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Practice of Aquasilviculture at Paikgachha Upazilla in Khulna District, Bangladesh

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Abstract

Aquasilviculture is currently the most frequent land-use practice of the South-western part in Bangladesh. The study was carried out to explore the status, benefits, problems, management strategies and marketing preference of practicing aquasilviculture. The study was conducted over a period of three months from September to November 2017. Convenience sampling method was used to select a total of 90 respondents involved in aquasilviculture practices at Paikgachha Upazilla in Khulna district of Bangladesh. Data were collected with the aid of the semi-structured questionnaire administrated interpersonally to the respondents. Among the respondents, almost two-thirds (64%) of them practices aquasilviculture on their own land and near about one-fourth (22%) of the respondents use their leased land for practicing aquasilviculture. In the study area, 63% of the respondents practice aquasilviculture in the land which was previously used for only paddy cultivation and 37% of respondents used their land only for fish culture. The study showed that farmers planted mainly *A. saman*, *S. macrophylla*, *D. sissoo*, *A. Indica*, *A. indica*, *A nilotica* etc. as trees species and *S. melongena*, *B. alba*, *L. cylindrical*, *A. esculentus*, *I. aquatica, L. niger*, *S. tuberosum* etc. as agricultural crops and and cultured shrimp, golda, mud crab and freshwater fishes such as *O. mossambicus*, *C. catla*, *L. rohita*, *C. mrigala*, *H. molitrix*, *M. tengara* into and/or besides their fish ponds. The management techniques in the study area involve soil working, thinning, pruning weeding, protection and application of fertilizer. Aquasilviculture system was contributed to meet the demand of fish, vegetable, timber, fuelwood, fruit and fodder as well as food and nutritional security. The ownership of land, lack of capital and natural calamities are the major problems in the study area.

Keywords: Agroforestry; Aquasilviculture; Bangladesh; Paikgachha Upazilla

Introduction

Bangladesh is now almost devoid of forested land, except in a few selected areas of the country (Giri and Shrestha, 1996). The forest coverage of the country is one of the lowest whereas the deforestation rate is the highest of any country in the world Rahman et al. (2010). The low forest cover of the country is due to massive loss of forest over a period of several centenaries which was once a largely forested country, but now undergoes only about 10% of the forest remaining. Hence, the major causes of deforestation are industrialization, rapid urbanization and high population pressure on existing forestland. Other causes include encroachment, grazing, fire, uncontrolled and wasteful commercial logging, illegal felling, fuel wood collection and official transfer of forest land to other sectors (UN-REDD, 2016). The country has a very small area with a huge amount of population (BBS, 2016) making it one of the densely populated countries in the world with the annual growth rate of 1.37% (BBS, 2017) contributing to extreme pressure on the forest resources. The issue of being worried again is that substantial amount of reduction in trees in the south-western zone of the country occurs due to the bio-environment of the region (Dutta and Iftekhar, 2004).

Crop production, crop yields, cropping intensity and the livelihood quality of people in the south-western part of

Bangladesh have reduced to a greater extent than other parts of the country (BBS, 2001). Normal growth and crop production rate are being restricted by the unfavorable environment and hydrological situation throughout the year (Haque, 2006). It is reported that due to the sea level rise by 0.3 m in coastal regions of Bangladesh, a net reduction of 0.5 million MT of rice production would take place (World Bank, 2000).

On the other hand, fish and fisheries play an important role in the socio-economic development, fulfilling the demand of animal protein, employment opportunities, poverty alleviation of a massive number of peoples and foreign currency earning. It contributes 5.25% GDP of the country and it provides about 4.76% of the total export earning which represents the second largest export merchandise. The increased production of fishes is being accomplished by the enhancement of areas of land and water under both culture and the use of modern farming technologies Ahmed et al. (2010). As the population of Bangladesh is increasing at an alarming rate; the demand of protein is also increasing day by day. In demand of fish of the country is 18 kg per head per year, whereas the country stands at only 13.5 kg per head per year (DoF, 2005).

To minimize the remaining gap of trees, crops and fish resources, it is needed to think about a technology that can provide both the plant (i.e. trees, crops etc.) and fish species on the same piece of land. Aquasilviculture is an effective technology that can fulfill such types of demand. It can play an important role as the most popular modern farming system. This system mostly consists of a profitable system and now it is widely accepted which are practiced in numerous countries around the world. It is the combination of aquaculture (growing of aquatic animals like fish, shrimp or crabs) and silviculture (growing of trees). In this way, outdated fishponds are usually converted into aquasilviculture allowing trees to be grown to provide shelter for some fish, shrimp and crabs (Gholz, 1988).

