Models/ Optional Technologies for Intensive Integrated Hill Farming with Special Reference to Mizoram

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Increase in food production must keep pace with the country's population. Not only the quantity of food made available but also quality of food should improve. To keep pace with the present population growth and consumption pattern, India's food requirement has been estimated to cross 225 million tons by 2010 AD. This would mean an annual agricultural growth rate of 6.7 percent. This may be a daunting task considering the rapidly shrinking resource-base and fast declining input-use efficiency in major cropping systems. Not withstanding the impressive gain in the agricultural production, the vast agricultural potential still remains highly under-utilized. There are serious gaps both in farm yield realization and technology transfer.

The North-eastern region comprising eight states viz., Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim has a total geographical area of 262180 Km^2 which is nearly 8 percent of the total area of the country with more than thirty nine million population. About 35 percent area in the region 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 percent) followed by Tripura (23.48 percent). Arunachal Pradesh has lowest net sown area in the region. Cropping intensity is highest in Tripura (156.5 percent) followed by Manipur (152.1 percent), Mizoram (136.36 percent) and Assam (123.59 percent). 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, roughly 1.3 million hectare suffers from serious soil erosion problem. The region, by and large, is characterized by fragility, marginality, inaccessibility, cultural heterogeneity, ethnicity and rich biodiversity.

Since the inception of Green Revolution there are problems of topsoil depletion, genetic erosion, groundwater 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 -environmental health, 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, 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.

Land use systems

The land use systems are of great value to achieve sustainable production on marginal lands under northeastern hilly region. A number of traditional alternate land use systems exist in one form or the other such as agro-silvi, agro- pastoral, agro- horti, horti- pastoral, agro-horti- silvi- pastoral, etc. These systems have been developed with a view in increase total productivity per unit areas and simultaneously for conserving and improving the natural resources of soil.

Agri- horti system

Agri- horti system plays an important role in rainfed areas, where production of annual crops is not only inefficient but also highly unstable. Fruit trees if suitably integrated in rainfed farming system could add significantly to overall agricultural production including food, fuel and fodder, conservation of soil and water, and stability in production and income. Thus, horticulture as a component of hill agriculture assumes high importance. Fruits of hill region are being deep- rooted and hardy, can better tolerate climatic aberrations that short duration seasonal crops do not tolerate. Hence in drought season when annual crops usually fail or their production is highly depressed, fruit trees species yield considerable food, feed and fuel and greatly obviate the sufferings from general shortages. Farmers mainly grow paddy and maize with vegetables and fruit crops like banana, passion fruit, pine apple, mandarin etc.

Agri- silvi system

Agri- silvi systems involve intercropping with trees and shelterbelts. Agricultural crops are normally grown between rows of trees planted at spacing of 5m to 30 meters. The agricultural crops provide seasonal revenue, while trees are managed at 8-to10 year’s rotation giving extra returns of timber, fuel wood and fodder. Several kinds of crops are also planted under trees.

Alley cropping is another form of this systems sometimes used in the semi- arid regions. In this method, fast growing leguminous trees such as *Leucaena leucocephala* are planted in rows, at 0.5 m x 2 m spacing to eliminate the weed species. During the arable cropping season, trees are lopped to about 0.5 m height. Lopping are then spread onto the alleyways as a mulch to reduce moisture loss and improve the nutrient status of soil. Popular

among the crops planted in the alleyways are: maize, legumes and cassava. Alley cropping is also form of conservation farming which enhances fertility and prevents erosion.

Silvi- pastoral systems

Silvi- pastoral system essentially consists of top feed tree species carrying grasses or legumes (preferably perennial) as under storey crops. This system is suited to marginal lands and is most preferable where the fodder shortages are experienced frequently. Further, there is a widespread recognition that to increase fodder supply in rural areas, effective interaction between animal husbandry, raising livestock in plantation crops, crop production and forestry is needed. It is critical that grazing and fodder resources be created in areas accessible to the villagers. One effective method would be the introduction agri- silvi- pastotal land use patterns such as the growing of: (i) fast growing fodder shrubs and trees in croplands and pastures: (ii) pastures under plantation crops: and (iii) pastures in forestry tree plantations.

