



MULTITIER RICE-FISH-HORTICULTURE BASED FARMING SYSTEM FOR DEEPWATER AREAS

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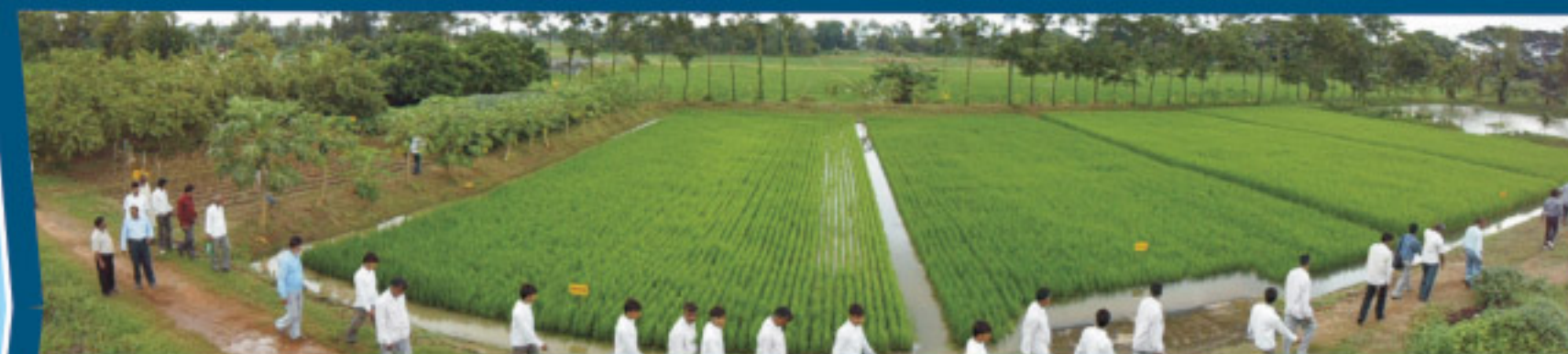
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MULTITIER RICE-FISH-HORTICULTURE BASED FARMING SYSTEM FOR DEEPWATER AREAS

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Introduction : Deep water rice is grown in about 4 million (m) ha in India out of total 44 m ha of rice area, of which around 3.0 m ha is in the eastern India. Mostly, a mono-crop of traditional rice is grown in deepwater areas with very low productivity of around 0.5-1.0 t of clean rice/ ha due to various abiotic and biotic stresses and poor socio-economic conditions. On the other hand, deepwater rice ecology is suitable for alternate farming by way of farm diversification with the integration of components like, horticulture, aquaculture, livestock, agro-forestry and others. Adoption of rice-fish-horticulture based farming system can ensure higher farm productivity, income and employment besides, providing food, nutrition and also environmental security in these under-utilized areas. This farming system is highly acceptable in the eastern India because of resources, food habits and other social conditions.

Multitier rice- fish-horticulture based farming system technology includes field design and land shaping and package of practices for different components.

1. Central Horticultural Experimental Station of IIHR, Bhubaneswar.
2. Regional Centre of CTCRI, Bhubaneswar.

Site Selection : Select semi-deep and deep water rice field with 50-100 cm (maximum 150cm) of water depth and free from repeated flash floods.

- Prefer farm having clay soil with higher water retention capacity.
- Choose farm size of one acre to one hectare or more.
- Prefer rectangular or even square shaped farm.

