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Self-sustainable Intensive Integrated Farming System (IIFS) through crop, livestock and forestry interventions for sustainable productivity enhancement in Meghalaya

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ABSTRACT

Farming system models are also necessary to achieve food security at household level particularly in rural areas of NEH region. To achieve food and nutritional security at household level and to develop sustainable food production system, it is advocated to include crops, animal, fishery, agroforestry and horticulture including many other location specific commodities for long term sustainable production. The productivity of five different IIFS models developed reveal that the fish productivity was recorded highest in Crop-fish-dairy-vermicompost-horticulture-hedgerow system. Among the livestock, daily weight gain was recorded highest in pig. Highest meat production was from crop-fish-poultry-multipurpose trees. The Crop- fish-dairy – mushroom vermicompost - horticulture hedgerow model was the most profitable followed by Crop-fish-poultry-multipurpose trees. Among these five models, Crop-fish-poultry-multipurpose trees model was the most profitable. While chicken-crop-fish- duck-horticulture system was ecologically most viable. It was crop-fish-dairy-mushroom -liquid manure-broom-horticulture-vermiculture system which was economically most viable with output/input ratio of 1.83(including labour cost) and 2.59 (excluding labour cost), respectively. In mid-hill conditions of Meghalaya, where low productivity and depleting soil fertility under the low input systems adopted by the farmers and there is need to develop this kind of IIFS models which can effectively recycle the available resources to increase the biomass production per unit area with appropriate farming practices for subsistence of the resource poor farmers as viable alternative to agricultural development in the region.

1. Introduction

Hilly regions of Northeast India are inhabited by various ethnic groups who depend largely on agriculture for their subsistence. From the ages *Jhum* (Shifting cultivation) is a major source of economy in its traditional and cultural integrated form which is economically and ecologically viable to the aboriginal people here (R Bhuyan 2019). However due to time factor and high population pressure, *jhum* has caused drastic decline in crops yield, loss of forest wealth, biodiversity and environmental degradation (Ramakrishnan P.S. 1992). Besides this, dependency on sole crops or an enterprise is highly risky with under-utilization of resources leading to unsustainable systems. Therefore, it is essential to have farming systems approach and integrate different components of agriculture such as agricultural crops, horticultural crops, trees, animal husbandry and fisheries. The emergence of Integrated Farming Systems (IFS) has enabled us to develop a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones. In this system an inter-related set of enterprises used so that the "waste" from one component becomes an input for another part of the system, which reduces cost and improves production and/or income. The advantages of IIFS include pooling and sharing of resources/inputs, efficient use of family labor, conservation, preservation and utilization of farm biomass including non-conventional feed and fodder resources, effective use manure/animal waste, regulation of soil fertility and health, income and employment generation for many people and increase economic resources (Bhatt BP

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& KM Bujarbaruah 2005). The IIFS is part of the strategy to ensure sustainable use of the natural resources for the benefit of present and future generations (Preston 1995). With a theme of "there is no waste" and "waste is only misplaced resources which can be become a valuable material for another product" (Edwards et al 1986), concept of Integrated farming system (IFS) was ventured. With an aspiration to explicate strategies for agricultural development in this region using appropriate farming practices for subsistence of resource poor farmers, sustainable and profitable farming system models were put in place. With an objective to assess the productivity of the whole system, productivity of five different Intensive Integrated Farming System models was estimated. Among these five models, crop-fish-dairy-vermicompost-horticulture-hedgerow model was found to be most profitable followed by crop-fish-poultry-multipurpose trees. The findings suggest that the intensive integrated farming system which furnishes unique opportunities for management, enhancing biodiversity and ensuring food security is a feasible alternative through restoration of marshy/low lands, water harvesting for agricultural development in the hilly region of NE India.

2. Material and methods

A study site was IIFS farm (colony side) of ICAR Research complex for NEH region, Umiam located at 25°39' - 25°41'N latitude and 91°54' - 91°63'E Longitude with altitude ranging from 890 – 990m asl. The soil of the experiment site is sandy loamy, characterized by P-deficient acidic Alfisol with pH range 5.2 – 5.5. The climate area falls under humid subtropical with observed annual rainfall of 2011mm (in 2013) to 2250mm (in 2019) under rainfed condition during 2013-19. The Monsoon rainfall ranging from 1182mm (in 2013) to 1473mm (in 2018). The T_{max} was 27.4°C to 28.7°C (in 2013) and 25.1°C to 29.6°C (in 2019), whereas T_{min} during this period was in the range of 21°C to 20.2°C and 25.7°C to 19.8°C. In this rainfed condition, the major crops taken were paddy, maize, groundnut, turmeric, ginger, elephant foot yam, colocasia, vegetables along with fishery, pig, dairy, poultry and goat as the integrated system in area of 2.52 hectare in which 1.158 ha was allotted for crop component, 0.79 ha for fish pond and rest for various livestock including fodder area. Poly culture fingerlings @ 9,000/ha (rohu 20%, catla 30% and mrigal 40%) were released into the pond (Table 1). Twenty-five poultry birds (Giriraj) were maintained in the poultry shed constructed on the fish pond. Goats (14 females + 3 males) were maintained in a shed constructed separately. To sustain the productivity the residues obtained in the system was recycled. Poultry droppings was allowed to drop into the pond directly which served as the source of food for fish. Fishes were harvested after completing one year using drag net. Observations on the productivity and economics of individual components of 5 subsystems (models) of IIFS along with one unit as a control having no integration were recorded (Table 2).