Agri-pastoral system

In north eastern hilly areas, livestock production is an integral part of farming with a view of income, nutrition, and recycling of wastes. Adequate production of fodder crops and pastures is fundamental to the increased and sustained production of livestock. However, the production of forages would have to be in harmony with the production of staple food crops. Thus, cropping patterns under rainfed conditions often include leys or grass-legume pastures seeded in rotation with grain crops. If the ley is based on legumes, it rapidly builds up soil nitrogen and improves soil organic matter, soil structure and water infiltration. The system, being low-cost, is particularly suited to resource-poor farmers whose risk-taking capacity for investing in costly mineral fertilizers is low.

Agri-horti-silvi-pastoral system

In the fragile ecosystem of northeastern region, agri-horti-silvi-pastoral land use system is acting as a boon for farmers. This system gives regular income with minimum risk. This system ensures better utilization of existing resources and sustainable income generation source. Under this land use system farmers accommodate all type of crops, which give diversified, produce. In a piece of land farmers grow following crops

Agri : Rice, maize, pigeon pea, cowpea, beans, etc.
Horti : Brinjal, okra, colocasia, banana, mandarin, pine apple, passion fruit, chilli, guava, papaya, etc.
Silvi : Teak, Tung, Gamori, Ficus, etc.
Pastoral: Congo signal, Setaria, Guinea grass, hybrid napier, etc.

These crops provide food, fuel and fodder to the farmers and ensure better socio economic condition of farmers.

Multi-storey cropping system

A compatible companion of crops having varying morphological frames and rooting habits, grown together in such a manner that their canopy intercept solar energy at varying heights and their roots forage the soil at different zones/ depth

Principles

Adequate utilization of land, light and water. In this case leaf canopies of component crops occupy different vertical layers one after another in succession. The taller component tolerant to strong light and high evaporative demand, whereas the shorter components are

shade loving and like high relative humidity. The combination utilizes soil and air resource in better way with much less competition.

Tropical horticultural crops like arecanut, coconut and rubber are grown for about 30-50 years in a particular sloppy land. Trees take nearly 4-7 years to reach bearing/maturity stage. Adequate alley spacing (75 percent) is available between trees. The root systems are also not spread beyond 2 meters. Hence these vacant spaces can suitably be used for raising other crops.

The topography of Mizoram permits farmers for multistory cropping in slope because it utilizes the land perfectly and they get different produce from a piece of land. Generally after jhuming farmers take annual crop and in the next year these lands are converted into orchards. They incorporate several crops by considering plant height and canopy. There are set of crops (Table 1), which are being practiced by the farmers.

Table 1. Multistorey cropping system

Schemes	1st Storey	2nd storey	3rd storey	4th story	5th storey
1	Arecanut	Mandarin	Banana	Papaya	Pineapple
2	Arecanut	Hatkora	Banana	Papaya	Pineapple
3	Arecanut	Black pepper	Mandarin	Lemon	Pineapple
4	Arecanut	Vanilla	Banana	Papaya	Pineapple
5	Rubber	Vanilla	Mandarin	Coffee	Pineapple
6	Arecanut	Banana	Tapioca	Pineapple	Colocasia
7	Arecanut	Banana	Tapioca	Pineapple	Ginger
8	Tung	Banana	Tapioca	Pineapple	Colocasia
9	Coconut	Banana	Tapioca	Pineapple	Colocasia

Soil fertility management in intensive integrated farming system

With continued increase in population pressure, soil fertility management also changes to practices characterised by intensified internal recycling of nutrients. Different crops remove different amounts of minerals from soil. The system followed in a **jhum** area can be compared to multistoried orcharding system. The nutrient status of soil available nutrients is given in Table 2 for such agriculture + horticulture integration. This system is practiced in ICAR farm, Kolasib, Mizoram.

Table 2. Available nutrient status for agriculture and horticultural land use system of ICAR farm Kolasib

Land use system	pH	EC	OC	OM	N	P	K	Ca	Mg	S	B	Mo	Cl
			(%)		(Kg/ha)			(meq/100g)		(ppm)			