The selected area is a coastal part of the country where both fresh and brackish water aquaculture is common practice like other coastal regions of Bangladesh; a rapidly expanding farming activity plays an important role in the overall silvofisheries development effort in Bangladesh, where Paikgachha upazila has a great opportunity to extract maximum benefit and creating employment opportunity by aquasilviculture practice. Therefore, the present study intends to provide information regarding the status, benefits, problems, management strategies and market preference of aquasilviculture at Paikgachha Upazila of Khulna district in Bangladesh.

Methodology

The study was carried out in Paikgachha Upazila (22˚28'-22˚43' N and 89˚09'-89˚23' E) in Khulna District of Bangladesh to explore the socio-economic condition of the farmers, operational land holding, types of trees, agricultural crops and fishes practices, management techniques and marketing facilities of aquasilviculture practice as well as some problems of the technique. The sampling design for the survey was purposive because of the uneven and discrete distribution of aquasilviculture land in the region. The sampling units were selected by Convenience sampling. Three unions named Chandkhali, Lascar and Garuikhali were selected by Convenience sampling method, where the aquasilviculture practices were most predominant. From every chosen union two villages were selected as sampling units, whereas fifteen respondents were considered from each village. In total, 90 respondents were selected for the study. The respondents were interviewed with a semi-structured questionnaire to collect data. Pre-testing of the questionnaire was done through a reconnaissance survey to know about the existing aquasilviculture of the study area to prepare a set of questionnaire to fulfill the study. The final survey was conducted during September-November 2017. To analyze data Microsoft Excel Version 10 has been used.

Results And Discussion

Socio-Economic Characteristics of the Respondents

Many People were found in the study area who develop their income level and change their livelihood strategies by practicing aquasilviculture. The socio-economic characteristics of the respondents surveyed in six villages have shown in **Table 1**. In the study area, 88% of respondents were male, while 12% of female involved in an interview through the semi-structured questionnaire. Men were mainly involved with aquasilvicutural practice in the study area. The respondents were classified into three categories according to their age class namely young aged (20-40 years), middle aged (41-60 years) and old aged (above 60 years). Education is considered as a crucial factor for the progressive attitude of the respondents towards the adoption of modern technology. More than half percentage (55%) of the respondents were primary level, while secondary passed were 39% and higher secondary passed were only 6%. The family size of the respondents was not very large.

Selected Characteristics	Categories	Percentage(%) of the respondents
Gender	Male	88
	Female	12
Age(years)	Young (20-40)	32
	Middle aged (41-60)	52
	Old (above 60)	16
Literacy Level	Primary	55
	Secondary	39

	Higher Secondary	6
Number of the family person	Small family size (2-10)	81
	Large family size (11-20)	19
Employment	Male	86
	Female	14
Annual Income (US$)	Below 1190	30
	1190- 5950	50
	5951-11900	13
	Above 11900	7

Table 1. Socio-economic characteristics of the respondents.

The small family size is specifically less likely to be poor, whereupon once again the trend favored small family size (81%) rather than large family size (19%). Male (86%) specifically tended to be better off, with greater employment opportunities than those with the female (14%). Based on the economic status of the respondents the households were classified into four types as; more than one-fourth (30%) of them practiced aquasilviculture had annual income below 1190 US$, while half (50%) of them had between 1190- 5950 US$, few (13%) of them had between 5951-11900 US$ and very few (7%) of them had above 11900 US$.

Land Use Characteristics of the Respondents Practiced Aquasilviculture

Table 2 represents that out of the total 90 surveyed respondents, where 40% of the respondents had below 2 acres fish farm, 46% had between 2-8 acres and only 14% had above 8 acres. Among the respondents, 64% used their own land. For several reasons (i.e. landowner having no interest in cultivation, the compulsion of outsider aristocrat's people on local landowner) lessee accept the land on a contract basis, and they have to pay a certain amount of money according to the productivity of the land. About 22% of respondents used only leased land and the remaining (13%) used both personal and leased land. A good percentage of the respondents (63%) practiced aquasilviculture in their land in which paddy was previously cultivated, while the remaining (37%) contributed to the fish pond. The inputs (i.e. seeds, seedlings) have to purchase generally from the nearest market. There were 71% of respondents who have purchased the planting material, while 29% of respondents raise the seedling and then plant into the fish farm dyke. Generally they plant the seedling during June or July. The age of the seedling purchased and/or raised in several times was found between 1-2 years practiced by a good percentage of the respondents (75%), while 16% and 9% of the respondents use the time range in between 2-3 years and 3-4 years respectively. Among the respondents, about 73% preferred high land for aquasilviculture, while 27% preferred medium high land.

