Small-scale aquaculture: Global and national perspectives

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Abstract

Fish has been a staple food for over a billion people. Its demand is increasing due to growing population and awareness about health benefits of aquatic animal food. Disappointingly, wild catch worldwide is on the decline and aquaculture is emerging as the only solution. It grew at 9%/yr in the last 10 years becoming the fastest growing food production sector. At present, aquaculture produces only about 45 million t per year but it needs to be doubled by 2030 to meet its growing demand. Asia produces over 85% of the global farmed fish - mostly by small-scale farmers. Nine of the top 10 fish producing countries in the world are in Asia, all of which started from small-scale aquaculture. Small-scale aquaculture has not only supplied animal protein to the rural poor but has also generated income. Apart from this, it has also served as a gateway to commercial farming and export earnings, e.g., pangasius farming in Vietnam and shrimp in Thailand. Total fish production in Nepal is estimated at about 45,000 t/yr supplying less than 2 kg/caput which is far below as compared to the neighboring countries. Protein intake from animal sources in the country is only about 10%. Furthermore, over half of the total fish consumed comes from India. The country plans to construct more dams to increase electricity generation which will seriously affect natural fish stock. Cage culture in reservoirs, trout farming in hilly areas and backyard fish farming in integration with agriculture in rural areas need to be promoted through government support, donor assistance and international collaborations.

Keywords: Small-scale aquaculture; Aquaculture success stories; Aquaculture extension

1. Global perspectives

1.1. Aquaculture/fisheries in general

Fish is a staple food for over a billion people in the world. It is well known for its lean and white meat with low fat and cholesterol levels. Diet-conscious people, especially in the West, are shifting from red to white meat (such as chicken) and then towards seafood, whereas consumption of aquatic organisms is a tradition in Asia and many other countries that are adjacent to sea. Because of the shifting consumption behavior coupled with ever increasing population, demand for fish is steadily increasing. At present, about 160 million ton of fish - captured and farmed - is produced annually, out of which only about 106 million ton is used for human consumption (FAO, 2006; De Silva and Davy, 2010). The remaining is used as feed for livestock and fish or lost during processing/handling. About half of the fish consumed by human is now farmed. Disappointingly, catch from the wild has either reached to the maximum point or even declining. Researchers have claimed that most of the species will disappear from the sea if the consumption pattern, catch level and other human activities keep increasing continuously (BBC, 2006), indicating that we have to culture ourselves if we want to have fish as a regular diet. Fish farming grew by 9%/yr in the last 10 years, becoming the fastest growing food production sector. Therefore, it has been considered as the only solution to compensate the decline in wild catch. At present, aquaculture produces only about 45 million t/yr but it needs to be doubled by 2030 (80 million t/yr (FAO, 2006) or has to reach at least 50% more production level by 2020 (De Silva and Davy, 2010). It is possible only if a significant technological break through - often termed as Blue Revolution - takes place. Asia is a hub of aquaculture development which produces over 85% of the global farmed fish, mostly by small-scale farmers. Nine of the top 10 fish producing countries in the world are in this continent, all of which started from small-scale aquaculture.

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The annual production of aquaculture products is valued at about US$ 70 billion. The trade (export and import) of fish is higher than that of meat, dairy products, cereals, sugar, or coffee. A large portion of the aquaculture products are still consumed at home or sold in domestic markets. The value of such products traded globally is approximately US$ 18 billions per year, out of which 90% comes from Asia and 75% from developing countries. China and India remained the top two, probably because of their size and population. They both started fish culture as a tradition a long time ago. China realized the value of aquaculture well and gave a high priority to its development. It is the only country which produces more than the wild catch and has always been on the top position, whereas in India, even though fish culture is a tradition, aquaculture has not been widely adopted probably because a large proportion of its population (at least a third) is vegetarian. Other top five fish producing countries are also from Asia, namely Indonesia, Bangladesh, the Philippines, Japan and Thailand. These countries produce fish for their domestic market as well as for export.

