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Integrated Farming Systems for Livelihood Security in Hilly Areas of Indian Subcontinent– A Review

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Abstract—*The Hilly region of India is mostly confounded to North-Eastern (NE) region comprising of eight states viz., Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim with total geographical area of 262180 Km^2 and which accounts for 8 percent of the total geographical area of the country with more than thirty nine million population. In the hilly region, only 35 per cent area is plain excepting Assam where plains account for 84.44 percent of its total geographical area. Net sown area is highest in Assam (34.12 per cent) followed by Tripura (23.48 per cent). Arunachal Pradesh has lowest net sown area. Cropping intensity is highest in Tripura (156.5 per cent) followed by Manipur (152.1 per cent), Mizoram (136.36 per cent) and Assam (123.59 per cent). About 1.6 million hectare area is under shifting cultivation in NE region. Out of 4.0 million hectare net sown area of the region, about 1.3 million hectare is under severe soil erosion problem. The region is characterized by fragility, marginality, inaccessibility, cultural heterogeneity, ethnicity and rich biodiversity.*

Keywords*: Integrated farming system, hilly region, sustainability*

1. INTRODUCTION

The entire North Eastern region is at low profile economic development although it has a tremendous potential to develop. Agriculture is prominent sector of the economy in the region. It is playing a significant role in determining varying nature of agro-economic activities. The farmers are small and marginal and about 80% of the population depends on agriculture for their livelihood. The region is characterized by fragility, marginality and inaccessibility and the agriculture in the region is complex, diverse and risk prone. Rural population is around 82% and out of which more than 40% population is below poverty. The basic problems facing by agriculture in the region are small land holdings, low cropping intensity, low productivity, inadequate access to appropriate technologies and other external inputs, inadequate irrigation facilities, increased natural calamities, shifting cultivation, soil acidity, steep slopes, improper nutrient management, low yielding/local varieties of crops and livestock are the major constrains in agriculture. Out of 4.0 million hectares net sown area of the region, nearly 1.3 million hectares prone to severe soil erosion problem (Sachchidananda, 1989).

Various technological interventions such as integrated farming system for effective natural resource management, agro-forestry for rehabilitation of degraded land, resource conservation technologies viz. system of rice intensification (SRI), integrated crop management (ICM), zero tillage, poly-house technology for nursery and year round vegetables production, composite pisciculture, supplying seeds/breeds of high yielding crops/livestock breeds/fish, multiple cropping to increase cropping intensity, scientific cultivation and value addition of spices and horticultural crops, usage of farm implements, subsidiary income generation activities, etc were taken up to boost and stabilize the income of the farmers at large scale.

The post Green Revolution had posed problems like topsoil depletion, genetic resources erosion, ground water contamination, increasing costs of production, decline of family farms, and the disintegration of economic and social conditions in rural communities. To redefine Green Revolution in pragmatic manner, sustainable farming system came into play. Sustainable farming system integrates three main goals – ecological balance, economic profitability, and social and economic equity. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Therefore, stewardship of both natural and human resources is of prime importance. Stewardship of human resources includes consideration of social responsibilities, while stewardship of land and natural resources involves maintaining or enhancing this vital resource base for the long term. To materialize this goal a systems perspective is essential for sustainability. The system is envisioned in its broadest sense, from the individual farm, to the local ecosystem, and to communities affected by this farming

system both locally and globally. An emphasis on the system allows a larger and more thorough view of the consequences of farming practices on both human communities and the environment. A systems approach gives us the tools to explore the interconnections between farming and other aspects of our environment.

Intensive integrated farming system involves a variety of approaches. Specific strategies must take into account, viz. topography, soil characteristics, climate, and local availability of inputs, plants, animals and the individual grower's goals. Following principles can be applied to help growers to make integrated farming system sustainable:

- Diversification of crops (including livestock) and cultural practices to enhance the
- biological and economic stability of the farm
- Management of the soil and water to sustain watershed
- Judicious integration of plants and livestock
- Efficient and humane use of inputs
- Consideration of farmers' goals and choices

In system approach the farm is viewed as a unit and living medium that must be protected and nurtured to ensure its long-term productivity and stability. Methods to protect and enhance the productivity of the farm include judicious use of existing resources including livestock.

