 diabetes and obesity-related diseases) that result from consumption of low quality foods, high in fat content and often low in nutrients because this is essentially all that the poorer sections (particularly urban populations) of the community can afford due to the decline in the access to fresh local food.

Governments across the western Pacific are well aware of this growing problem and have examined ways to address the issue. Fish farming has been identified as one solution because it can potentially address two important social problems at the same time; providing high quality, fresh animal protein at a reasonable cost, while also providing livelihoods and employment to the local people, in particular, to those at the poorer end of the social spectrum. Since fish culture has not been a traditional practice in PICTs, the industry is however new and its development has been slow because skills, infrastructure and experience need to be developed from a very limited starting base. Having said this, it is appropriate to recognise that there has been considerable investment made by some governments (notably in Papua New Guinea and Fiji) and also by some international donor agencies and NGOs (e.g., Australian Centre for international Agricultural Research-ACIAR, Japan International Cooperation Agency-JICA, and Secretariat of the Pacific Community-SPC) to assist the development of aquaculture there. The problem has been, however, that most aquaculture ventures overtime have either failed or the few that have survived produce products that are either beyond the purchasing power of most local people (marine prawns) or that are exported to wealthy markets overseas or that provide luxury items for local tourist industries (e.g., Pearl oysters). While development of high value export culture industries may appear at first sight to be an indirect way of increasing revenue for local development, the impacts of these industries on the local people can often be marginal because they generally employ only a relatively small number of low paid workers (often casual) and in most cases, the companies are not owned by the local people and profits may be repatriated to home countries. The question then is, why have so many fish farming ventures in the western Pacific that have been directed at assisting local development failed even after considerable financial and technical assistance has been provided?

The answer(s) to this question are likely to be quite complex and in many situations will be case-specific. The authors here have been engaged in research directed at assisting

aquaculture industry development in the western Pacific, both directly in long-term positions in national fisheries agencies and via engagement in Australian research programmes since the early 1990s and we believe that we have developed some knowledge of this issue and can potentially provide some insights that may help to explain this apparent dilemma. In addition, we also believe that we can offer some suggestions that could contribute to better outcomes in the future. As a general observation, we believe that major factors which have contributed to many of the failures of fish farming attempts in the western Pacific often relate to choice of culture species, level of culture intensification attempted and how well the farming system fits into the general life-style and social cultural practices across the region. Our main contention is that fish culture systems that have failed in the region were developed without careful consideration of one, and in many cases, all of the issues identified above. The choice of the species, culture system and intensity of productions practiced have, in our opinion, often been based primarily on observations about what has worked elsewhere (particularly in southeast Asia and some western nations) and the attempt has been to simply transfer similar systems to the Pacific and assume that they will also work there. The following sections will attempt to expand on this idea and provide some evidence where it is available to support the contention.

A diverse array of aquatic species have been trialled, or are currently being trialled in aquaculture in the western Pacific; these include marine prawns, sandfish, milkfish, pearl oysters, marine algae, giant clam, trochus, some carp species, tilapia and giant freshwater prawn. Most have failed or are failing currently. Other species have also been suggested as potential candidates for the region, including some indigenous marine tropical predatory fishes (e.g. groupers and snappers) and non-indigenous marine/freshwater fish (barramundi), mudcrabs, and even tropical marine lobsters, but the experience has so far clearly shown that the choice of the species for culture by the locals is critical. To date, the only real success story for the local farmers has been the culture of Nile tilapia with freshwater prawns which begin to show some promises as

well, at least in Fiji. The best results have been obtained with pond culture of Nile tilapia, an omnivore that can grow well on a variety of diets, including feeding on plankton in simple fertilised ponds (addition of animal manure or organic fertilisers) and also on various farm by-products and simple artificial feeds. While culture of marine prawns (*L. vannamei*) has been successful in New Caledonia, this is an example of a local industry developed, subsidised and maintained by support directly from the French government with little engagement to date from indigenous farmers. Thus, the success stories for the region are really limited to a single (or perhaps two species). Our view is that the culture system employed in Tilapia farming, intensity of production used and general culture requirements (production cycle, intensity of management required, human and physical resources required to make it work) are such that they are compatible with the local farming practices and engagement in the region, while species that have failed are generally not.

Tilapia produced in ponds, as an economic crop in particular, have adapted well to the local farming systems and practices as well as social and cultural traditions in most PICTs, where they have been trialled. Where tilapia farming was not successful in the region in the past, this has often been attributed to production of 'small-sized' fish due to precocial spawning which results in large numbers of fry swamping ponds and stunted populations. The problem has been addressed in some places, following improvements to husbandry and replacement of poor performing stocks with an improved Nile tilapia strain (Genetically Improved farmed tilapia - GIFT). Tilapia culture in Fiji, PNG, Vanuatu, Samoa etc. are now exclusively based on GIFT. Although early maturation of tilapia in ponds remains a problem in some places, in actual practice scarcity of productive fingerlings has, somewhat strangely also been a major constraint, particularly in small-scale rural farming. Mass production of fingerlings for stocking ponds cannot yet be considered as a well-developed approach that is routinely practiced by rural farmers. Methods of broodstock production, selection and rearing, design and preparation of

spawning ponds and tanks, fry rearing and nursery management will also need additional attention across the region.