1.2. Small-scale aquaculture

Almost all (98%) of the world's small-scale fish farmers are in developing countries - mostly in rural areas. In many communities, fish farming has been practiced as a tradition. Fisheries and aquaculture employs over 40 million people worldwide. It contributes significantly to the daily diet such as in Cambodia, where fish accounts for up to 75% of the total animal protein intake. Fisheries and aquaculture contribute about 6% of the Gross Domestic Product (GDP) in Laos. Various reports have shown that there are over a million fish ponds in Bangladesh - mostly belonging to the poor, which are often called fish factories. Bangladesh earns about US$ 0.5 billion from fish exports from which small-scale farmers are also receiving direct benefits. Fish farming has proved its potential to increase their income up to four times, especially from prawn farming in rice fields. The country earns about US$ 400 million a year from shrimp and prawn export (Nesar, 2009). An increase of 28% in the income of farm families was possible in Malawi through a fish farming intervention. Cage farming in Cambodia and Vietnam has also provided shelter to the landless people who live on the water, popularly known as "floating villages".

Small-scale aquaculture also serves as an entry to commercial aquaculture. Being small and less risky, it can be adopted easily by resource-poor farmers. Upon learning the farming techniques, they can scale up it if they find it comparatively advantageous. Shrimp culture in Thailand, which is valued at about US$ 2 billion annually over the last two decades with a large proportion related to export, was started as a small-scale enterprise and may still remain like this only. More recently, pangasius culture in Vietnam has made a dramatic turn to commercial level, the total value of which is about US$ 1 billion per year since 2007 (Phuong et al., 2008). The majority of the farmers (72%) are still relatively small-scale (Phan et al., 2009). Shrimp culture in Thailand and pangasius culture in Vietnam play a considerable role in foreign currency earning in these countries and also in job creation for the local people both directly and indirectly. For example, a single processing plant in Vietnam employs over 1,000 persons, most of whom are women. The position of these women in the household has improved by virtue of their stable earnings.

2. Aquaculture: National perspectives

2.1. Present status

Directorate of Fisheries Development (DoFD), Ministry of Agriculture and Cooperatives has estimated that total fish production (catch and culture) in Nepal is about 46,000 t for 2008. FAO statistics also show an impressive double digit annual growth (Fig. 1). However, fish farming is concentrated in Terai region (southern plains) (90%) and mainly in earthen ponds (95%). Average productivity of ponds has been achieved at 3.6 t/ha with limited amount of inputs and no commercial feed. Existing system includes occasional feeding of rice bran and cakes without any regular fertilization. There is a scope for intensification by promoting on- farm feed using locally available ingredients, in addition to regular fertilization of ponds with urea and di-ammonium phosphate (DAP). Considerable improvement in the production can be achieved through an effective extension program.

Based on the FAO data (2006), silver carp has been the number one species produced in the country, followed by grass carp. Grass carp has not received adequate attention for semi-intensive farming as in China where it is considered the most important species for polyculture. Emphasis on using grass carp could further enhance productivity. Although rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) are widely cultured especially in polyculture systems, their production has been reported only after 2002. Similarly, African catfish farming has rapidly expanded in recent years mainly because it can be cultured in small ditches and even in dirty water with high density. However, its further expansion is questionable. As it is carnivorous in nature, it can be a big threat to local indigenous species and farmers face feeding problem as well. Some are using chicken and livestock viscera, while others are struggling to collect snails, tadpoles and other aquatic organisms from the wild. Similarly, attempts have been made to promote Nile tilapia (*Oreochromis niloticus*) as it breeds easily in any culture systems without requiring hormone injection. This means farmers in rural areas do not need to purchase fry and fingerlings from the hatcheries repeatedly. However, it has not been promoted adequately fearing that this species also affects natural habitats of indigenous species and compete with them for food. Biodiversity and environmental concerns have presently received overriding attention compared to the rampant malnutrition and food insecurity. Although this is a never-ending debate, in a country where the majority of people are suffering from malnutrition and low income, biodiversity conservation and environmental issues should get low priority (Stewart and Bhujel, 2007). However, promotion of indigenous fish species has been one of the main agenda of the government. Basic principle is that indigenous species are assumed to have had better adaptation to local environment. Breeding programs for two of such species - sahar (*Tor putitora*) and asala (*Shizothorax sp.*) - have been carried out. Although they are highly preferred fish, their slow growth hinders farmers to adopt them for commercial purpose. More research is needed as regards to the type of fish to be promoted but time is running out; farmers cannot wait for a new technology to be developed when techniques and species are already available domestically or can even be imported easily. The promotion of exotic species and the development of culture techniques of indigenous species should go side by side. Considerable efforts have been made in the development and transfer of technology for rainbow trout culture (Rai et al., 2005). However, it has not been expanded as it was expected for various reasons. One of them might be the high capital investment for the construction of facilities and need of specialized care as the fish is very sensitive to water quality fluctuation. Arranging high investments and managing risky businesses require capable and willing entrepreneurs which is lacking in the country. In order to expand trout culture widely, either existing techniques have to be subsidized heavily or new cheaper techniques/systems need to be developed through research.