2. POND BASED INTEGRATED FARMING SYSTEMS

Farmers in plains of Assam, Manipur, Tripura, Meghalaya etc., follow intensive integrated farming system to meet their demand for food and earn livelihood. It is common situation the each household will have farm pond. Around the ponds, crops like banana, arecanut, kitchen garden etc., are maintained in embankments and nearby uplands and along with the house hold would have at least one animal component like cow/ buffalo/ pig / goat etc. or their combinations. Local poultry/duck is also integrated to use the resource effectively. Compost pit is maintained in the corner of the field and also in backyard. Pond is used for pisciculture and during the lean season pond water is used for life saving irrigation to crops and fruit trees. Pond is also maintained in the middle of field especially for life saving irrigation of vegetables and for fish culture. The vegetable wastes are added to pond as feed for fishes like grass carps etc. rice is cultivated in lowland and wastes of farming systems are recycled in rice/vegetable field. Some farmers maintain small pond in the corner of the rice fields for fish rearing as well as for irrigation. The significant aspect of that system is that all most all the components are maintained organically except for vegetables and rice where a low amount of fertilizer is applied along with farm yard manure.

3. FISH CUM VEGETABLE FARMING IN MEGHALAYA

Farmers in selected site of Meghalaya grow plantation crops in mixed farming and also *Jhum* farming system is prevalent. Paddy and maize are the major cereals crops and cashew nut and areca nut are the major plantation crops grown. Whereas, vegetables are grown in a very small scale. Before RRTC interventions people in the selected clusters of South Garo Hills District used to cultivate few types of vegetable with little care which resulted in very low production which could hardly meet their family requirements. Fishery is also another source of livelihood for the farmers in Sibbari cluster. Farmers are having small size ponds (500-600 m2) in their backyards or near their paddy fields. However, fishes are reared in unmanaged ponds infested with weeds and economically less fish species resulting in very low water productivity. But after RRTC intervention the farmers realized the potential of fish cum vegetable farming. Now the farmers are growing at least five to seven types of vegetables round the year near in the pond dykes and the productivity of fishes has increased from a meager 500-600 kg/ha to 2.5 t/ha. They are now able to produce surplus quantity of vegetables and fishes. Farmer has realized the benefits from IFS where he could earn a net income of Rs. 15,000 from vegetables and Rs. 60,000 from fishes in a single year from his farming. The B: C ratio was 3.30:1 (Cyril Tirkey *et al*.).

4. INTEGRATED LIVESTOCK – FISH CULTURE IN MIZORAM

Fish culture has assumed greater significance presently in view of its potential role in regulating organic waste and early economic returns with low investment. However, it is not well developed in Mizoram. Fishes that are transported from other parts of the country meet the fish requirement of people. It has also been observed that farmers are not able to afford for the feed requirements of fishes due to their socio economic status of the farmers. It is the need of the hour to find out some alternatives, and in this direction, integration of piggery to fish pond could assist as the pig dung could add the plankton growth in the ponds, which could be utilized by the fishes. The manure of pig is much richer in nutrients; hence, smaller quantities would go a long way to increase fish production. Besides this, integrated pig and fishery farming may promote full utilization of land area and recycling of organic manure through minimizing the operation expenses in feeds and improve the living condition of the farmers. Though the integrated farming of animal and fishes has been practiced in many places, very few farmers have adopted in Mizoram. Integrated pig – fish farming system links two different systems, which are otherwise separate, where by pig and fish forms subsystems of a whole farming system. In integrated pig – fish farming system, the focus is emphasized on optimal utilization of waste or by product of one subsystem as input

for other subsystem within the farm unit. Thus, it improves the productivity and lowers the cost of production.

Fresh pig manure is rich source of nutrients and pig manure is potential source of feed to pigs, which otherwise go as waste. In this system, supplementary fertilization and feeding are not required for fish culture. Pig manure is rich in phosphorus and nitrogen, which are highly essential to sustain a good stocking density of fish fingerlings per ha. The nutrient content of pig manure is about 0.6, 0.5 and 0.2 per cent N, P and K, respectively. On an average, 30 – 40 pigs are sufficient to fertilize one ha pond water. In the existing pig – fish integrated farming system; the pig sty is constructed on the pond itself with the front part of it having support on the bund. The pig sty is constructed with locally available materials and the pig dung, urine and washings are allowed directly to fall into the pond. The farmers do not practice any particular stocking density either for pig or for fish. They usually practice composite fish culture and depending upon the availability, fish fingerlings are introduced in the pond in the month of April – May. No specific pond preparation or water quality management measures are followed by the farmers except for providing an inlet and out let to the pond for maintaining water level. Horticultural crops like papaya, banana and areca nut are planted on the bunds of the pond by some farmers. Colacasia is also planted in the bunds of the pond and utilized for feeding pigs.

