

Promotion of Sustainable Aquaculture for Livelihood Improvement

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1 Abstract

Demand for fish is increasing because of rapidly increasing population and shifting trend of food consumption from red meat to white meat, especially seafood. Catching fish from seas, lakes, rivers and rice fields is a tradition, especially in Asia. Due to over-fishing and other human activities, wild catch is declining worldwide. Some researchers have even predicted almost all the species caught from the sea today will disappear soon, if the current trend continues. Need for the promotion of “farming of aquatic organisms i.e. aquaculture” has been increasingly realized recently in many countries. Its importance has been highlighted due to its comparative advantages as well as compatibility with existing farming systems in a wide range of environment and also other infrastructure development programs. Originated from Asia, it has grown rapidly from primitive or subsistence type to more specialized commercial forms which are practiced in various parts of the globe. Abundant but un- or under-utilized water resource of developing countries like Nepal could be exploited for aquaculture development integrating with irrigation and hydropower projects. This paper presents a summary of the successful integrated aquaculture systems existed or implemented which could serve as models for the improvement of livelihoods of millions of people in other parts of the world.

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2 Global perspective

2.1 Background knowledge

Fish is well accepted lean and white meat healthy food. It is a staple food for more than a billion people. Demand for fish or seafood is rapidly increasing. Because of its health benefits more people are consuming fish, shifting from red meat to white meat. Currently, about 160 million mt of fish is produced in the world; out of which slightly over 100 million mt is used for human consumption; about half of which is from farming. Fish catch from the wild has either reached to a maximum limit or declining.

However, due to over-fishing and other human activities that cause environmental degradation and pollution, climate change and global warming, the wild fish catch is rapidly declining and according to some fisheries scientists, most species we catch today will disappear in the near future if current trends continue (BBC, 2006). Clearly more joint efforts are needed to sustainably manage fisheries resources.

The importance of farming fish termed as “Aquaculture” has been increasingly realized recently with a view to compensating for the decline in wild fish catch. Aquaculture has been growing at an average rate of 9% annually over the past 10 years and is the fastest growing food production sector. Global farmed-fish production was about 45 million metric tons last year, about half of the fish we consume but it has to be doubled by 2030 to meet the ever growing demand for fish (FAO, 2006). Among the top 10 fish farming countries, nine are in Asia. In many Asian countries, aquaculture has been a lucrative business and source of export earnings and provides food and employment for nations. Thailand, for example, earns about 2 billion US dollars a year from exporting shrimp. Similarly, Vietnam has become well-known for farming catfish with an export value of over 1 billion US dollar in 2008.

A large portion of aquaculture products are consumed by the farming families or sold in domestic markets. The value of global trade of aquatic products is approximately US\$18 billion per year; out of which 90% is from Asia and 75% from developing countries. China and India remained the top two fish producing countries because of their size or the population. They both started fish culture since long time ago as tradition. China realized the value of aquaculture and gave high priority quite early. It is the only country which produces through aquaculture more than the catch from wild. It has been always on the top position whereas in India, even though fish culture was a tradition, aquaculture has not been widely adopted probably because of large population (at least one-third) is vegetarian in nature. Other five top producing countries are Indonesia, Bangladesh, the Philippines, Japan and Thailand.

2.2 Fisheries/aquaculture and livelihood

Fisheries sector employs over 40 million people worldwide contributing significant portion of the daily diet. Fishing is one of the easiest jobs available for the poor, especially living nearby water bodies. At the same time, it is a highly specialized and gigantic business. In Cambodia fish contributes up to 75% of the total animal protein intake. In Laos, more than 6% of the GDP comes from fisheries. In Bangladesh there are over a million fish ponds which are often called as “Fish Factories” mostly belong to the poor. The country earns about US\$0.5 billion a year from the exports of fishery products benefiting the poor. From prawn export alone, the country earns over 100 million US\$ a year. Many poor farmers have been able to lift their livelihood up from the poverty bench mark using the technology of prawn farming in rice fields. An average of 28% increased income of farm families was possible in Malawi. In Bangladesh, Cambodia and Vietnam cage farming has also provided shelter to the landless people who live on the water, popularly known as “floating villages”.