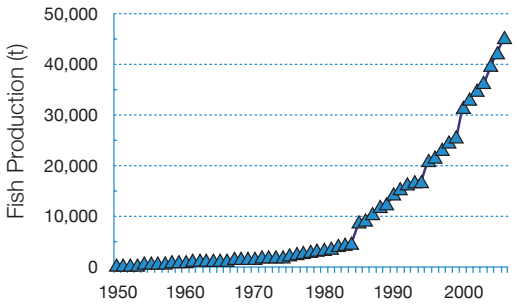

Fig. 1. Annual total fish production (t) (catch and culture) in Nepal.
Source: FAO, 2006

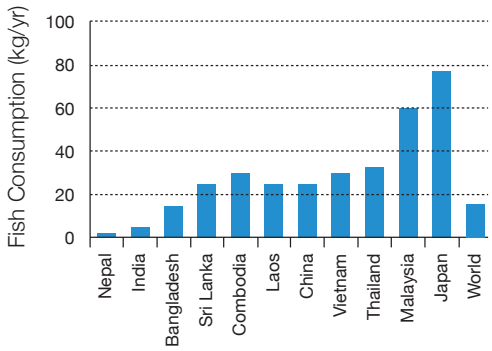

Fig. 2. Annual per capita fish consumption (kg) in various countries.
Source: FAO, 2006

From the viewpoint of human health, about 33% of the total protein should come from animal sources (AIT, 1994), whereas it is only 10% in the case of ordinary people in Nepal. Based on this fact, at least a three-fold increase in the animal protein supply is required. Similarly, it is estimated that over 80% of the fish consumed in major cities of Nepal come from India (Tiwari, 2008). To be self-sufficient, production thus needs to be doubled. There is general consensus that the consumption and import of fish have dramatically increased in the past few years - mainly from India, which was also observed by the author during his visits to various shops in Chitwan and Kathmandu. It was found that almost every shop was selling rohu, pangasius catfish and even some marine species which had come all the way from Bengal or Andhra Pradesh of India loaded in trucks with ice. Consumption of fish is increasing probably because of the increased awareness of the health benefits of fish such as low fat, well-balanced amino acids and w-3 fatty acids, and increased prices of other meat products. Growing import is inevitable as catches from the rivers and lakes have declined. However, no reliable data are available so far and more research is needed on this aspect. Nevertheless, annual per capita fish consumption (less than 2 kg) is far below as compared to other Asian countries (Fig. 2). Even in India, where at least a third of the population is vegetarian, annual per capita consumption is still over 5 kg. The same for Bangladesh, which is known as fish-eating country in South Asia, is over 15 kg and for most of the Southeast Asian countries well over 25 kg. Although Japan is considered to be a seafood-loving country with annual per capita consumption of 77 kg, the Maldives, where main occupation is fisheries and every item of the diet consists of fish or fishery product actually tops the list with 190 kg (FAO, 2006). These facts demonstrate that Nepal is far behind and needs a lot of efforts in promoting small-scale aquaculture by setting immediate and long-term objectives. Immediate need is to increase awareness among rural communities about the backyard fish farming, while in the long term, private sector should be encouraged. Agriculture Prospective Plan (APP) targets 2.3 kg per caput by 2018, which might have been already achieved. As there is no reliable data collection mechanism in place, fish catch, production and consumption figures provided by the government are mainly based on the estimates. The target was perhaps determined while political uncertainty was engulfing the country, leaving little hope for any development. Current development indicates that out of a growing interest among people and various organizations, production and supply have increased considerably. Therefore, a new target should be set in the context of political change and subsequent change in the aspirations of the people, considering the demand to be created by chain reactions of various other factors such as tourism and potential of export market. As the country plans to attract more tourists, there will be bright scope for the fish farmers to sell their products in hotels/restaurants at high prices and earn good incomes, in addition to supplying for the family consumption only.