As per the recommended stocking density (30 pigs/ha water area for plain areas), Hampshire pig was integrated with fish culture. The pig sty was constructed as per the standard requirements on the embankment of the pond. The pig was fed with standard ration in recommended quantity and the growth rate was recorded based on the monthly body weight throughout the study period. Pig dung, urine and washings of the pig sty were directly released into the pond (Figure 2). The pig was offered 1, 2, 2.5 and 3 kgs standard concentrate feed per day at 2 – 4, 4 – 6, 6 – 8 and more than 8 months of age, respectively.

Composite fish culture, comprising of both Indian major carps (catla and mrigal) and exotic carps (common carp and grass carp), were under taken. The fishes were stocked at a density of 7000 ha. The fishes were fed only with pig manure and during the period of study no feed supplements were given. After 11 months of stocking, the fishes were harvested and growth of fish was recorded. The body weight of Hampshire pig in integrated farming system at 11 months age was 90 kg. The growth rate of different carps was observed that the growth of catla *(Catla catla)* was significantly higher than other carps followed by the grass carp. In the integrated pig – fish culture, under the above mentioned managemental conditions, the fish yield was 2, 209 kg per ha water area. As majority of the household in the state has at least 1 – 2 pigs, integration of pig – fish culture can profitably be practiced by the farmers having pond(s). If the farmers follow the recommended stocking density for pig as well as for fish and water quality is maintained in recommended scientific way, the pig – fish integrated farming system would prove more profitable in the state.

5. INTEGRATED KITCHEN GARDEN, POTATO AND POULTRY FARMING SYSTEM IN NAGALAND

Agriculture (*Jhum* cultivation) is the main stay of people of the villages in Mon District, Nagaland. 87% of the population is very poor. Malnutrition prevails in almost every family. Their main employment is agriculture but the field is very far, Therefore, for enhancing the productivity to get nutritional security and income generation, also to utilize the land near the households, kitchen garden concept was introduced including green leafy vegetables, ready to eat vegetables etc. Potato was introduced for the first time to get nutrition as well as to generate income and also to use the cultivated *Jhum* land after the harvest. The villagers were rearing birds but local breed which is small in size, Therefore, broiler and vanaraja were introduced for more meat production. Vegetable crops like chilli, bean, raddish, tomato, brinjal etc. were introduced in kitchen garden/homeyards. Potato varieties Kurfi kanchan, Kurfi jyoti, Kurfi giriraj were introduced, 10-15 t/ha. Application of organic manure was advocated for higher productivity. 10 nos. of broiler birds were distributed to each household. In kitchen gardening the production of vegetables was 135kg/250 m^2, net income was Rs. 1675 and B:C ratio was 5.78. Whereas the production, net income and B: C ratio from potato was 955/1000m2 and , Rs. 5550 and 2.38 and from poultry production was 2.5 kg/bird, net income of Rs. 2750/unit (10 birds/unit for 40 unit).

6. WATER HARVESTING AND MULTIPLE BASED (CROP-FISH-PIG) SYSTEM

In the NEH Region, scarcity of water particularly during the lean season is a major constraint in increasing the cropping intensity and its productivity. Due to the hilly terrain, the rain water is lost either in the form of surface water or quick sub-surface runoff leading to low soil moisture status and acute water scarcity for domestic agricultural consumption during the rainy season. By and large, monocropping is therefore, prevalent in the region. However, wherever water is available, farmers opt for second cropping. Keeping this fact in view, an attempt has been made to harvest water so as to make its judicious use for cultivation of the crops, fishery and livestock in an integrated manner. Since shifting cultivation was the mainstay of economy of the villagers before implementation of the project, the concept of water harvesting and its multiple uses was new to them. During the implementation of the project, major thrust was given for water harvesting and its multiple use based on the lessons learnt from the past. The net monetary income of the farmers has increased significantly with the present intervention. It has open up a new avenue for increasing production and productivity not only in the target area but also in other villages of Mon district of Nagaland.