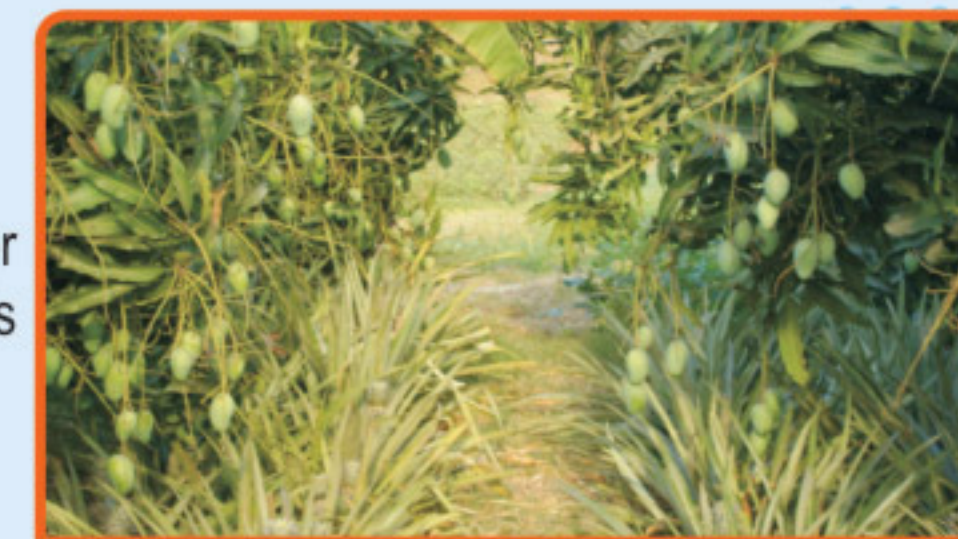
Field Design and Construction: The design includes multitier way of land shaping in the form of an upland (Tier I and Tier II) covering about 15% of the field area followed by rice field area of 40% comprising half of the area as rainfed lowland (up to 50cm water depth, Tier III) and the rest half as deep water (50-100cm water depth, Tier IV). In upland, 50% of the area (Tier I) is used for short term and long term fruit crops and the rest area (Tier II) again is equally divided into two portions to utilize the first one for growing tuber crops and the second one for round the year vegetables' production. A gentle gradient of about 0.5 % is maintained across the Tier I and II. Similarly, a gradient of about 1% is also made across the rainfed lowland (Tier III) and deepwater (Tier IV) portion of the rice field. Two ponds (micro-water sheds) covering a total area of 25% area are constructed in the farm. These water sheds include a bigger one of about 18% area and 2.5 m depth connected to the rice field by a 'mouth' of 5 m wide to serve as fish and prawn refuge at the lower end and a smaller one of 7% area and 2 m depth at the upper end adjacent to upland (Tier I) of the farm for use of fish fingerlings' and yearlings' production. The harvested rain water in the two ponds is used for irrigation of various crops grown in the different tiers of the system according to their suitability and water requirement. Raised bunds of 1.5 m height and 2 m wide are made all around using 20% of the farm area. The side slope on both sides of bunds should be at least 1:1 in heavy soil and more than that in light soil. The height of the bunds is kept 50 cm higher than the maximum water level in the field. A provision of 1 m 'berm' in between ponds and bunds besides, soil compaction and grass pitching are made to minimize soil erosion. The area and dimensions of different tiers, ponds and bunds can be modified as per the agro-climatic situations, hydrology and needs of the farmers.

The duck and poultry houses are constructed on the bund of pond refuge and are projected around half of their area over the pond water to utilize the droppings, including unused feeds as manure and also fish food. Low-cost duckery and poultry units may be made using bamboo or wire net with straw thatching or asbestos top.

The cost of field construction (earth work) for one ha farm area will be around ₹1,30,000 and the same for duck and poultry houses will be ₹20,000.

Production Methodologies:

The production technology for one hectare of farm area is as follows:



In Upland (Tier I and II)

Tier I (Fruit crops)

- **Mango:** Plant 15 seedlings of improved (grafted) mango varieties such as, *Gulabkhas, Amrapali, Mallika, Dashehari, Banganapalli* etc after 3-4 monsoon showers with a spacing of 5mx5m between rows and plants. Follow management practices like, canopy management, manure and fertilizer application, irrigation, pests and disease control, mulching and pruning. Rely more on Integrated Pests Management (IPM), bio pesticides and organic sources of nutrients.