Agriculture (upland rice)	5.38	0.31	1.16	2.00	85.3	19.7	68.9	0.41	0.31	8.58	0.12	0.01	0.3
Groundnut	5.46	0.68	0.75	1.29	87.7	29.1	218.4	0.69	0.48	9.63	0.33	0.01	0.2
Soybean	5.79	1.04	0.58	1.00	76	29.4	161.5	1.44	0.90	6.69	0.32	0.11	0.2
Horticulture Guava	5.30	0.65	1.00	1.80	283.4	9.3	100.8	1.40	2.00	32.0	0.12	0.01	0.4
Arecanut	5.31	0.89	1.26	2.17	219.5	11.0	95.7	0.90	0.70	43.0	0.52	0.02	0.1
Pineapple	4.59	0.29	1.56	2.69	173.8	25.6	150.5	0.50	0.10	18.0	0.10	0.11	0.2
Citrus	5.20	0.98	1.00	1.80	283.4	9.3	100.8	1.40	2.00	29.0	0.39	0.02	0.2
Banana	5.90	1.00	1.30	2.20	230.4	23.2	187.5	5.32	4.30	7.36	1.46	0.01	0.2
Litchi	5.20	0.80	1.20	2.00	200.7	13.7	119.6	0.50	0.10	41.0	0.12	0.33	0.1

This system is highly nutrient exhaustive. The causes of soil fertility decline are very easy to know in such type of integration. Banana which is known to be high in potassium, remove high amounts of it and this potassium must be replaced. Maize depletes high levels of manganese. In natural ecosystems soil nutrients basically maintained in place. Trees uptake nutrients and pass the nutrients to the leaves, and the leaves fall back to the earth where the process starts all over again. Farmers remove the crops before the nutrients can be replaced in the soil. There are ways to reduce the nutrients loss, but there is no way to stop it from happening completely. Nutrients must be replaced from the outside. A comparison of advantages in sole and under integration for planting of field crops and horticultural crops is given in Table 3.

Table 3. Advantages of agri-horti land use system in a hillock

S. No.	Parameter	Sole	Integration
1.	Natural resource utilization	Lesser Nutrient cycling	Higher nutrient recycling due to more redistribution
2.	Utilization of land, labour, capital	Lesser	Higher
3.	Form of mixing	Specialization	Diversity
4.	Place of mixing	Mainly on-farm	May be between farms

5.	Weed infestation	more	Less as less area available
6.	Erosion hazards	More	less
7.	Yield advantage	low	High
8.	Advantages due to climatic adversaries	Less	More
9.	Land use factor	Less	More
10	Income to farmers	Less	More
11.	Cultivation	Periodical	Round the year

On-farm mixing implies mixing within one level, and between-farm mixing involves a higher level of integration. In Mizoram mostly mixed farming systems operate in situations of declining crop/forest land ratios, shortening fallow periods, and without adequate replenishment of soil fertility from other sources. They are characterized by declining nutrient balances, declining soil fertility, increased erosion and losses in soil micro-flora and fauna that ultimately cause significant reductions in agricultural productivity. Generally in *jhum* areas productivity of all the major crops are below their production potential systems.

Soil fertility management options in intensive land use system

Maintaining fertility of the soil is an important step in making agricultural system sustainable. In sustainable systems, the soil is viewed as a fragile 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 soil include using cover crops, compost and/or manures, reducing tillage and maintaining soil cover with plants and/or mulches. A healthy soil will produce healthy crop plants that have optimum vigor and are less susceptible to pests. Some of the soil fertility options are given below:

Amending soil acidity

Soil acidity affects soil fertility, nutrient availability and the biological activity of the soil. The soils of uplands of Mizoram are strongly to very strongly acidic in nature and accordingly lime addition is very essential to ameliorate the acidity related constraints. Liming will have some more favourable actions on such soils:

- Lime will improve nutrient availability in acidic soils
- The increase in soil pH will influence the solubility of most plant nutrients, making phosphorus more available to the plant
- Toxic concentrations of aluminum, manganese are neutralized
- Nitrogen usually becomes more available as a result of more favorable conditions for both nitrogen fixations
- In addition, liming a soil can greatly influence its physical and microbial properties
- In general as a result of lime addition increasing calcium and magnesium content and pH of the soil will stimulate microbial growth positively influencing nitrogen availability

Improving nitrogen use efficiency

Availability of nitrogen can be increased by following activities:

- Sowing of crops early (favouring early crop root growth) to improve efficiencies, use and uptake of nitrogen from mineralization of soil organic nitrogen reserves as most of Mizoram soils are rich in organic matter content
- Growing of legume crops either in mixed cropping or in rotation with upland paddy
- Avoiding long fallows as this encourages more leaching losses in upland conditions
- Incorporating plant residues (stubbles) into the soil to conserve moisture and in long run add nitrogen by the breakdown of such residues
- Use of biofertilizers preferably PSM and Azotobacter as seedling dipping techniques will augment Nitrogen availability

Addition of bulky organic manure or vermicompost

A liberal dose of FYM or vermicompost @ 5t/ha either by broadcasting or spreading in the furrows or pot holes will be of immense benefit for managing various soils related constraints. It will have positive effect on soil aggregation, soil moisture retention and water holding capacity besides adding some macro and micro nutrient in the soils.