Entering into small scale aquaculture and learning gradually, many poor people actually expand their family business to large commercial ventures. Starting from small with less risk, resource poor farmers learn about farming techniques, they scale up the business seeing its comparative advantages. For example, farming of shrimp in Thailand with the export value of about US\$2 billion per year was started from small-scale, and still many are small. Growing very rapidly, Pangasias catfish (*Pangasias hypothalamus*) culture in Vietnam moved to highly organized export oriented business. The value of which is about 1 billion US dollars per year. Shrimp culture in Thailand and Pangasias culture in Vietnam play considerable role in foreign currency earning and also in creating jobs for the local people including direct and indirect activities. For example a single processing plant in Vietnam employs over 1,000 employees and they are mostly women.

3 Nepalese context

3.1 Why fish / aquaculture?

Extension workers and promoters of aquaculture should be able to highlight comparative advantages in their own contexts. Some of the examples are described in this section.

Rice is the main crop in Nepal and farmers allocate majority of land for rice. A rice growing farmer would compare between growing rice and fish before taking decision to construct a pond. Various data have showed that average production of rice is about 4 ton/ha per crop. Same amount of fish can be easily obtained with limited input. But price of fish is 10 times higher than the price of rice that means farmers can get 10 times higher revenue from the same area of land. In terms of time and labor used, rearing fish requires a lot less; about one

fourth. Housewives and children can take care of fish easily without any burden once they are stocked. Compared to other animals, frequent watering and feeding is not necessary for fish. Because of these reasons, fish farming has become so popular as a result rearing of large animals is rapidly declining in Thailand and in other parts of Southeast Asia. Milking cows/buffaloes need very intensive care every hour. Although, milk is considered a good diet for children and adults, compared to fish it actually supplies little amount protein e.g. 100g milk has 4g protein (if no water has been added) whereas 100g fish (75% DM) has about 25g protein. Among the people of Nepal, the most preferred meat is that of goat. Decline of pasture/forest, goat farming is also declining. As a result, goats are becoming rare and goat meat is expensive i.e. over NRs. 500/kg whereas fish is only around NRs. 100-150. Even to celebrate the Dashain festival, people in towns have to wait until the herds of goats to come from high hills and Tibet. In rural areas, people still rear goat. Whole village has to get together to slaughter a goat to have meat. This can be once a month or once in 3-4 months in many rural areas. Therefore, frequency of meat consumption in regular diet is very rare even for those who can afford. Recently, commercial chicken farming in Nepal has taken off in some districts of Terai (e.g. Chitwan) and peri-urban areas. The country is said to be self-sufficient for chicken meat and eggs; however, in rural areas farming is still in traditional way. Raising few chickens has been a tradition in some communities especially for their festivals, rituals and to offer to their guests. As they consume anything they get including wastes when they are reared in open area, they are considered unhygienic. The locally raised chicken are expensive which may cost over NRs. 300/kg and it has very little amount of meat. Compared to vegetables, meat items are becoming either rare or expensive which has restricted their access to the common people. Therefore, fish farming has a scope as an alternative source of protein which could easily fill that gap if promoted adequately in appropriate way.