2.2. Some success stories

Nepal already has typical success stories in aquaculture and fisheries. These tested models should be highlighted and scaled up for their 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.

2.2.1. Cage culture

The cases of roaming fisher communities converted to permanent settlers practicing cage culture, in addition to fishing in lakes (Phewa and Begnas) and reservoir (Kulelkani), is a unique example. Based on a recent research, on an average, a fisher family living around Phewa lake is earning about 13,000 NRs/month (nearly US$ 200), which is considerably high. Management effort on the part of the user groups of lakes and reservoirs has been very successful. This should be promoted to other areas of the country where there are unused lakes, reservoirs and swamps, for the benefit of local communities, especially the landless.

2.2.2. Tanks and raceways

Research and development in Rainbow trout farming has proved that it is also possible to promote even exotic species and the associated technology. For various reasons, it has though not spread as widely as it was expected. Trout farming could utilize abundant clean and cold waters of mountainous parts of the country if the techniques are made cheaper and easily adoptable by the poor people in rural areas. For example, finding ways of reducing tank construction costs and developing methods of producing on-farm feed locally are necessary. One of the ways to reduce cost might be using plastic liners in earthen ponds.

2.2.3. Commercial pond aquaculture

The first phase of aquaculture development project, which was started in 1980, has shown that relatively better-off farmers are interested in producing fish at a commercial level. Most of them have larger ponds of over 2,000 m^2 which were constructed from loans under a government scheme. They are found mainly in central and eastern parts of Terai. In some of the areas these farms are organized in groups / clusters (such as those in Shankar Chowk and Madi of Chitwan). There is growing appreciation that such cluster- based approach is likely to be an ideal commercial aquaculture model in the country.

2.2.4. Backyard pond aquaculture

Women in Aquaculture (WIA) project, launched in Chitwan and Nawalparasi since 2000 by Asian Institute of Technology (AIT), Pathumthani, Thailand and Institute of Agriculture and Animal Science (IAAS), has been considered one of the successful initiatives under which small-scale aquaculture has been promoted by initially forming women's groups and later organizing them in cooperatives. The conceptual model (Shrestha et al., 2009; Bhujel and Shrestha, 2007; Bhujel et al., 2008) includes formation of fish farming groups (15-20 farmers/group); construction of small family fish ponds (~200 m^2) close to home; fertilization of the pond water to enhance natural food (green water); use of kitchen wastes and on- farm byproducts as feed inputs; and vegetable farming on the dykes using fertile pond water. Results showed year-round nutrition supply (40% fish consumed) and a cash income from the sale of the remaining (60%) of the total fish produced. Among the vegetables, pumpkins, gourds or other summer vegetables hanging over the fish ponds at the corners or along the dikes are popular in Bangladesh and Vietnam and could be worthwhile trials elsewhere. The model has been found highly successful as evidenced by increase in the size of existing ponds or construction of additional ponds. This is now under expansion in Mid-western (Lamjung and Gorkha) and Western (Banke, Bardia and Kailali) parts of Nepal, with the support of Aquaculture without Frontiers (AwF) and United Sates Agency for International Development (USAID), respectively. As a result, over 2,000 family fish ponds have already been constructed (Pandey et al., 2009). Similar effort on the part of the government and other development organizations is needed.