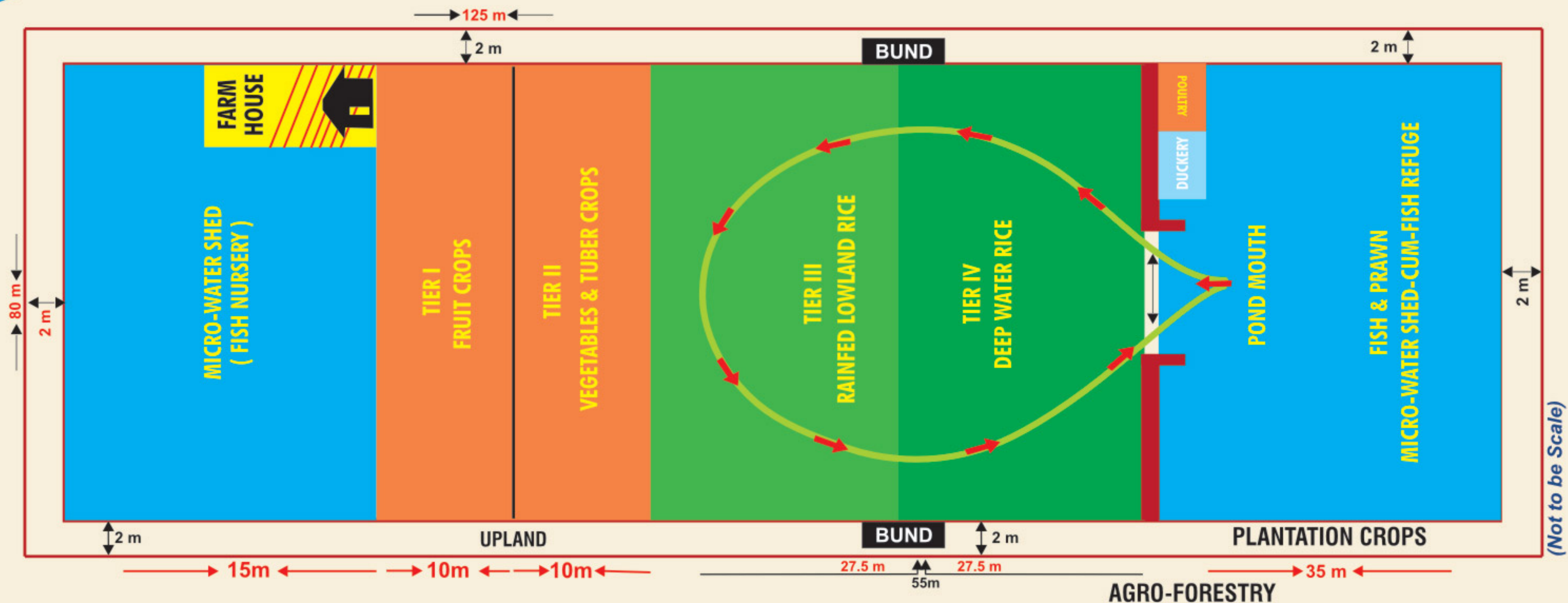
- **Guava:** Plant 15 seedlings of improved (air-layered or grafted) guava varieties like, *Allahabad Safeda, Arka Amulya, Arka Mridula, Safed Jam, Sardar* etc during rainy season with a gap of 4-5m in between rows and plants. Maintain low plant height by regular pruning. Follow all management practices as in the case of mango plants.



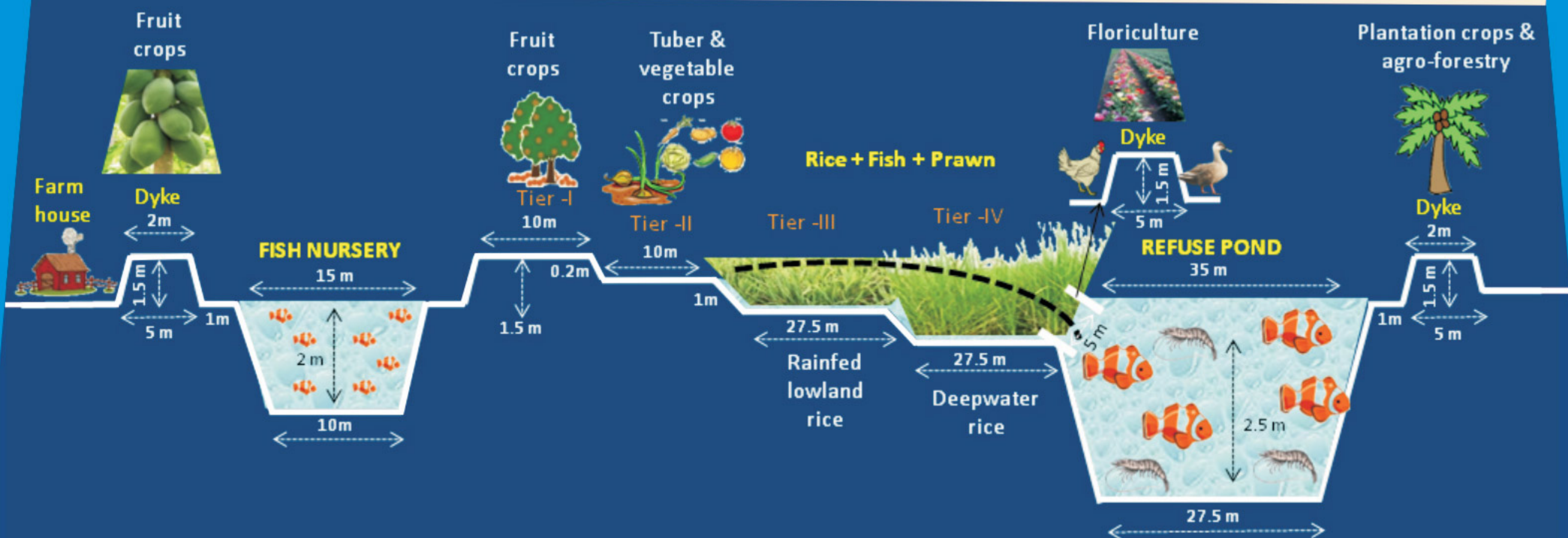
- **Sapota:** Plant 6 seedlings of improved sapota cultivars like, *Kalipatti, Cricket Ball, CO-1, CO-2, PKM-1, PKM-2* during rainy season with a gap of 5mx5m between rows and plants. Follow management practices as in the case of mango and guava plants.

