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Pond-based Integrated Farming System Model for Rainfed Uplands

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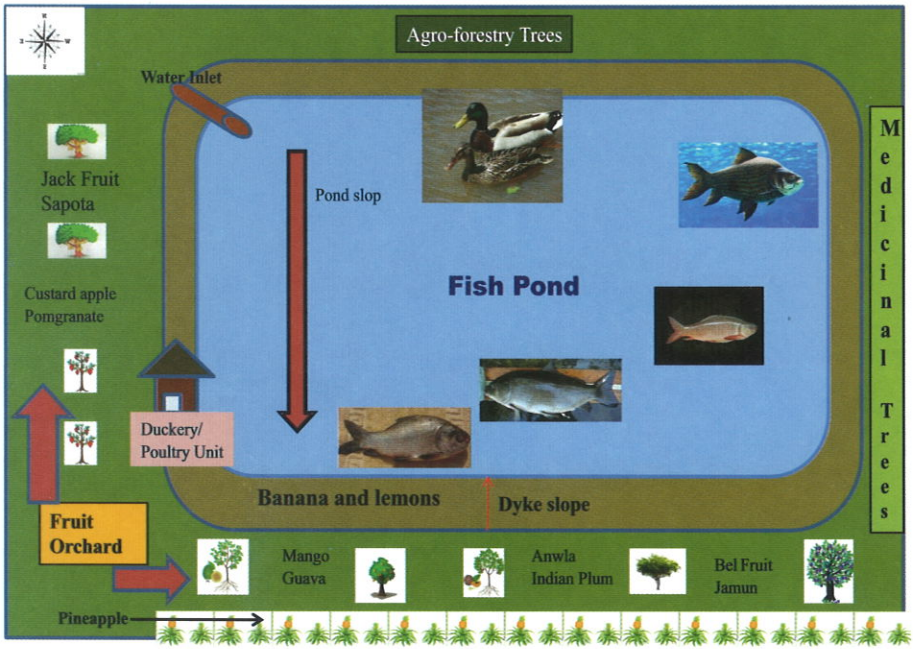
Out of 42.3 million hectares of total rice area in India, rainfed upland rice occupies 5.1 million hectares of which 4.3 million hectares are located in eastern India (Assam, West Bengal, Orissa, Jharkhand, eastern Uttar Pradesh and Chhattisgarh). Eastern part of India is endowed with adequate rainfall varying from 1100 mm to more than 1500 mm with nearly 80 percent of it being received during monsoon period (July to October). Rainfed Uplands either bunded or unbunded fields without surface water accumulation is a naturally well-drained soils. Farmers have limited options to grow either rice or some minor millets, pulses during wet (*kharif*) season and no crop grown during winter/dry (*rabi*) season due to scarcity of water, keeping the land fallow. The upland environment is endowed with light textured soil, poor fertility and drought-prone, usually sloping land with erosion problems, and has soils with both poor physical and chemical properties. In spite of getting low and unstable yield in upland rice due to erratic southwest monsoon, moisture stress during crop growth period, light textured soils with low water retention capacity and severe nutrient deficiencies with acidic and high p fixation, existence of biological constraints like weeds (*Cyperus rotundus, Echinochloa colona etc.*), diseases (blast, brown spot) and insect-pests (gundhi bag, termite, worms), farmers of this region opt for

mono-cropping of traditional rice to cover up the lands during wet season. Due to lack of knowledge of alternate sustainable cropping systems, they are poverty stricken. The Farming/cropping system and productivity of upland rice ecosystem is difficult to be raised to a desired level to alleviate poverty unless the excess rain water is harvested and stored for diversification through inclusion of low duty high value crops or introduction of other farm enterprises as a compliment to the crop production. Keeping the importance of crop diversification in the rainfed upland ecosystem for enhancing crop and soil productivity, rain water use efficiency, a pond-based farming system model was initiated in 3 hectare of land at Krishi Vigyan Kendra (KVK), Santhapur, Cuttack under ICAR-National Rice Research Institute which is 30 Km away from the Institute.