3.2 Current status

Approximately, 10% of the total protein is available from animal sources in Nepal whereas from the human health point of view it should be at least 33% (AIT, 1994). Based on this, animal protein supply has to be increased by three times. Directorate of Fisheries Development (DoFD), Balaju, Kathmandu has estimated total production of fish (catch and culture) is about 45,000 mt for 2008. Similarly, a recent survey showed that about 60% fish consumed in Nepal come from India. Consumption of fish is rapidly increasing but catches from rivers and lakes are declining. Annual per capita consumption of fish (1.7 kg) is still far below as compared to other Asian countries. Even in India where about half of the people are said to be vegetarian, per capita consumption is still over 5 kg. Bangladesh, known as fish loving country in South Asia has about 15 kg while most Southeast Asian countries have well over 30 kg (FAO, 2006). These facts show that Nepal is far behind and needs more efforts in promoting aquaculture by establishing immediate and long term objectives for the fulfillment

towards achieving the goal of improving people's livelihoods. For this purpose, identification of indigenous knowledge and also acquiring from other country experiences are necessary.

Aquaculture development in Nepal was initiated three decades ago. However, it is limited to southern plain (Terai) and mostly in earthen ponds. Rohu (*Labeo rohita*), an Indian carp has been popular among the consumers; however, production of two Chinese carps; namely, silver and grass carp have showed tremendous growth. In order to enhance production, few new species of fish have been introduced, for examples, African catfish, tilapia, prawn and others. Because of these species, some biodiversity and environmental concerns have been raised but rampant malnutrition and food insecurity of the people should not be overlooked by environmental issues (Stewart and Bhujel, 2008). Whether indigenous species should be promoted has been a debate in many developing countries. Basic principle is that indigenous species are assumed to have better adaptation to native environments. With view to promoting the native species; namely, Sahar (*Tor putitora*) and Asala (*Shizothorax* sp.), considerable efforts have been made. Their slow growth does not make economically viable option, despite their preference by people. It might be possible to develop cost-effective technique in the future through research but farmers can't wait until the technology is developed given that the knowledge and skills for exotic species could easily be acquired from other countries.

Although Nepal has no coastal area, there is plenty of water. Over 6,000 rivers and streams which are flowing down to India could provide water for aquaculture development. However, these rivers are considered as if they are only for electricity generation. This has overshadowed their contributions as sources of fish for the people living along the banks in various communities. While electricity is important for daily life of the people and for the industrial development, it doesn't mean country should overlook the contribution of natural food supply to the communities. One can argue that indeed food security should come first. However, power crisis has hit the whole country any projects for electricity plan cannot be stopped. There is a need of consideration of fishery resources while developing plans for electricity generation.

Country plans to generate massive hydropower constructing many dams but how it will affect fish populations and the rural communities depending on them should be investigated and appropriate mitigation measures need to be applied. Environmental concerns and food insecurity of the local people should not be overlooked (Stewart and Bhujel, 2008). If cooperation is made while planning, all the stakeholders involved could benefit. A small hatchery like that of Kali Gandaki reservoir could be built within the plan which is be a small part of hydropower project. The objective of the hatchery is to breed indigenous species and release them into the upstream and the reservoir itself so that wild stock will not be depleted. Similarly, many more dams means more reservoirs will be there suitable for cage culture this creates new opportunities of developing fish farming in cages in reservoirs, a unique example of in Kulekhani. Having cage culture in the reservoir does not affect power generation.

Therefore, it should be considered a potential venture while developing any projects. In addition, the water spared or released after its use by the power plant could be utilized to irrigate crops and culture fish integrating into the existing farming system. Adding small components would be substantial to the local communities and would add value to the project without any significant increase in cost but avoiding the resistance from local communities and environmentalists. In addition to rivers and reservoirs, policies should be made to utilize unused swamps and natural lakes for pen and cage aquaculture. However, joint efforts and consultations with experienced fisheries/aquaculture experts while designing such projects are required.