2.2.5. Rice-fish/prawn culture

Fish culture in the rice fields has been reported in various parts of the country but with little success. It requires at least one year of culture cycle, whereas rice is harvested in 3-4 months. Various reports have shown that nursing of fingerlings is more suitable for this short period. Another option is to culture fast- growing fish such as tilapia. Social factors affecting rice farming are overlooked by many organizations. Poaching is unavoidable if fish are stocked in the fields that are far away from home. Therefore, rice fields that are close to home might be suitable for fish farming. Growing freshwater prawn (*Macrobrachium rosenbergii*) with rice has now been the most promising option. One of the Royal Thai Government (RTG) projects in Thailand has demonstrated that 200 m^2 pond can yield 10 kg of rice giving only 120 Baht (approx. NRs 240), while growing prawn together can earn more than 10 times revenues (up to 1,300 Baht or NRs 2,600). A similar system has alsobeen practiced in Bangladesh, generating up to 4 times returns on investment. Most of the farmer culture prawns in small rice plots. This still has good potential of reducing poverty among thousands of people as they can be sold at high price. For instance, their price in Kathmandu goes up to NRs 850/kg. Realizing this, AIT and IAAS are working together, distributing about 20,000 post-larvae introduced from Thailand to the farmers. Research has shown that the farmers have been successful in growing prawns and now asking for seed which is the main constraint. Prawn breeding program is underway at IAAS. Hopefully, seed can be produced and supplied to the farmers in the near future.

2.2.6. Fish-livestock

Many people might think that fish farming is alternative to animal husbandry but the both can be actually very well integrated, using urine and litters of animals as pond inputs. Ducks is the most suitable species as they like water. Buffaloes, which need water for wallowing, can be another option. Poultry farming over fish ponds, which is quite popular in Thailand at a large commercial scale, can be another possibility. Efforts were also made to promote this in Nepal. However, it was not adopted widely. The possible reasons are yet to be analyzed. Traditionally, pigs are reared over or at the side of fish ponds in Vietnam. Possibility of rearing goats by the side of fish ponds should be explored in Nepal since goat meat is preferred most and each family requires at least one for annual Dashain festival.

2.3. Comparative advantages

During the symposium on small-scale aquaculture held in Kathmandu on 5-6 February 2009, the then Right Honorable Prime Minister said that small-scale aquaculture would be promoted as a campaign and that it would form part of action for building "New Nepal". The fundamental question to be posed by the people then would be: Why is small-scale aquaculture a better alternative as compared to others? Extension workers and promoters should be able to answer this question showing comparative advantages of small-scale aquaculture in relation to their local contexts. Some of them are described with examples in this section.

Rice is the main crop in Nepal and farmers allocate the majority of their lands to its cultivation. A rice-growing farmer would obviously compare between growing rice and farming fish before taking a decision to construct a pond. Various data have shown that average production of rice is about 4 t/ha per crop. The same amount of fish can easily be obtained from the same area of land with even limited input. But the price of fish is 10 times that of rice whichmeans that farmers can get 10 times higher revenue. With regards to time and labor use, rearing fish requires a lot less - about a fourth. Housewives and children can easily take care of fish without any additional burden once they are stocked. Unlike other animals, fish do not require frequent watering and feeding. For these reasons, fish farming has become so popular that rearing large animals is rapidly declining in Thailand and other parts of Southeast Asia. Milking cows/buffaloes needs very intensive care around the clock. Although milk is considered a good diet for children and adults, compared to fish, it supplies little amount of protein; 100 g milk contains 4 g protein (if no water is added), whereas 100 g fish (75% DM) has about 40 g protein. Among the people of Nepal, the most preferred meat is of goat. With the decrease in pasture/forest, goat farming is also on the decline. As a result, goats are becoming rare and their meat is getting expensive, i.e., over NRs 400/kg, whereas the price of fish is only around NRs 100- 150. Even to celebrate Dashain, people in towns have to wait for the herds of goats to arrive from the high hills or Tibet. In view of the frequency of consumption as well, it is not a suitable option. In order to slaughter a goat and have meat in rural areas, the whole village or a number of families have to come together and share the meat, which can be possible only once a month or even once in 3-4 months. Hence, frequency of meat consumption is very low even for those who can afford it. Recently, commercial chicken farming in Nepal has taken off in some Terai districts (e.g., Chitwan) and peri-urban areas. Raising a few chickens at home is also a tradition in some communities, especially for festivals and to treat guests. The country is said to have become self-sufficient in chicken meat and eggs. In rural areas, farming is still carried out in a conventional way though. Since chickens consume anything they get, including wastes, they are reared in an open area, which is absolutely unhygienic. Besides, the locally-raised chickens are so expensive that they may cost over NRs 300/kg and have very little amount of meat. Compared to vegetables, meat items are becoming either rare or expensive, which has restricted the common people's access. As an alternative source of protein, fish farming has a good scope to fill this gap, if promoted adequately and appropriately.