Layout design of pond based integrated farming system

Construction of water harvesting structure:

- While selection of site for water harvesting structure, it should be kept in mind that land area should have a gentle slope and layout ponds in a way that will take advantage of existing land contours. A farmer should select an area large enough for the present plans and any future expansion. Also, ensure that such an area is not prone to flooding. The water source must be able to keep the pond full throughout the culture period. Relatively shallow ponds are

productive, but the shallow end should be at least 0.5 m deep to avoid invasion by weeds.

- Use the excavated soil to build the pond dykes. Do this gradually, and compact each layer of soil added on the dyke before the next layer. Construct the dyke large enough to *resist the water pressure* by virtue of its weight
- The inlet pipe should be placed about 0.15 m above the water level so that the incoming water splashes down into the pond. This helps to mix air (thereby introducing oxygen) into the water. It also prevents fish from escaping by swimming into the inlet pipe. An overflow pipe can be installed at an angle into the pond. During heavy rains, the overflow pipe takes excess rainwater and runoff water out of the pond.
- During the construction of inlet, filters should be used in the channel so that unwanted fish and other materials do not enter into the pond.

Lining material: Lining of the pond with loose soil areas shouldbe done after the excavation of the pond to prevent water loss through seepage and percolation. Impervious lining should be done using Poly Vinyl Chloride (PVC)/ Low Density Polyethylene (LDPE) with 200 microns with the 30 cm of soil cover on the edge.Use of plastic lining has an impetuous impact on holding water from seepage losses.

Fish Rearing in the pond: Grow-out fish culture with Indian Major Carps i.e., *Rohu, Catla* and *Mrigal* along with Tilapia should be done with single stocking-single harvesting per year where the water harvesting structure store adequate water for at least for 6-8 months. However, water harvesting structure in the form of pond refuge will ensure availability of water round the year for fish culture depending on the regions and soil.

Production Technology

Fruit orchard

Establishment of an orchard is a long term investment and deserves a very critical planning. The selection of proper location and site, planting system and planting distance, choosing the varieties and the nursery plants have to be considered carefully to ensure maximum production. The system of layout can be grouped under two broad categories viz. (a) vertical row planting pattern and (b) alternate row planting pattern. In the former planting pattern (e.g. square system, rectangular system), the trees set in a row is exactly perpendicular to those trees set in their

adjacent rows. In the latter planting pattern (i.e. Hexagonal, Quincunx and Triangular), the trees in the adjacent rows are not exactly vertical instead the trees in the even rows are midway between those in the odd rows. Manures & fertilizers should be generally done twice, ie., beginning of monsoon i.e., July and post-monsoon season in the month of October. Irrigate the crop after fertilizer application. Manure and fertilizer should be mixed well in the soil by spreading it under the branches, away from the stem. Fertilization every year, increases the chances of good fruiting. Regular pruning in all the fruit trees are done once the fruit is harvested. However, in later years the dry twigs and crossed branches are removed. While training the plants, the framework of branches is allowed to develop above 60 to 100 cm from the ground level.The details are cited below.