4 Success stories

In the field of aquaculture and fisheries, country already has typical success stories. These tested models should be highlighted and scaled up for the expansion throughout the country and some of the potential systems from abroad should also be adopted with necessary modifications. Some of these are briefly described in this section as:

4.1 Cage culture

Culturing fish in cages is very old practice. It is practiced in lakes, reservoir, rivers and canal in various parts of world. Tilapia cage culture in Thailand and Vietnam has been very popular. The cases of roaming fisher communities converted to permanent settlers practicing cage culture in addition to fishing in lakes and reservoirs in Phewa, Begnas and Kulekhani are unique examples. Based on a recent research, fisher's families around Phewa Lake are earning about 13,000 NRs/month which is considerably high. Effort of management of lakes and reservoirs by the user groups has been very successful which should be promoted to other areas of the country for the benefit of local communities, especially the landless people, where there are unused lakes, reservoirs and swamps.

4.2 Tanks and raceways

Research and development in rainbow trout farming has proved that it is also possible to develop techniques and promote even exotic species and the associated technology. Although, it has not spread as widely as it was expected due to various reasons. Trout farming could utilize clean and cold water if the technique is made cheaper and easily adoptable by the poor people in rural areas, for examples, finding ways to reduce capital cost and produce locally made on-farm feed are necessary. Indeed, other cold water species could also be raised if such system can be developed. One of the ways to reduce cost of constructing concrete tanks is use of plastic liners and culturing trout in cages in rivers and reservoirs where water quality does not deteriorate so much during the rainy season.

One of the examples is a rainbow trout. An effort has been made to develop techniques of rainbow trout farming in Nepal and transfer its technology to the farmer with a view to help expand the sector (Rai *et al.*, 2005). Despite a very good scope, various factors are acting as hurdles; namely, high capital investment for the construction of facilities and need of specialized care to maintain good water quality. In order to manage businesses with high investment, good entrepreneurs are required which is lacking in the country.

4.3 Commercial pond

The first phase of the aquaculture development project started in 1980 funded by ADB and UNDP with the technical assistance of FAO has also showed that there are relatively richer farmers interested in producing fish at a more commercial levels. Some of the examples of farmers organized in clusters should be highlighted such as those in Shankar Chowk and Madi of Chitwan. If this model can be further developed towards establishing cooperatives and assisted in post-harvest handling, preservation and marketing, this might be a model for commercial aquaculture to produce and supply more fish in the country.

4.4 Family fish ponds

A project known as Women in Aquaculture (WiA) launched by AIT and IAAS since 2000 in Chitwan and Nawalparasi has been considered one of the successful projects under which small-scale aquaculture integrated in existing farming system has been promoted forming women's groups and now organizing as cooperatives. Similar approaches have been applied in Hungary and China. The conceptual Model (Shrestha *et al.* 2009; Bhujel *et al.*, 2007; 2008) includes formation of fish farming groups (15-20 farmers/group), small-fish pond (~200 m²), close to house, fertilization of the pond water to enhance natural food (green water), use of kitchen wastes and on-farm byproducts as feed inputs, and growing of vegetables on dykes using fertile pond water. Results showed year-round supply of nutrition (40% fish consumed) and a cash income from the sale of remaining 60% fish. Among the vegetables, pumpkin, ash gourds or other summer vegetables hanging over the fish ponds at the corners or along dikes are popular in Bangladesh and Vietnam which could be worthwhile trials. The model has been found highly successful as evidenced by increased size of ponds or added more number of ponds in the area. Now this model is under expansion such as in Lamjung supported by Aquaculture without Frontiers (AwF) and in Western Nepal by USAID under which over 1,000 family fish ponds have been already constructed and another 1,000 ponds are under the plan (Pandey and Khatiwada, 2009). Similar efforts should be made by the government and other development organizations.