- **Papaya:** In the initial 2-3 years, plant 100 seedlings of dwarf varieties viz., *Coorg Honey Dew, Pusa Dwarf, Pusa Majesty, Pusa Giant, Pusa Nanha, Pusa Delicious, CO-2, CO-6, Washington* etc during wet season with a gap of 1.5-2.0 m in the interspaces between mango, guava and sapota plants. Adopt proper management packages. Replace regularly the virus infected plants with healthy ones.





Design for rice-fish-horticulture based farming system model in deepwater area (1ha)



Selection through length of a Deepwater Rice-Fish Farm (1 ha area)

(Not to be Scale)

- **Banana:** In the initial years, plant 25 suckers of improved/tissue cultured varieties of both table (ripe fruits) and vegetable (plantain) purpose in the interspaces of other fruit crops during rainy season in a gap of 2 m. Popular banana varieties are Dwarf Cavendish, Robusta, Grande Naine, Rasthali, Monthan, Poovan etc. Adopt proper management packages.



- **Pineapple:** Plant 300 pineapple suckers in the interspaces of fruit crops during rainy season in staggered double row system with a spacing of 30 cm between plants, 60 cm between rows and 90 cm between two beds. Grow varieties like Queen, Kew etc. In the later years, grow the pineapple crop under the canopy of mango, guava and sapota plants. Follow the management practices like, fertilization, irrigation and pests and diseases control.
- **Elephant foot yam:** Grow 100 plants of Elephant foot yam (var. Gajendra) as intercrop in between papaya plants in initial years. However, in the later period also, this crop can be grown as intercrop in guava orchard. Apart from these crops, vegetables like cowpea, okra, french bean, chilli etc can also be grown in the available vacant areas during the initial years.

Tier II Tuber crops

- Grow improved varieties of a tuber crops like, sweet potato (vars. Samrat, Sourin, Kalinga, Kishan, Gouri, Sankar, Pusa Safed, Rajendra Sakarkand, Bidhan Jagannath, Narendra Malti), Elephant foot yam (Gajendra, Sree Padma, Sree Athira, Bidhan Kusum, NDA-9, NDA-5), colocasia (Mukthakesi, Satamukhi, Sree Pallavi, Sree Rashmi, Bidhan Chaitanya, Bidhan Joydeb) and yam (Orissa elite, Hatikhoja, Sree Shilp, Sree Karthika, Konwari aloo, Indu). Follow recommended management practices such as, land preparation, planting, intercultural operations (mulching, weeding, earthing, staking), fertilizer and manure application, irrigation, pests and disease control, harvesting etc.



- In the sweet potato growing portion of the field, follow a cropping pattern as, okra (June-September)-sweet potato (October/November-January/February)-cowpea (February-April).

Vegetable crops

- Grow round the year location specific vegetables using the suitable high yielding varieties.
- Grow vegetables like, okra, ridge gourd, cowpea, snake gourd, bottle gourd etc during wet season, tomato, french bean, radish, cabbage, cauliflower, leafy vegetables etc during winter season and Amaranthus, cowpea, bitter gourd, pumpkin, cucumber etc during summer season.
- Follow the recommended management practices, like land preparation, sowing, manure and fertilizer application, irrigation, weeding, earthing, insect pests and disease control and harvesting.



In lowland (Tier III and IV)

In wet season

Rice: During wet season, select high-yielding rice cultivars with the desirable characters such as semi-tall/tall, long duration, stiff-culmed, photo-period sensitive and in-built tolerance to pest and diseases.