3. Policy implications

3.1. Water resource utilization

There are plenty of water resources in Nepal, although it does not have coastal areas. Over 6,000 rivers and streams, which are flowing down to India, could provide water for aquaculture development in the country. However, only their potential for electricity generation has been recognized well. This has over shadowed their contribution as sources of fish for various communities living along the banks. While electricity is important for the daily life of the people and for industrial development, the country should not overlook the need for natural food supply. Indeed, one can argue that food security should come first. At the same time, the present electricity crisis has hit the whole country so hard that any power project cannot be stopped either. There is a need for consideration of fishery resources while developing electricity generation plans. As the country plans to generate massive hydro power (10,000 MWT), many dams will be constructed, but how they are going to affect fish populations and the rural communities that depend on them should be investigated and appropriate mitigation measures need to be applied. If integrated properly, the fisheries/aquaculture sector could benefit from the hydro power sector. A hatchery like that of Kali Gandaki reservoir could be built as a small part of hydro power projects, with the view to breeding indigenous species and releasing them into the upstream and the reservoir itself so that wild stock would not be depleted. More dam construction means more reservoirs, which could be utilized for cage culture. Cage culture in reservoirs does not affect power generation, and hence should be considered a potential venture. In addition to utilizing rivers and reservoirs, policies should be made to utilize unused swamps and natural lakes for cage as well as pen aquaculture.

3.2. Institutional set-up

Institutional set-up and human resource play important roles in the development of any sector. IAAS of Tribhuvan University, Fisheries Research Division of Nepal Agriculture Research Council (NARC) and DoFD of Department of Agriculture are responsible for education, research and extension, respectively. However, their activities are mostly overlapping and they work in a competitive way rather than sticking to clear mandates and building good cooperation. More importantly, there is a lack of apex body to coordinate and oversee the aquaculture/fisheries sector in the country. A national advisory board/council such as Aquaculture/Fisheries Development Board (A/FDB) should be established comprising experts from various organizations in the country as well as those working abroad who can play a considerable role. At the same time, present DoFD should be upgraded to Department of Fisheries/Aquaculture (DoF/A) with full authority of planning and decision-making for the sector.

3.3. Human resource

Research is greatly needed to develop new technologies in the country, and hence the backbone of development. If introduced from outside, they have to be adapted to the local conditions before they can be recommended to the masses. There are a very few fisheries/aquaculture researchers in Nepal, for instance, Fisheries Research Division of NARC has only eight scientists. In DoFD as well, personnel with higher education are very limited. If aquaculture is to be launched as a campaign throughout the country, at least one Subject Matter Specialist (SMS) is needed for each district. Many of the current officials are retiring soon, and shortage of human resource is going to be further critical. Concerned authorities need to take this issue seriously and make a plan (short- as well as long-term) for human resources development urgently. In order to produce more technical experts, greater collaboration with national and international academic institutions is needed. Promotion and leadership training program for existing personnel might also help mitigate human resource problem to some extent. Policies to encourage all officer-level researchers and extensionists to write project proposals and compete both nationally and internationally should be implemented. More importantly, projects should be allowed to be handled independently by the winners as Principal Investigators (PIs), with the provision of agreed reasonable overhead (say 10-15%) to the central fund. Aside from this, they should be allowed to have supplementary salaries on top of their base salaries. While evaluating the performance, generation of project funds from internal and external donors, professional publications, community services and direct impacts should be used as criteria. In addition, there should be mechanisms to reward and recognize best performers and punish those who do wrong intentionally.