Table 1. Productivity and stocking density of animal/birds and fishes of different IIFS:

Sl. No.	IIFS model	Productivity/yr	Stocking density of animals/birds and fishes
1	Chicken-crop-fish-duckhorticulture along with hedgerow on contour bunds.	Duck: 24 Nos. Eggs: 13.5 Kg Fish: 6.43 q/ha	Duck- 38 nos./ha Fish-9000 fingerlings/ha
2	Crop-fish-poultry-multipurpose trees	Live chicken: 6.43q Fish: 4.25 q/ha	Broiler birds 200/batch Fish-9000 fingerlings/ha
3	Crop-fish-goat-multipurpose trees	Meat: 116 kg Fish: 4.29 q/ha	Goat- 12 nos./ha Fish-9000 fingerlings/ha
4	Crop-fish-pig-vermicompost - bamboo-multipurpose trees hedgerow-broom	Pork: 0 .78 q/ pig Pond underwent repairing and hence fish yield not obtained	Pigs- 2 nos./ha Fish-9000 fingerlings/ha
5	Crop- fish-dairy-vermicompost-horticulture-hedgerow	Milk: 1634 liters Fish: 16.22 q/ha	Cattle- 3 nos./ha Fish-9000 fingerlings/ha

Table 2. Productivity of various IIFS models

IIFS models	Area (ha)		Components	Var./Breed	Area (ha)	Productivity
Duck-fish-hedge row-vegetables-annual crops	Pond	0.160	Duck (24 nos.)	Indian runner	0.166	
	Pond dyke	0.049	Egg			145 nos.
	Duck shed	0.022	Soya bean	JS-335	0.051	2.45 t/ha
	Crop area	0.360	Maize	DMH-849	0.19	2.15 t/ha
	Hedgerow	0.300	Up land Paddy	Bhalum-1	0.032	1.39 t/ha
	Total area	**0.856**	Low land paddy	Shasarang	0.12	2.61 t/ha

			Turmeric Ginger Lentil Mustard Rapeseed Vegetables:	Lakadong Nadia PL126 ,L-4147 M-27 TS-36, Varuna	0.05 0.03 0.10 0.03 0.063 0.14	25.6 t/ha 15.9 t/ha 0.7 t/ha 0.4 t/ha 0.79 t/ha 0.62 t/ha
Poultry-fish	Pond Pond dyke Poultry shed **Total area**	0.143 0.058 0.013 **0.24**	Poultry birds (200 per batch) Eggs Meat Poultry dropping	Kroiler/Broiler	0.13 157 nos. 1100 kg/yr 800 kg/yr	
Goat-fish	Pond Pond dyke Goat shed **Total area**	0.980 0.098 0.008 **0.143**	Meat (17 nos.) Goat manure		0.11	190 kg/yr 1700 kg/yr
Pig-fish-MPTs-crops	Pond Pond dyke Pig shed Crop area **Total area**	0.530 0.057 0.001 0.151 **0.306**	Pig Meat (4 nos.) Paddy Groundnut	 Bhalum-1 ICGS-76	0.121 0.10 0.05	340 kg 1.2 t/ha 1.25 t/ha
Cattle-fish-MPTs-crops-vermicompost	Pond Pond dyke Dairy shed Crop area **Total area**	0.085 0.025 0.016 0.03 **0.226**	Milk FYM Vermicompost		 0.001	3561 ltr/yr 18 t/yr 900 kg/yr

Table 3. Economics of IIFS

Farming system	**BC ratio**	**Net Income (Rs/ha/yr)**
Broiler chicken-Crop-Fish-Duck-Horticulture-Nitrogen fixing hedge row	1.69	65,306
Crop-Fish-Poultry-Multipurpose trees	1.57	31,573
Crop-Fish-Goat-MPTs-hedge row	1.60	33,735
Crop-Fish-Pig-Bamboo-MPTs-Fruit trees-Hedge rows	1.47	34,276
Crop-Fish-Dairy-MPTs-Fruit trees-Hedge rows-Vermiculture-Liquid manure-Broom	1.83	1,21,634
Upland crops, and fish farming without integration (control)	1.01	13,965