Table 1. Package of practices for fruit orchard

Crops	Number of plants	Spacing	Fertilizer management	Varieties	Yield
Mango *(Mangiferandica)*	12	5m x 5m	50 kg FYM, 1 kg N, 1 kg P_2O_5, 1.5 kg K_2O	Amrapaali, Malika, Neelam, Dasheri, ChausaBombaygreen	80-100 t/ha
Guava *(Psidiumguajava)*	16	4m X 4m	FYM 50 Kg and one Kg in each of N, P_2O and K_2O per tree	Sardar, Allahabad Safeda, Lalit, Pant Prabhat, Dhareedar, ArkaMridula, Khaja (Bengal Safeda)	15-50 t/ha
Sapota *(Achras zapota)*	15	5m x 5m	10 kg FYM, 200 gm N, 200 gm P_2O_5, 300 gm K_2O	Cricket ball, Kalipatti, Baramasi, PKM 1	20-25 t/ha
Lime *(Citrus aurantifolia)*	15	3m x 3m	10 kg FYM 360 N, 180 gm P_2O_5 and 400 gm K_2O	Vikram, PKM, Prumalini, Rasraj, Kagzi	25 t/ha
Jamun *(Syzygium cumini)*	8	8m x 8m	Well rotten FYM @75 kg/tree	Badama, Bhado, Ashada, Kaatha, RajendraJamun 1,Goma Priyanka, NarendraJamun 6	6– 7 t/ha
Bel *(Aegel Marmelos)*	15	5m x 5m	Needful organic manure	CIHS B -1, CIHS B -2 Pant Sujata, Pant Urvarshi	200-300 fruits/tree
Awnla *(Phyllanthus emblica)*	12	4m x 4m	10 kg of FYM, 100 g of N, 50 g of P_2O and 75 g of K_2O.	Banarasi Chakaiya Francis Krishna Kanchan	15 to 20 t/ha
Pomegranate *(Punica granatum)*	15	2.5m x 4.5 m	20 kg FYM 400 gm N 250 gm P_2O_5 800 gm K_2O	Kandhari, Kabul, Muskati RedMridula, Aarakta, Jyoti, Ruby	20-25 t/ha
Jack fruit *(Artocarpus heterophyllus)*	8	10m x 10 m	50 kg FYM, 750gm N 400 gm P_2O_5 500gm K_2O	Honey Gold Gold Pillow Cheena Jackfruit	60-80 t/ha
Banana*(Musa acuminate)*	20	1.5m x 1.5m	150 gm N, 90 gm P_2O_5 200 gm K_2O	Chinichampa, Red Banana, Grand Naine, Bantala, Nendran, Poovan, Robusta	40-50 t/ha

Pineapple: Plant 400 pineapple suckers in the border and inter space of the orchardduring the rainy season in staggered double row system covered with thin plastic mulching to avoid weed infestation and maintain moisture level. Keep the spacing of 30 cm between plants, 60 cm spacing between rows and 90 cm spacing between two beds. Grow varieties like Queen, Kew etc. Follow the management practices like fertilization, irrigation, insect-pests and diseases control.

Figure 1. Pineapple
(vt. *Kew* with plastic mulching)

Tuber crops: Grow improved varieties of different tuber crops like Elephant foot yam (var. Gajendra) , Colocasia (varieties Muktakeshi, Satamukhi, Sreepallavi, SreeRashmi, BidhanChaitnya, Bidhan Joydep) as intercrop in between the trees and Yam (varieties Orissa elite, Konwarialoo, SreeKarthika, Hatikhoja, Sreeshilp) on the fence area of the orchard. Follow the recommended management practices such as land preparation, planting, intercultural operations (mulching, weeding, earthing up, staking etc.), fertilizer and manure application, irrigation, pest and disease control, harvesting etc.

Elephant Foot Yam Colocacia Yam

Figure 2. Tuber crop- an excellent crop for uplands under rainfed condition

Vegetables/ pulses: Short duration vegetable crops like cowpea, Okra, chilli, pumpkin etc and deep rooted pulses like Pigeon pea can be grown in the vacant area during the initial growth years of fruit orchard taking advantage of the rain water.

Figure 3. Pegionpea with deep root system

Figure 4. Mustard with two irrigation

Fodder crops: Grasses like Para grass, Guinea grass, and Napier grass can be grown on the marginal area of the orchard as the cover crop throughout the year. These grasses are fed in the green form to the livestock and are not suitable for conservation either as hay or as silage. Leguminous fodder such as cowpea and *sesbania* can also be taken as intercropped with cereal fodder which improves the soil nutrient status as well improves the structure of the soil. First harvest is to be done on 75 to 80 days after planting and subsequent 5-8 harvests can be taken at intervals of 45 days.

Enterprises on the bunds

Duckery and Poultry: Rearing of 50-100 ducks of Khaki Campbell or other improved breeds can easily be done by living them for grazing in the pond area. Rear 75-100 dual purpose colour poultry birdsof breeds Vanaraj, Gramapriya, CARI Devendra and UPCARI in the low cost housing. Follow four cycles (60-75 days in each cycle) of bird rearing in a year.