Selected Characteristics	Categories	Percentage (%) of the respondents
Total area of fish farm	Below 2 acres	49
	2-8 acres	44
	Above 8 acres	7
Ownership status	Own land	64
	Leased	22
	Both	13
Previous land use system	Only paddy	63
	Only fish	37
Planting material	Raised	29
	Purchased	71
Age of seedling	1-2 years	75
	2-3 years	16
	3-4 years	9
Sustainable land for aquasilviculture	High land	73
	Medium highland	27

Table 2. Land use characteristics of the respondents in the survey area

Features of Aquasilviculture in the Study Area

Aquasilviculture system is more beneficial for its integrated production system as it provides trees, crops and fishes on the same pieces of land as a pond-dyke system. It provides diversified products such as timber, fuelwood, fruits, vegetables, cereals, spices, shrimp, gold, crabs and freshwater fishes. The daily requirements for household consumption are highly satisfied by practicing aquasilviculture. Different types

of products getting from aquasilviculture have mentioned below.

Perennial plant on the dyke

The most visible trees species in the study area were *A. saman, S. macrophylla, D. sissoo, A. indica, A. nilotica* and *S. apetala*. Nevertheless, F. *limonia, P. guajava,* P. *sapota, Z. mauritiana, E. camaldulensis, E. agallocha, C. nucifera, A. officinalis* etc. were also practiced in the study area **(Table 3)**. The salt tolerant plant has a greater capacity to survive in the study region such as *A. Indica, A. saman, A. nilotica, S. apetala, E. agallocha, A. officinalis* etc. Rahman et al. (2015), SRDI (2010), Miah (2013) and Dutta and Iftekhar (2004) findings which reported such species as salt tolerant have better able to adjust internally to the osmotic effects of high salt concentrations than salt-sensitive plants. They prefer a different type of fuelwood species, fruit trees and timber production species. Trees for example, *S. macrophylla, A. nilotica, A. procera, D. sissoo* are produced for good quality timber. Stem, branches, leaves and barks of many trees are usually used as fuelwood. *A. nilotica, E. agallocha* and *C. decandra* are mainly raised for producing fuelwood. *E. camaldulensis, Z. mauritiana and C. nucifera* are highly used for pole construction. Some fruits species such as *P. guajava, P. sapota, M.indica, F. limonia* etc. are also raised in the study area.

Agricultural crops on the dyke

The respondents who practice aquasilviculture, especially in winter season they cultivate various types of agricultural crops such as *S. melongena, B. alba, C. sativus, H. esculentus, I. aquatica, L. niger, C. annuum, S. lycopersicum* etc. **(Table 3)**. The agricultural crops practiced by the local people mostly consumed by them, whereas a very little portion is sold in the local market. These crops meet food security mainly at household level of the local farmers. The respondent's opinion also showed that the production of rice is being decreased day by day at Paikgachha upazila.

Fishes practices in fish ponds

The study showed that shrimps (*Penaeus monodon*) were mostly practiced in the study area as the main livelihood sources, whereas golda (*Macrobrachium rosenbergii*), mud crab (*Scylla serrata*) and others freshwater fish were cultured also in high amount. In the case of shrimp culture, the respondents start it in January or February and harvest it in April to October. After leaving in the pond, the actual development of *P. monodon* needs near about 2 months. Each month they release shrimp post larvae (PL) in the fish pond once and/or twice and catch after fifteen days interval. The shrimp culture required a huge amount of land, whereas it provides a lot of money to them. But, now the risk of the virus is a common problem of shrimp cultivation. Some respondents mentioned the reasons may be the land are tired due to long-term waterlogging for shrimp aquaculture. With the recent outbreak of virus infection in shrimp people should practice it as planned and more sustainable way.

The respondents prefer different types of freshwater fishes mainly cultured in their fish pond such as *O. mossambicus, C. catla, L. rohita, C. mrigala, A. mola, P. chola, H. molitrix, C. carpio, C. idella, C. striatus, M. tengara, P. pangasius, L. calbasu, S. serrata* etc **(Table 3)**. These types of fishes are locally called Sada fish. In the study area, the respondents start culturing freshwater fish in June to July and catch fish after every two or three months. Such types of fish production are very essential for meeting their protein demand.