Tilapia, while amenable to high input, high resource intensive farming systems, can also be very productive in relatively low input (simple pond fertilisation systems), low resource (feed diversity, ration and quality), low technology systems and can therefore be easily adopted by local farmers with limited land (pond area), culture expertise and experience. Given that the production cycle is also relatively short, i.e. varies from only 3 to 6 months on average, farmers can receive a return from their limited investment rapidly where alternate sources of income are often scarce. Small farms (even consisting of one or a few small ponds) can produce 3 to 4 crops of fish per year and thus provide a regular source of income, while providing fresh animal protein, income and employment for family members. In addition, because tilapia are quite hardy fish, they will survive in limited water volumes at quite high densities in relatively low oxygen levels for a considerable time and hence can be transported and sold live at local markets to maximise prices for 'fresh fish', a practice that may require refrigeration if the product had been sold dead. In contrast, many alternative aquatic species that have failed in culture in PICTs require very different management and culture practices that include much higher resource inputs, longer production cycles, more intense culture stock management, expensive diets and/or large production areas for them to be viable culture options.

While the experience in Asian countries suggests that fish farming can be introduced easily into communities and is successful, where land as well as access to water resources are vested in the individual, in the western Pacific countries in contrast, land ownership, use and leasing systems are controlled by an extended family, clan or communal group that varies according to local custom and to conditions within various indigenous groups. Clans and clan members are bound by traditional obligations that are paramount. Under these systems, land and resources are usually inherited and are commonly based on a founding lineage and its descendants. As such, any community member seeking permission to build a small fishpond would usually need approval from the clan, but use

of large production areas is usually not favoured because all members of the communal group have access rights as well as the rights to a share in any product produced from this land. Therefore, commercial fish farming that requires relatively large land areas for an extended period of time is unlikely to be compatible with community norm practices, while small tilapia ponds are not generally viewed as a business undertaking, but as an activity comparable with taro or cassava farming on which the welfare of a household depends. Some of the 'fish' produced will probably also be shared with other members of the community or clan.

While freshwater prawns (*Macrobrachium rosenbergii*) are not yet widely farmed in the western Pacific and are yet to be identified as a priority species in the development plans of most PICTs, like Tilapia, freshwater prawn farming has been showing a considerable promise where it has been trialled (e.g. in Fiji). This is because recent experimental and commercial trials have identified a better performing strain (from Vietnam) for the local industry that has yielded encouraging results allowing many indigenous tilapia farmers to convert to prawn culture since requirements are similar to those identified above for Tilapia. In general, freshwater prawns can be grown to a marketable size in a relatively short period of time (production cycles are similar to tilapia), and production intensity can be relatively low as are feed costs and required expertise. Prawns also grow well in relatively small ponds and their market demand is very high with a value about 4-5 times higher than for tilapia, so returns to farmers are very favourable. In Fiji, we note that many farmers who have learned their aquaculture skills farming Tilapia often make rapid transition to freshwater prawn culture that produces higher returns. Freshwater prawns are also relatively hardy and can grow well even in comparatively poor pond conditions, giving reasonable yields. This species, like Tilapia, is also omnivorous and is therefore complementary in its feeding habits to Nile tilapia. A potential disadvantage compared with tilapia, however, is the hatchery cycle that is more complex than that for tilapia, because brackishwater and specialised live diets are required for larval metamorphosis to be completed successfully, and this adds a cost and complexity to the system. It has

been demonstrated, however, that PLs can be produced routinely across the year in the tropical/subtropical conditions, even in simple backyard hatchery systems which is an advantage over many alternative species (in particular marine predatory fish and some mollusc species).

Even while scarcity of quality fingerlings and PLs remain major constraints on development of tilapia and freshwater prawn culture in the western Pacific respectively, only standard methods of producing marketable fish and prawns have been developed to a level that matches the simplicity with which locals produce their crops, such as cassava and taro. Once the main constraint on 'seed' supply is overcome, it will be necessary to develop more efficient production systems, including improving pond management measures. Thus, our considered opinion is that the choice of culture species, the production system employed and the intensity of management practiced are all key factors that determine why certain culture species have been farmed successfully by indigenous populations (notably tilapia), while others have been relatively unsuccessful or failed in culture in the western Pacific. We strongly believe that these issues should be considered before new culture species are considered for development in culture across the region in particular, where the primary focus is on improving food security and nutrition for local people while increasing average family livelihoods and employment opportunities for poorer sectors of the community.

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Professor Mather is an academic with expertise in the fields of population genetics and ecology and has research interests that focus on diversity of wild and cultured aquatic species and more recently he has focussed his research in the fields of aquaculture genetics and genomics. He has developed both a national and international research profile in the Asia-Pacific region and engaged in research directed at characterisation of wild and farmed aquatic genetic resources, optimising their productivity in culture, development of improved culture lines and identification of key genes and mutations that affect variation in important production traits. As part of this work, he has developed collaborative research partnerships and networks that engage international governmental agencies and academic institutions working in the fisheries and aquaculture sector in the Asian-Pacific region and south Asia notably in Malaysia, Vietnam, India, and Fiji. This has led to many invitations to present the outcomes of his research group's work at international scientific meetings, to chair national and international sessions at scientific conferences and to provide advice to government agencies, universities and NGOs. He is also a member of the international advisory boards of a number of university science faculties in Malaysia.

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