The stake holders have gained the needful employment, food and nutritional security besides income generation with the present intervention. Integrated fish farming is becoming very much popular and farmers are trying to integrate fishery with poultry and even with cattle.

7. FISH-CUM-LIVESTOCK BASED INTEGRATED FARMING SYSTEM FOR LIVELIHOOD IMPROVEMENT OF *JHUM* FARMERS IN ARUNACHAL PRADESH.

Farmers of the Daporijo, Arunachal Pradesh has been practicing *Jhum* farming from time immemorial. In the *Jhum* field generally they grow as many crops as possible to meet their daily

Demand. However, hardly they integrated *Jhum* farming with aquaculture and livestocks. In the valley lands of *Jhum* fields farmers can go for digging ponds or the ponds can be made by making dykes in one or two sides due to natural hillocks in other sides. Such ponds can be brought under composite pisciculture and may be integrated with livestocks like pigs, poultry etc as per the demand of the farmers. Farmers with their own cultivation practices harvesting the cereals (1.14t/ha), vegetables (3.45 t/ha) and tuber crops (5 t/ha) in 1.2 hectare area. The total return from her traditional way of cultivation was Rs. 13896/- only. However, after integrating the various components and increased her production and productivity of cereals by 2.71t/ha, vegetables 5.25 t/ha and started earning Rs. 73, 800/- from the above said area and components. Farer mostly earned the said amount from livestock and fish. By seeing the performance and profit of animal components and now converting agricultural land to fish pond.

Another farmer Mr. Pugo Digbak of Digbak village is a beneficiary of the activity. He has the *Jhum* area of 1.0 ha and wet land of 1.5 ha. Before implementing IFS he was growing more no. of crops on *Jhum* and rice on wet land. After getting exposed with trainings at ICAR Basar, he was confident to take up the activity on his land with possible integration. As his farm is away from home, he was not convinced to integrate livestock because of the unavailability of labour and possibility of theft. Therefore, he kept the livestock like pig and poultry on his home and crops on field. Manures were recycled to field after composting at site. The cost of cultivation was Rs. 13,000/- before and Rs. 21000/- after imposing the activity. The cost includes construction of poultry and pig shed. Before integration his earning was about Rs. 16,100/ annum/ha but after integration his earnings increased to Rs. 39,000/annum/ha. The B: C was 1.24 before and 1.86 after the activity. By integrating the livestock and by growing sequential crops he used his family labour throughout the year. Neighboring farmers were also convinced by seeing the performance of Mr. Pugo and hopefully they will also integrate the components in best possible manner.

8. MUSHROOM AS COMPONENT OF FARMING SYSTEM FOR NUTRITION AND LIVELIHOOD IMPROVEMENT IN DHALAI, TRIPURA.

The farmers in the selected cluster *viz.* Balaram and Maracherra of Dhalai district of Tripura are mainly dependent on agriculture as their source of livelihood. In those areas, paddy is the main staple crop which is cultivated twice in a year. Besides, some vegetable crops are also grown which is not enough for their need and to meet the demand of the local markets. The main hurdle for the area is the scarcity of irrigation water leading to low cropping intensity. Therefore to improve the livelihood of the community certain additional source of income is most important. Mushroom cultivation is such a practice which can significantly serve the purpose. Through mushroom cultivation, people can easily generate some decent amount of extra income with least investment. In all 216 farmers cultivated mushroom during the period starting from June, 2008 to December, 2010 (Table 1). They produced 2062 kg of fresh oyster mushroom. Total expenditure was calculated as Rs. 46,492 @ Rs. 12 for a poly bag filling. The farmers sold their produce @ Rs. 80 per kg fresh mushroom to the local markets and earned Rs. 1,65,045, which resulted Rs. 1,18,509 as net profit. A number of framers have learnt a new technique to enhance their income. Mushroom cultivation is a totally new technique for Balaram and Maracherra cluster. They learned the mushroom cultivation technologies after participating in training. “Mushrooms cultivation ensured enhancement of family income at cost of less investment. Waste materials easily deposed into food materials enriching with nutrition is the extra benefits at farmers’ hand.