Serial no.	Trees species		Agricultural crops		Fish species	
	Local name	Scientific name	Local name	Scientific name	Local name	Scientific name
1	Raintree	*Albizia saman*	Brinjal	*Solanum melongena*	Shrimp	*Penaeus monodon*
2	Mahogany	*Swietenia macrophylla*	Pui saag	*Basella alba*	Tilapia	*Oreochromis mossambicus*
3	Sissoo	*Dalbergia sissoo*	Sponge gourd	*Luffa cylindrical*	Rui	*Labeo rohita*
4	Neem	*Azadirachta Indica*	Dharosh	*Hibiscus esculentus*	Catla	*Catla catla*
5	Babla	*Acacia nilotica*	Water spinach	*Ipomoea aquatica*	Mrigal	*Cirrhinus mrigala*
6	Kaora	*Sonneratia apetala*	Bean	*Lablab niger*	Silver carp	*Hypophthalmichthys molitrix*
7	Peara	*Psidium guajava*	Potato	*Solanum tuberosum*	Grass carp	*Ctenopharyngodon idella*
8	Shofeta	*Pouteria sapota*	Bottle gourd	*Lagenaria siceraria*	Common carp	*Cyprinus carpio*
9	Kodbel	*Feronia limonia*	Cucumber	*Cucumis sativus*	Golda	*Macrobrachium rosenbergii*
10	Tal	*Ziziphus mauritiana*	Peppers	*Capsicum annuum*	Baan	*Anguilla bengalensis*
11	Narikel	*Cocos nucifera*	Cabbage	*Brassica oleracea* var. *capitata*	Punti	*Puntius chola*
12	Eucalyptus	*Eucalyptus*	Radish	*Raphanus sativus*	Shoal	*Channa striatus*

		camaldulensis				
13	Date palm	*Phoenix sylvestris*	Cauli flower	*Brassica oleracea* var. *botrytis*	Tengra	*Mystus tengara*
14	Gewa	*Excoecaria agallocha*	Tomatoes	*Solanum lycopersicum*	Mola fish	*Amblypharyngodon mola*
15	Bean	*Avicennia officinalis*	Black gram	*Vigna mungo*	Pangas	*Pangasius pangasius*

Table 3. The species mostly observed into aquasilviculture practice.

Management Strategies

Different management techniques adopted for practicing aquasilviculture at Paikgachha Upazilla have shown in **figure 2**. The farmers in the study area who practice soil working that is associated with the preparation of land by ploughing, digging and tillage operation. Almost all of the respondents (96%) in the study area were involved with soil working activities.

Weeding is done by cutting back all weeds that will compete with crops for food and nutrition in the same land. So it is required for good growth of crops and free movement of fish as well as to increase yield. Weeding is essential during making a seedbed, transplanting of seedlings, after two or three months of sowing when seems to be needed. It is an essential treatment, which was done by 87 % of respondents to remove the unexpected plants grown along with useful crops.

In the study area, thinning is done for selected removal of organs/plants, primarily undertaken to improve the growth rate or health of remaining trees by giving adequate space. It is necessary for felling in the immature stand for the purpose of improving the growth and stem of the trees without permanently breaking the canopy. First growing species required thinning earlier and slow growing species required thinning later. When some trees are removed from the stand, the remaining trees are given more space, light, nutrient and moisture thus positively affecting their general physical process. In the study area, 84% of the respondents were involved with such activities.

Pruning is done to remove the parts of the plants are no longer useful that has many benefits, including maintaining plant health, restricting overgrowth of plants and promoting the quality of plants flowers, fruits and foliage or stems. Moreover, only 19% of the respondents were found to practice such a strategy.

Most of the respondents take protection in their cultivated areas. They generally use fencing to protect their agricultural crops and trees from cattle that are useful for good growth and development of seedling. In this study area, most of the respondents (93%) take protection in their aquasilviculture practice.

In this study area, respondents mainly use urea and cow dung as fertilizer. They use both organic and inorganic fertilizer. Usually TSP, DAP, Gypsum and mixture of salt and lime are used for the treatment of fish. The respondents in the study area mentioned that the fertilizer is normally applied twice per cropping season if they think land is tired. 94% of respondents were found to use fertilizer to get more vegetable and plant species as well as fishes.