3.4. Education and training

Formal education and training should be adequately emphasized for the dissemination of technologies and the rapid and sustainable growth of the sector, of which the country is in dire need. There is a worry of over-production of post-graduates as apparently there are no jobs available in this sector. However, high-caliber graduates may not necessarily seek jobs, and hence not be a burden for the country. They can be innovative and job creators themselves depending upon the type of education they get. IAAS has been working with various national and international institutions in improving curricula and delivery methods of aquaculture education with the view to making it very effective and adaptive so that its graduates can play a crucial role in the development of the sector. An internship program launched with the assistance of EU/AIT focused onthe field-based knowledge and skills. Aquaculture education should be incorporated more in the curricula of secondary schools, colleges and universities. Improving traditional curricula and teaching methods in these institutions is important. More efforts are needed in generation and sharing/dissemination of knowledge and skills through collaboration among individuals and organizations from within the country and abroad.

3.5. Extension and outreach

Aquaculture technologies (systems, species and other inputs) that are suitable for different agro-ecological zones need to be identified and promoted. However, extension services have been hindered by the shortage of experts. Most of the SMSs promoting aquaculture have only a bachelor's degree in general Agriculture. Many of them might not be capable of receiving new information and technologies regularly, and transferring them to the communities in need. They need regular interactions, guidance and monitoring. There also seems to be overlap of activities between researchers and extensionists, resulting in confusion or feeling of competition which hampers technology transfer. This should be eliminated through clear demarcation between the research and extension work. Otherwise, ultimate impact will be that farmers or the end users will be deprived of new knowledge and technologies. As far as research is concerned, it should be carried out exclusively by NARC and IAAS. Once fruitful results are produced, they should be handed over to the extension and development offices, which perform the piloting and then transfer to the masses. However, it has been perceived that researchers develop technologies and possess the required skill, but extensionists have problem of understanding them and transferring to the farmers. Firstly, they do not feel the ownership of technologies produced. Second, neither do researchers want to give the ownership to extensionists. In this situation, there is a need to make a provision to involve some of the extension officials in research and researchers in extension. Extension officials often think hi-tech knowledge is needed to pass on technologies to farmers, which is not true. To offer examples from Thailand, nursing of fry for about 1-2 months in hapas before stocking into pond for grow-out significantly increased the survival of fingerlings, and fertilizing pond water with animal manure and chemical fertilizers (e.g., Urea) to make it green helped 2-3 folds increase in production. These were proposed and tested after identification of the problems of low survival and slow growth while surveying farmers' fields. Similar approach could be applied by the extensionists in Nepal as well.

4. Conclusions and recommendations

Protein deficiency is critical in Nepal, and the first and foremost step towards addressing this problem is the realization of its seriousness by community leaders and managers, who can create awareness among people. Aquaculture should be promoted as a campaign by establishing national A/FDB. Although small-scale aquaculture is more suitable to increase resilience of rural livelihoods, it can also serve as entry to commercial aquaculture once private sector gets attracted towards it. Very unique and successful aquaculture development models that are suitable for both the purposes exist in the country (described above). Their potential of addressing the problems in the ground should be adequately analyzed. While campaigning, approaches, salient features and values of small-scale aquaculture need to be highlighted. Models from other countries should also be explored. Some might be suitable for certain ecological zones, and hence should be scrutinized and tested before their adoption. Care should be taken to avoid competition and conflicts of aquaculture with other sectors of farming systems such as goat, chicken and pig farming. Instead, it should be integrated with them for which various ways need to be identified. Several methods should be used for extension of technologies such as producing effective posters, brochures and documentaries of successful farmers. Besides, farmer-to-farmer extension, formation of womenís groups and cooperatives, and other potential field-based methods should also be emphasized. Extension officials should be trained in groups for doing so. Promotion and other performance - based incentives should be established for extension and research staff. Skilled human resource is badly needed, and hence should be developed. Appropriate planning needs to be carried out well in advance to meet the present as well as the future needs.

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