Crop rotation

Different crops use and replenish different nutrients differently. By rotating crops, some of the nutrient loss is decreased particularly rotating maize, and a legume crop.

Use of crop residues

Farmers can also leave crop residue on the field after harvesting. As in erosion control, farmers can leave maize stalks on the field. The nutrients in the maize stalks decompose back into the soil.

Mulching

Placing mulch on fields and letting fields lie fallow for a season helps to replenish their vitality. Mulch also works better in sandy soils than clays. However, timing is also critical in mulching. If mulch is applied too early and covers a plant, its growth can become stunted. One very important benefit of mulching is that it can smother out competitive weeds.

Use of cover crops

Use of cover crops regularly leads to addition of organic matter. This can increase soil aggregate stability, soil tilth, and diversity of soil microbial life. Cover crops are also helpful in increasing moisture availability in the soil.

Crop livestock integration

In such integration optimum diversity may be obtained by integrating both crops and livestock in the same farming operation. Mixed crop and livestock operations have several advantages. First, growing row crops only on more level land on steeper slopes will reduce soil erosion. Second, pasture and forage crops in rotation enhance soil quality and reduce erosion; livestock manure, in turn, contributes to soil fertility. Third, livestock can buffer the negative impacts of low rainfall periods by consuming crop residue.

It can be concluded that appropriate combination of crop inventories not only help to increase net farm income but also utilize all available resources efficiently. The farming system approach provides an opportunity for effective recycling of the product and by products of any one of the components as input on the other component. It helps to generate flow of cash to the farmers round the year. This increased profitability, a benefit to both

farmers and rural communities, arises mainly from decreases in production costs associated with planting, harvest and storage of various crops.

Integrated livestock – fish culture in Mizoram

Fish culture has assumed greater significance presently in many places in view of its potential role in regulating organic waste. 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. 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 farming is generally considered particularly relevant to benefit the rural poor for nutritional security and for increasing income. It gained considerable attention due to the growing concern for maximizing productivity through optimal utilization of existing resources. Livestock – crop systems are wide spread and rather well documented. Integrated pig – fish farming system links two different systems, which are other wise 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 with in the farm unit. Thus, it improves the productivity and lowers the cost of production.

Fresh pig manure is regarded as highly efficient for pond fertilization. Moreover, the fish can utilize directly the feed spilled by the pigs, which would other wise 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.

Though pig – fish integration is not widely practiced in Mizoram, few farmers do practice, but with out adequate technical know-how. 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 (Figure 1). 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.

To study the feasibility of pig – fish integrated farming system under Mizoram agro climatic conditions; a study was undertaken at ICAR Complex, Mizoram Centre, Kolasib.

Fig. 1. Integrated pig – fish culture at farmer's field

Pond preparation for fish culture

The pond was prepared in the recommended scientific way. Briefly, cow dung and lime were applied at the rate of 5,000 kg and 200 kg per ha, respectively. Water was filled up to 1.5 m height and the submerged, emergent and floating weeds were cleaned manually before stocking. Water quality was monitored at regular interval as per the standard procedures.

Pig component

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.

Fig. 2. Pig – Fish integrated farming system at ICAR, Mizoram Centre

Fish component

Composite fish culture, comprising of both Indian major carps (catla and mrigal) and exotic carps (common carp and grass carp), was 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.

Growth rate of pig and fish

The body weight of Hampshire pig in integrated farming system at 11 months age was 90 kg. The growth rate of different carps is given in Table 4. It was observed that the growth of catla *(Catla catla)* was significantly higher than other carps followed by the grass carp.

Table 4. Weight and length increment of carps through feeding of pig excreta

Parameter	Catla	Grass carp	Common carp	Mrigal
Weight increment				
Initial weight (g)	6	7	5	6
Final weight (g)	433	293	171	271
Absolute growth (g)	427	286	166	265
Growth increment (g/fish/day)	1.29	0.87	0.50	0.80
Length increment				
Initial length (cm)	4.5	4	4	4.3
Final length (cm)	24.11	23.25	17.89	19.25
Absolute length (cm)	19.61	18.95	13.89	14.95
Length increment (cm/fish/day)	0.059	0.057	0.042	0.045

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.