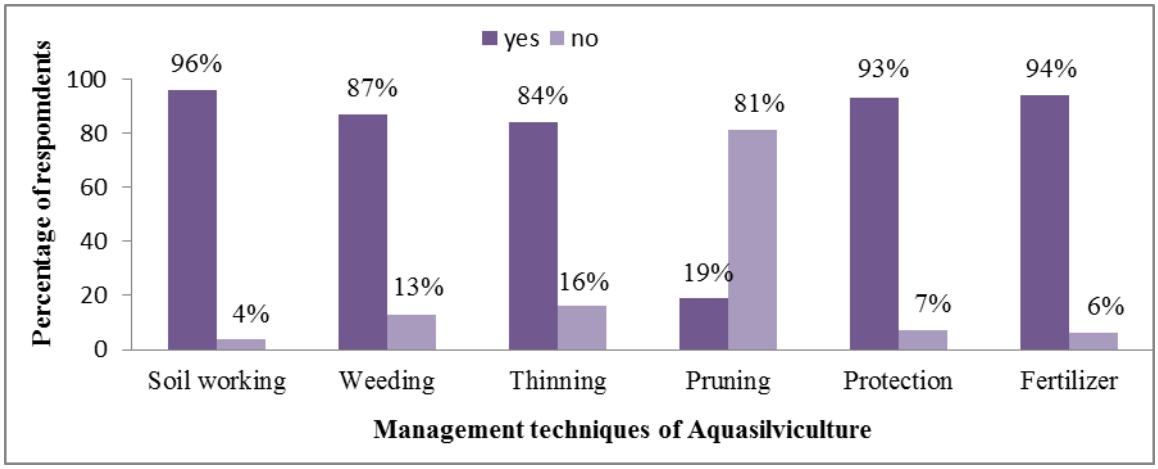

Figure 2. Different management techniques of aquasilviculture at Paikgachha Upazilla.

Market Preference

The contribution of aquasilviculture system was found to meet the demand of fish, vegetables, timber, fuelwood, fruit and fodder as well as food and nutritional security. By learning from the respondents in the study area, the information about different market opportunities was collected. The marketable product, market demand and market facilities of practicing aquasilviculture in Paikgachha Upazilla have been shown in **figure 3, 4 and 5** respectively.

Marketable Product

Fish prawn was the most preferable marketable products in the study area. All the respondents (100%) raise it for selling in the market because it provides the main source of earning by giving a lot of money to them. The next preferable marketable products were vegetables such as bean, potato, cucumber, peppers, cabbage, radish, caili flower, tomatoes, black gram, mung bean, turmeric, brinjal etc., where 86 % of the respondents raise it for selling purposes, especially in their local market. The fuelwood and timber products getting from aquasilviculture practice in the study area, are generally used for their own housekeeping. Only 33 % and 16 % of the respondents were found who can market their fuelwood and timber products respectively. Fruit, fodder, nutrition and some other products were raised by a good percentage of the respondents (44%) for marketing reasons also.

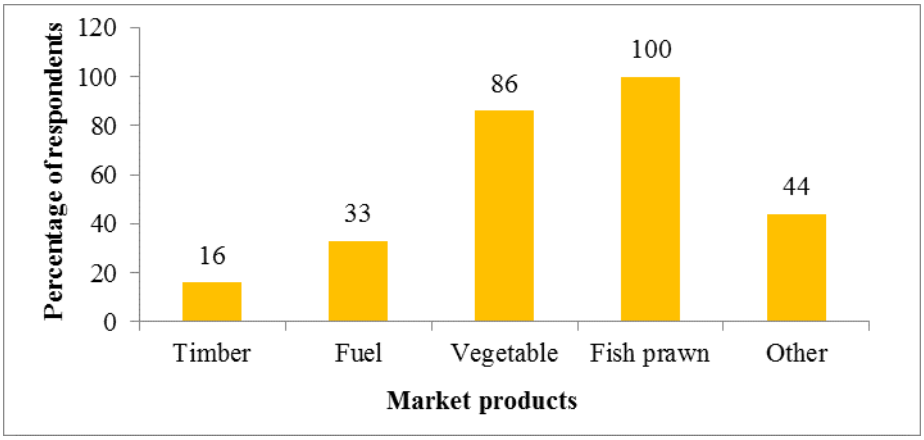

Figure 3. Percentage of marketable product in study area.