In Tier III (rainfed lowland), cultivate varieties like Gayatri, Pooja, Sarala, Bhudev, Golak, Jogen, Sudha, Maduhkar, Barh Awarodhi, Ranjit, Jalashree etc.

In Tier IV (semi-deep/deepwater), grow cultivars such as, Varshadhan, Durga, Hanseswari, Saraswathi, Jalaprabha, Jalpriya etc.

In dry season

In Tier III (rainfed lowland), grow non-rice crops like, sweet potato, watermelon, mung bean, ground nut, sunflower, vegetables with irrigation from the harvested rainwater. Zero tillage-established sweet potato can also be grown after rice with the advantages like saving of two irrigations and reducing crop duration by about two weeks.



In Tier IV (deep water), cultivate high yielding dry season rice varieties like, Naveen, Shatabdi, Lalat, IR 36 etc after deepwater rice in half of the area or more/less depending upon the amount of harvested rainwater. In the remaining area, grow vegetable like, okra.

Management

Wet season rice

- Prepare the land well before the monsoon using bullock/ tractor drawn plough.
- Apply FYM @5t/ha at the time of land preparation or in furrow at the time of seeding.
- Sow in dry soil well before the monsoon using 75 to 100 kg/ha of good quality seed. Use a spacing of 20 cm in between rows and 15 cm in between plants. Line sowing preferably, dibble seeding using 3-5 seeds is advantageous.
- Transplant, if so required, early using around 40 days-old and healthy seedlings.
- Apply fertilizer at the time of seeding @ 50:25:25 kg N, P₂O₅ and K₂O/ha for the lowland rice in Tier III and @40:20:20 kg N, P₂O₅ and K₂O/ha for the deepwater rice in Tier IV.
- For weeding, use finger weeder in dry condition and/or cono-weeder in 5-10 cm standing water. Fill the gap with fresh seedlings.
- Avoid insecticides and herbicides. Use sex pheromone traps (@ 20 numbers/ha) in rice field and light traps (electric bulb or kerosene lamp above water of pond refuge in 3-4 places) for control of yellow stem borer and other insects pests. In sex pheromone traps, replace the chemical (sex pheromone) once or twice with a fresh one during the rice growing season. Neem based botanicals like Nethrin or Nimbecidine @1% can also be used for control of insect pests.



Dry season rice

- Puddle the field twice in a gap of 7-8 days between initial and final puddling and properly level the land.
- Apply 5t/ha of FYM during land preparation.
- Plant 20-25 days old seedlings in January/February with a spacing of 15 cm between rows and 10cm between plants. Gap fill the sparse areas after a week of transplanting.

- Apply fertilizer @ 120: 60: 60 kg N, P₂O₅ and K₂O/ha. Put 50% of N, entire P and 75% of K as basal or 10-15 days after planting in the case of N and apply the rest amount of N in two equal splits at 3 weeks after transplanting and at panicle initiation stage. Also apply remaining 25% of K at panicle initiation.
- Alternately, wet sowing of sprouted seeds @ 70kg/ha in puddle condition using drum seeder is a viable and labour saving option.
- Avoid use of herbicides and insecticides. Use sex pheromone and/or light traps for control of yellow stem borer and other insects. Neem based botanicals like Nethrin or Nimbecidine @1% can also be used for control of insect pests. However, seedling root-dip with Chlorpyrifos @ 0.02% or with Imidacloprid @ 0.01% for overnight before transplanting is also effective.

Fish and prawn

Grow-out culture in pond refuge -rice field environment (during wet season)

Fish: Grow Indian major carps viz., catla, rohu, mrigal. Other species like, silver carp, common carp and silver barb (*Puntius gonionotus*) can also be grown with the advantage of weed control in rice field particularly by the latter two species.



Prawn: Grow freshwater giant prawn (*Macrobrachium rosenbergii*) with fish.

The fish and prawn are grown in the waterlogged rice field and pond refuge during wet season; after which they are reared further in the pond refuge after the harvest of rice crop.

Management

- Release fish fingerlings of 8-10 cm size and prawn juveniles of 5-8cm size in the ratio of 7:3 at 7,000 population /ha of water area.
- Maintain a species ratio of 30% as surface feeder (catla), 20% column feeder (rohu) and 50% bottom feeder (mrigal and prawn). However, in the absence of prawn, release 35% each of surface feeder (catla, silver carp) and column feeder (rohu, silver barb) and rest 30% as bottom feeder (mrigal and common carp).
- Apply cowdung @5-10t/ha and 200-500 kg lime/ha of water area in monthly split doses.
- Provide feed daily @ 2% of body weight of fish and prawn with a mixture containing 95% of oil cake +rice bran (1:1) and 5% of fish meal.