9. TUBER CROP BASED FARMING SYSTEM FOR FOOD SECURITY AND LIVELIHOOD IMPROVEMENT IN DHALAI, TRIPURA

The *tilla* land of tripura is suitable for cultivation of tuber crops. Inclusion of tuber crops in farming system would enhance the productivity per unit area besides improving food security for small and marginal farmers. Before intervention, the self help group *Abachanga* had 0.48 ha of *tilla* land (moderate hillock upland) which was kept fallow with full of weeds and shrubs. As the portion of the land was *tilla* and without any source of irrigation, it was selected for cultivation of tuber crops *viz.*, Dioscorea, Elephant foot yam, Tapioca, Ginger, Sweet Potato etc. After clearing, the land was divided into small plots of about 800m2 each for the individual tuber crops. Boundary of each plot was planted with Banana Suckers. The materials were planted at 90cm ×90cm (Dioscorea, Elephant foot yam, Tapioca), 60cm ×20cm (sweet potato) and ginger which was planted @ 1.5 ton/ha. One unit pig (2 piglets) was integrated for fattening by utilizing tapioca, sweet potato etc as feed. Farmers provided kitchen waste, some concentrate for better growth of pigs. Before intervention, tuber Crop based farming system was completely a new concept for the farmers in the selected villages of

Dhalai District, because there was no such type of tuber crops cultivation. The farmers do not have any idea to utilize the fallow land. They would consume the tuber crops during the monsoon season while the food availability used to be less due to continuous rain and also during working in *Jhum* land after collecting from adjacent jungle. As per their concept it is very highly energetic and durable items. They were using tapioca (*Kathaloo*) as fencing materials. The tuber crops were also used as pig feed. The productivity of discorea, elephant foot yam, tapioca, ginger and sweet potato was 5.63t/ha, 3.75 t/ha, 1.9 t/ha, 2 t/ha and 4.25 t/ha, respectively. Farmers could earn a net income of Rs. 20950 from 0.48 ha area with a B: C of 2.15.

10. AGRI+HORTI+PIGGERY+FISHERY INTEGRATED FARMING SYSTEM IN UNUSED *TILLA* LAND OF DHALAI, TRIPURA

The *tilla* lands (small hillocks with gentle slope) in the selected clusters (Balaram and Maracherra) of Dhalai district of Tripura are suitable for cultivating agricultural as well as horticultural crops however it is left fallow by the farmers and the land generally remains infested with weeds and unproductive shrubs. Hardly a few farmers are using their *tilla* land for cultivation of tuber crops, banana, Assam lemon, pineapple etc. and even if some farmers are cultivating they are mostly growing local varieties. They are not aware of the high yielding varieties that are available in the market, hence the productivity of crops is very low and the income derived is minimal. Fish culture is also a common practice among the farmers of Dhalai District of Tripura where they would culture fishes in small size ponds of 400- 500 m2, but most of the ponds are constructed in plain areas mostly near paddy fields. But fish culture is not practiced near theses *tilla* lands may be due to scarcity of water or the water source is not available. However, there is ample scope for integrating crops with aquaculture and animal husbandry in these *tilla* lands by conserving rain water during monsoon season and using it for irrigating crops and for fish culture. Before Dhalai Zilla Parishad intervention of Agri+Horti+Pig+Fish farmers are not using their *tilla* land but after intervention they have realized the benefits that they can derive from their unused land by practicing integrated farming system. Farmers are now self sufficient and they are using the produce not only at house hold level but they are selling the surplus amount thereby enhancing their income and livelihood substantially.

11. CONCLUSION

The indigenous farming system of North East India have rich traditional base of water harvesting, soil fertility management, inclusion of fish and animal component along with forestry in a sustainable diversified way. However, farming systems have either remained confined to their place of origin or are in the course of extinction due to the introduction of new technologies and farming systems which are more food grain production oriented and have little scope for environment. These traditional systems were sustainable as long as the population pressure was low. With the increase in population, pressure on land other natural resources increased and farmers started intensive cultivation leaving hardly any time for building soil resilience. Judicious care and management of soil, water, plant and animal resources are necessary for pollution free environment and save the region from further degradation of natural resources by adopting various integrated based farming systems in Hilly regions of the country.

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