Goatary: 4-5 goats mainly known as "poor man cow" can be raised in an acre of land and requires less maintenance than any other livestock. Goat is mostly raised for meat, milk, fibre and skin and it is more profitable than the sheep rearing. Breeds like Jamunapari is reared for milk and Black Bengal can be reared for meat and skin purpose.

Agroforestry: Agroforestry trees like Teak(*Tectona grandis*), *Acacia catechu*, *Phoenix dactifera*, *Artocarpus* spp, *Cocos nucifera*, *Mangifer aindica*, *Syzygium aromaticum* can be raised successfully in the southern and western bund. Benefits from the agroforestry are infinite - food, fruits, feed, fodder, fuel, fiber, manures, favourable climate and many others in terms of controlling land degradation, sheltering crop and livestock, improving their landscape and enhancing diversity. Woody trees like *Eucalyptus*, *Glyricidia*, *Grevillea*, *Gmelina*, *Leuceana*and *Albizia* species are more remunerative and a good source of generating additional farm income in rural areas.Trees should be pruned regularly to prevent them from competing with nearby crops for sunlight and water. When pruned regularly, hedge rows can provide a reliable source of animal fodder and fuel. Farmers can cut the trees when they become competitive and carry the branches to pens where animals are sheltered. Longer cutting cycles of 4-6 months provide relatively more wood than shorter cycles. Short cycles produce relatively more foliage. Most species should not be pruned more often than every 30 days.

SPECIES	CLIMATE	OTHER USES
Acacia tortillis	semiarid tropics	fuelwood
Albizia lebbek	humid tropics, semiarid tropics	fuelwood, timber
Calliandra calothyrsus	humid tropics	lumber, fuelwood
Dalbergia sissoo	semiarid tropics	timber, fuelwood
Gliricidia sepium	humid tropics	food, fuelwood, poles
Leucaen aleucocephala	humid subtropics, humid tropics	fuelwood, poles, crop shade, timber
Prosopis cineraria	semiarid tropics, arid tropics	wind break
Sesbania grandiflora	humid tropics	fuelwood, food
Ziziphus mauritiana	semiarid tropics, subhumid tropics	food, shade

Honey bee: Ten number of honey bee colonies can be placed in the orchard and within fruit and agro-forest trees.Honey bees helps to increase the productivity 25-35%.

Table 2 Estimation of Profit and Loss for 10 colonies of bee

	1st Year	2nd Year	3rd Year
Income	15000.00	33250.00	33250.00
Expenditure 35100.00	35100.00	2000.00	2000.00
Profit	(-)20100.00	(+)31250.00	((+)31250.00
Cum ulative Profit & Loss	(-)20100.00	(+)11150.00	(+)31250.00

Source: Mahapatra RN 2019

Piggery: Pig can be reared under traditional small holder, low-input demand driven production system. They have higher feed conversion efficiency that meansthey can convert all types of inedible feeds, forages, certain grains by-products obtained from mills, damaged feeds, meat by-products, garbage etc. into valuable, nutritious and delicious meat and reach the market weight of 60-90 kg in a period of 7-10 months.

Benefits of integrated farming system Model:

Benefits of RFDIFS

1. Ecological Benefits

- Enhance biodiversity and ecosystem stability through erosion control and conserving moisture
- Controls insects and pest
- Enhance carbon sequestration and reduces CHG emission
- Organic in nature through natural farming

2. Economic Benefits

- Enhances production, profitability and marketability in organic way
- Maintains soil and ecological health
- Reduces chemical hazards through organic cultivation

3. Social Benefits

- Availability of animal protein
- Availability of complete nutrition through fruits and vegetables
- Aesthetic satisfaction

4. Cultural Benefits

- Rain water harvesting in the pond
- Recycling of agricultural waste and reduced cost of cultivation
- Availability of clean water and environment

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