3. Results and Discussion

The productivity from all the models was estimated from Crop, animal and fish production. The integration of crop with fish, poultry and goat resulted in higher productivity as compared to control (crop and fish alone). Compared to control, net income from Integrated farming system showed more than one-fold increase in poultry, goat and pig-based systems. Whereas broiler based and dairy based systems showed 4-fold and 8-fold increased productivity respectively. The results when compared to studies of Bhatt BP & KM Bujarbaruah, 2005 during 2000-2007 reveals that monetary output/input could further increase if family labour is involved. In the both cases (labour components from farming family or outsourced), the Crop-fish-dairy-MPTs-fruit trees-hedge rows-vermiculture-liquid manure-broom based IIFS ranked first and hence more economically viable system.

The productivity of five different IIFS models developed reveal that the fish productivity was recorded highest in Crop-fish-dairy-vermicompost-horticulture-hedgerow system (1.13 t/ha). Among the livestock, daily weight gain was recorded highest in pig (0.29 kg/day). Highest meat production was from crop-fish-poultry-multipurpose trees (3.18 q/ha). Among these five models, Crop- fish-dairy – mushroom vermicompost - horticulture hedgerow model was the most profitable followed by Crop-fish-poultry-multipurpose trees. Among the livestock, daily weight gain was recorded highest in pig (0.21 kg/day). Highest meat production was from crop-fish-poultry-multipurpose trees (0.69 t/ha). Among these five models, Crop-fish-poultry-multipurpose trees model was the most profitable. Ecological and economic efficiency of various IIFS was worked out. All the systems have been found ecologically and economically viable. While chicken-crop-fish- duck-horticulture system was ecologically most viable whereas crop-fish-dairy-mushroom -liquid manure-broom-horticulture-vermiculture system which was economically most viable with output/input ratio of 1.83 (including labour cost) and 2.59 (excluding labour cost), respectively. Among the cropping sequences under integrated farming systems, turmeric-groundnut system yielded the maximum closely followed by vegetables. Integration of fish component with livestock and crop is a profitable in farming system, productivity of fish was recorded highest in Crop-fish-dairy-vermicompost-horticulture-hedgerow system (1.62 t/ha). Among the animal components daily weight gain was recorded highest in pig (0.28 kg/day). Highest meat production was from crop-fish-poultry-multipurpose trees (0.64 t/ha). Among these five models, Crop-fish-poultry-multipurpose trees model was the most profitable with cost benefit ratio (table2). Among the various components, Dairy based model recorded the highest benefit cost ratio (1.76) followed by Broiler-duck (1.58) based systems. This was followed by goat based (1.55), poultry-based system (1.51) and pig-based system at ratio 1.42 which is higher than the control (1.09). Results discussed revealed that IFS enables the agricultural production system sustainable, profitable and productive. Most of the nutritional requirement of the system is self-sustained through resource recycling. As the number of enterprises is increased, the profit margin increases. On an average profit margin on account of IFS varied from Rs 31,573 to Rs 1,21,634/ha/annum in comparison with only crops and fisheries components as control having net income at Rs. 13,965 i.e., without any integration.

The overall premise of IIFS is to put in place a process for increasing the productivity and promote crop-livestock synergies and interactions that aim to integrate crops and livestock effectively with careful land use, raise the productivity of specific mixed crop-livestock systems, facilitate expansion of food and feed production and simultaneously safeguard the environment with efficient use of natural resources.

4. Conclusion

In the present study, Intensive Integrated Farming System (IIFS) with five different land use systems, the complementarity of crop-fish-livestock-horticulture-agroforestry could be utilized for long term sustainable production on one hand and to bring food and nutritional security to a farming family having small land holding on the other. The practical implication of developing such land use models is that the stakeholders could replicate the land use model of their choice in similar agro climatic zone in this part of country where *jhum* has already caused severe environmental degradation.

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6. Conflict of Interest

There are no conflict of interest

7. Declaration on Ethical Conduct of Research

I declare that this research has been conducted ethically.

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Figure1. Various Components of IIFS

a) Goat + Fish

b) Duck +Rabbit+ Fish

c) Poultry+ Fish

d) Dairy + Fish

e) Crops + Fish

f) Piggery

g) Multipurpose tree *Parkia roxbhurghii*

h) Hedge rows with crop (soybean)