Market Demand and Market Facilities

The ability of product value is depending on the market facilities. In that study area, 24% of respondents had agreed about excellent market demand mainly for shrimp and fish, while 72% of respondents had agreed about good market demand mainly for shrimp, fish, timber and annual crops. Only 4% of respondents had agreed about the poor market demand. In terms of poor storage facilities, there was very poor demand for the products. Farmer products facilities at Paikgachha upazila which was favorable to aquasilviculture practice, whereas only 19% respondents had agreed about worthy market facilities mainly for shrimp, whereas 68% respondents had agreed about good market facilities mainly for shrimp and fish. Only 13% of respondents had agreed about poor market facilities. In terms of storage facilities for annual crops, there were very poor facilities. The market facilities for tree products were not so good. In the depot, the timber is felled down on an open place and so it is gradually damaged by fungal attack.

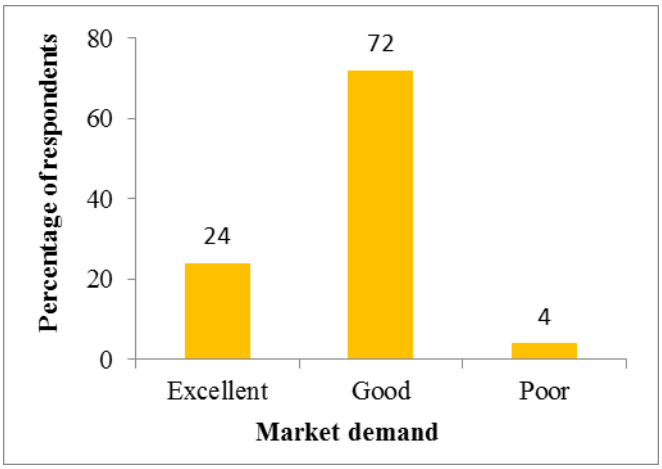

Figure 4. Market demand of the product.

Figure 5. Market facilities of the Product.

Problems of Aquasilviculture in the Study Area

Almost all of the respondents (> 98%) in the study area reported that the infection of virus is a common problem for the cultivation of fish and every year a lot of fish die for this reason. There was a massive mortality of shrimp, crabs as well as different viral and bacterial fish disease. Furthermore, shrimp farmers incur losses when importing countries impose import bans due to harmful components in the processed shrimp. There were also crop disease and some trees are negatively affected due to salinity problems for both natural and anthropogenic reasons. Some respondents reported that due to perennial trees on the dyke, the fish harvesting meets some difficulties. They also reported that falling leaves from perennial trees pollute the water and the pond does not get sufficient light due to the remained perennial plant on the dyke. The lack of capital was also a problem for them. They have no knowledge about the term 'aquasilviculture' and they practice such technology only as traditional manure. That means that they have no proper knowledge on how to manage fish farm along with trees and annual crops. Natural disaster is a serious problem in the study area along with climate change warning. Acidification of soil and poor water quality negatively affect the area also. The land ownership was a major problem in the study area. There was a conflict between fisheries officer and farmers. In the study area, the collaboration among research and development institutions and local parties is critical in training and empowering local communities to adopt aquasilviculture technology. The implementation of efficient policies and good science are also critical instead of their practice as traditional manure.

Conclusion

In the study region, the livelihoods of a large number of farmers are associated with only fish farming when long-term waterlogging by saline water reduces soil fertility, declines in water quality cause various infectious fish diseases as well as it reduces freshwater wetlands and rice growing areas. Nowadays, aquasilviculture system means the combination of fishes, trees and crops on the same pieces of land have recognized as much effective technology where land is degraded and fertility is decreased due to the saltiness of the water. It provides alternative livelihood opportunities for the rural poor, especially small land holding farmers can support their manifold needs by practicing this system. For this reason, aquasilviculture system is practiced as the best alternative as well as a supplementary source of income to the rural poor/farmers which provide fish, trees and crops all together that can fulfill the diverse needs of them. On the other hand, there are good market facilities for both shrimp and annual crops. Natural calamity often occurs in the study area that causes various trees and crops disease as well as massive mortality of fish. Besides, the region is most vulnerable to the impact of climate change because of its geographical location, when aquasilviculture practice is more adaptive to this situation compared to other land use practice. Risk analysis in aquasilviculture needs to be undertaken to evaluate the danger and weakness of aquasilviculture practice in adapting to natural calamity and/or climate change. For this reason, research and development institutions need to disseminate scientific information on well planned aquasilviculture practices to the rural poor/farmers. Aquasilviculture practice could be a climate-smart and environment friendly practice in the area through increasing green coverage and at the same time for the betterment of the livelihood of local peoples and farmers.

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