4.5 Fish/prawn in rice fields

Culture of fish in rice fields has been reported in various parts of the country but with little success. As the fish culture needs at least one year of culture cycle whereas rice is

harvested in 3-4 months. Various reports have showed that nursing of fingerlings is more suitable for this short period. Another option is to culture fast growing fish such as tilapia. One of factors affecting rice farming is social which is overlooked by many organizations. Poaching is unavoidable problem if fish are stocked in rice fields which are far away from home. Therefore, rice fields close to home might be suitable for fish farming. The most promising model has been now is growing of freshwater Prawn (*Macrobrachium rosenbergii*) with rice paddies. In Thailand, Royal project has demonstrated that 200 m² pond can yield 10kg of rice giving only 120 Baht (approx. NRs.240). While growing prawn together can earn more than 10 times higher revenues up to NRs. 2,600. The same system in Bangladesh has been practiced recently. Reports have shown that it can generate up to 4 times return on investment. Most farmers culture in small rice plots. This has a good potential of reducing poverty of thousands of people as prawn can be sold at high price e.g. in Kathmandu the price goes up to NRs. 850/kg. Realizing this potential AIT and IAAS are working together. About 20,000 post-larvae were introduced from Thailand to distribute to the farmers. Research has showed that farmers have been successful in growing prawn and now asking for seed which is the main constraint. Prawn breeding program is on-going at IAAS, Chitwan. Hopefully, seed can be produced and supplied in the near future.

4.6 *Fish with Livestock*

Fish farming can be an alternative to rearing animals. They can also be integrated very well as animal manure, urine and litters can be used as inputs for fish ponds. Duck which like water is the most suitable species. Another species of animal may include buffalo which need water for wallowing. Chicken farmers over fish ponds can be another possibility which is quite popular in Thailand on a large commercial scale. Although some efforts were made in Nepal; however, it has not been adopted widely. The possible reasons have to be analyzed. Traditionally pigs are reared over or at the side of fish pond in Vietnam. Possibility of rearing goats by the side of the fish should be explored as goat meat is most preferred and at least one goat is required for each family for Dashain festival.

4.7 *VAC System in Vietnam*

One of the most well-known traditional integration farming system can be found in Vietnam which is popularly called as VAC system. In this system pig, vegetables or fruits are kept near the fish pond.

5 Knowledge / technology management

Sustainable development is possible only when transfer knowledge or technologies is effective. It requires appropriate institutional support with adequate and well-qualified and motivated human resources. Aquaculture Program was established in 1981 to promote sustainable development in Asia through aquaculture and aquatic resources management. The program grew tremendously in within the first two decades becoming one of the most successful Fields of Study at AIT. The program has been so distinct and visible in the reason as it built the capacity of national and international partners. The main reason behind its success is because it is functioning as a Learning Organization. In this section, salient features of the program are described especially focusing on how knowledge or technologies are generated, shared and re-used to move further.

5.1 On-station research

The program Coordinator organizes a regular meeting (monthly) to discuss about the activities of the program and also the research priorities for the generation of new knowledge based on the needs of the discipline. Tireless efforts are made to develop project proposals and receive funding for sponsored research. Thesis research to be conducted by students is also streamlined with the research priorities. Larger project are assigned to a person who enrolls as a doctoral student. Most research facilities were built or maintained and equipment were purchased under various projects. Aquaculture program even runs a commercial unit generating income to carry on research and other related activities.

5.2 Curricula/course development

Basic knowledge of integrated farming system has been incorporated into the curricula of Fisheries and Aquaculture at college and University levels. However, as it is applied discipline, new knowledge and experiences emerged continuously over the period of program implementation. Any new knowledge generated through research and field testing should be incorporated into the curricula. AIT Aquaculture program has been revising its curriculum regularly and also assisting other partner institutions in the region to do the same. Recently, revision was in 2006 with the funding support of European Commission. In each course, the new knowledge or experience are incorporated as case studies. As AIT is more independent, revising curricula is possible in short period of time. However, difficulties have been encountered by the partner institutions as they are part of country's whole education system. For them it took more than three years just to put the revised curricula in place. Improving traditional curricula as well as teaching methods in those organizations is important. Aquaculture program developed a 'Seminar Course' in order to provide platform for the students, researchers, professors and visitors to present their on-going work to share amongst all. It is common that people within the same program unaware of what research activities are going on.