- Provide hideouts (earthen pipes, twigs) for shelter of prawn during moulting.
- Monitor health condition by regular nettings. Control deadly disease like Epizootic Ulcerative Syndrome with the application of CIFAX@ 1 litre/ha metre of water. Alternately, lime application@ 200kg/ha can also effectively control the infection at preliminary stage.
- Harvest periodically the bigger size fish and prawn from the pond refuge.

Fish fingerlings production

Raise fish fingerlings of catla, rohu and mrigal species in the small pond at the upper end of the farm.

Management

- Apply cowdung @ 3-4t/ha one week prior to release of fish fry followed by fortnightly equal dose of 0.5t/ha. Also fertilize the pond with urea and single super phosphate @ 10 and 15kg/ha, respectively, for plankton production.
- Release good quality fish fry of about 2.5 cm size of catla, rohu and mrigal species at a ratio of 35%, 35% and 30% @ 2-3 lakh/ha of water area.
- Feed the fish fry daily with a mixture of rice bran and ground nut oil cake at 1:1 ratio by weight @ 8-10% of stocked biomass (body weight) during first month, followed by 6-8% and 4-6% during the second and third months, respectively.
- Harvest the fish fingerlings of 8-10 cm size and 8-10g weight by periodical nettings after three months of culture onwards.
- Release the required fingerlings in the pond refuge of the farm and sell out the rest produce.
- Rear the left over stock up to yearlings/marketable size, which also will fetch good amount of money.

On bunds

Fruit crops: Plant 150 seedlings of improved varieties of papaya and 50 suckers of banana of ripe fruit and plantain types.

Plantation crops: Plant 20 coconut (TxD varieties) and 20 arecanut on bunds of the pond refuge. Follow the management practices like, manure and fertilizer application, irrigation, pruning and pests and diseases control.

Agro-forestry: Plant *Acacia mangium*, *A. auriculiformes*, *Casuarina equisetifolia* (in coastal areas) 2-3 m apart east to west on northern and north to south on western side bunds.

Floriculture: Grow marigold, tube rose, gladiolus, rose etc.

Apiculture: Maintain 3-4 bee boxes on upland and bund and harvest honey at regular intervals.

On platforms: Make raised platforms of bamboo/other low-cost materials over the water of pond refuge to grow round the year creepers vegetables like snake gourd, bitter gourd, ridge gourd, bottle gourd, ash gourd etc.

Duckery: Rear 50-100 ducks of Khaki Campbell or other improved breeds. Allow them to graze in rice field until flowering of the rice crop and after that put them in a pen (enclosure) in pond refuge.

Poultry: Rear in cage 75-100 dual purpose coloured birds of breed, *Vanaraja*, *Gramapriya*, *Swarnadhara*, CARI DEVENDRA and UPCARI. Follow four cycles (75-90days in each cycle) of birds rearing in a year.

Productivity and economics: Multitier rice-fish-horticulture based farming system can annually produce about 14-15 tonnes (t) of food crops, 1 t of fish and prawn, 0.5-0.8 t of meat, 10,000-12,000 eggs in addition to flowers and 3-5 t of animal feed from one hectare farm area. The productivity of food crops further increases to 16-17 t besides, 10-12 t of fibre/fuel wood from eighth year onwards due to addition of produce from perennial fruit crops and agro-forestry components. The net income in this system is around ₹1, 00,000/ha in the first year. This will increase to ₹1, 50,000 or more from the eighth year onwards.

Benefits: Rice-fish-horticulture based farming system can increase farm productivity by 15-17 times and net income by more than 20 folds over the traditional system of rice farming in deepwater areas. This system generates additional farm employment up to 300 man-days /ha/year.

Rice-fish farming accrues other benefits like, provision of life saving irrigation to crops during drought as well as drainage of water from the field due to in-built micro-watersheds besides, improvement of soil nutrient status and bio-control of weeds and insect pests because of gainful interactions among rice, fish, duck and other components in the system.

Technology adoption: Multitier rice-fish horticulture based farming system has been adopted in some areas of Odisha. This is a bankable technology supported by NABARD in the state.