5.3 Aqua-Outreach and participatory research

Establishing an Aqua-Outreach, AIT aggressively promoted various forms of aquaculture since early 90s especially fish farming in ponds integrating into the existing farming systems which consists of rearing of ducks, chickens, goats and/or other animals in rural Cambodia, Laos, Thailand and Vietnam. Learning, from the fields and farmers, the fact that farmers in rural areas are resource poor, AIT developed low-cost technologies through series of research trials on-station e.g. fertilization of pond water with animal manures/urines to enhance the growth of planktons as food for fish. Similarly, techniques were also developed feeding fish with rice bran, oil cakes and kitchen wastes as fish feed. The research results (generated knowledge) were transferred to farmers in targeted areas through joint collaboration with the government mechanism, basically the Department of Fisheries (DoF). Results of the impact studies have showed that productivity of fish farms have increased 2-3 folds in Thailand. Similar results have also showed in other countries as well. The impacts and the lessons learned are again used when new programs are designed and implemented.

5.4 Training

Continuing Education or Training should be emphasized adequately for the dissemination of new knowledge and technologies for the sustainable growth of the sector. AIT Aquaculture Training Unit was established to transfer knowledge. Training courses were developed based on the outcomes of on-station and field research. AIT Aquaculture Training Unit has trained over 1,000 participants including high government officials from more than 30 countries. Many of them have used their knowledge to expand the sector and improve its performance further. One of the trainee alumni has supported thousands of families; many of whom are landless, in Chandpur district, Bangladesh using his knowledge on cage fish farming. He has established three tilapia hatchery farms to supply fingerlings. The system has been improved a lot from the original system at AIT. This improvement has been now realized by AIT which is used for teaching and new batches of training.

5.5 Internship

AIT aquaculture program has recently launched Aqua-Internship program with the assistance of EU/AIT with a view to providing field based knowledge and skills to the post-graduate students. The internship period ranges from 1-6 months and is a part of degree programs. Under this program, students are placed in farms and research centers so that they are exposed to real life experiences. At the end of the period they share their experiences giving public seminars.

5.6 Private sector partnership

Aquaculture was also promoted through partnership with private sector. A fish hatchery was established in 1994 in Thailand which became the world's largest of its kind. With five year-contractual arrangement, the farm was established with the technical assistance of AIT expert who had an accumulated knowledge generated through research at AIT. The farm paid royalty for its revenue generated. The quality of product was monitored and certified by AIT monthly. This served as a model for many others in Thailand as well as in other countries. It also directly uses its experiences franchising arrangement. AIT places its students in the farm for research and internship. Learning from the farm, AIT has accumulated a vast experience which is used for training to others again. In addition, consultancy services have been provided to other companies with the knowledge or experiences gained to other companies e.g. a large on-going project in India (200 ha integrated farm). Similarly, various companies have benefitted in Bangladesh and Indonesia.

6 Conclusions

Aquaculture plays an important role in improving rural livelihoods. It has potential to serve as entry to commercial aquaculture. Unique and sustainable aquaculture development models suitable for rural livelihoods as well as commercial ventures exist in Asia. Their potential of addressing the real community problems should be adequately analyzed. Some of these are suitable for certain ecological zones; therefore they should be scrutinized and tested before adopting them right away. While promoting aquaculture, care should be taken to avoid competition and conflicts with the other sectors of farming system such as goat farming, chicken pig and so on but it is necessary to find ways to integrate with them. Integration can be with infrastructure development project such as irrigation and hydropower. Aquaculture program of AIT serves as learning organizing as it updates its curricula regularly, updates and offer training courses, provides consultancy to establish private businesses and also assist in building capacity of partner institutions in the region. Lessons learned while doing so are again used to update its program. As a result, the program has been very dynamic and highly rated for the field of aquaculture and fisheries.

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