Diversified rice-fish farming system for enhancing productivity, profitability and sustainability of lowland rice ecosystem of Odisha

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'Rice is life' and the term is more appropriate for the state like Odisha. Nearly 70% of state's population directly or indirectly depends on rice cultivation and rice is the stable food of Odisha. Mono culture of rice under lowland rice ecologies is no more profitable and ecologically sound. Different farming system options are available to adopt in unfavorable rice ecologies for sustainable crop production under the scenario of climate change. Among the farming system options available, rice - fish farming system is one of the best economically viable and acceptable choice considering the resources, food habits and socio-economic cultures in Odisha. Integrated rice-fish farming accommodates crop diversification, increase productivity, generate employment opportunity, enhance income and provide nutritional security to resource poor farming community. The hydrological characteristic of semi deep and deep-water ecologies of rice farming area is suitable for rice-fish farming. Only minor modifications in terms of construction of dykes, digging of refuge ponds/ditch for shelter of fish are required to develop appropriate rice-based farming system. Several research institutes have developed integrated rice-fish diversified farming system models and validated at farmer's field.

Diversified rice-fish farming system

Diversification of existing rice-based farming systems will help generation of additional income, regular employment to farm family and to improve their dietary standards. A judicious combination of available agricultural enterprises like fish, poultry, duckery, cattle rearing, green manuring, mush room, apiary, horticulture, silviculture, vermicompost etc. will useful for recycling of nutrients, better efficiency of natural resources and biological control of weed and insect pest and diseases in the field crops thus helpful in reducing cost of cultivation. Selection of components purely dependent on resources available with farmer, farmers preference, demand in market so that a farmer will get employment throughout the year and maximum profit without deteriorating the ecosystem. Some of the diversified rice-fish systems and their economic and ecological importance are described in this chapter.

Diversified rice-fish-duck-goat-horticulture farming system for irrigated ecologies

Rice-fish diversified farming system for rainfed waterlogged areas consists of components of rice in main field, fish in pond refugee, trenches and rice field during rainy season, poultry, duck, and goat in pond dyke. The system facilitates rain water harvesting in an in-built micro-watershed and its subsequent

use for farm diversification. Intervention of dry season vegetables in rice field helps in enhancing the cropping intensity. Fruit, silvicultural and vegetables in bunds add more diversification of the system.

Rice-fish-horticulture-goat-mushroom-vermicompost farming system

Management of rice under rice-fish farming system

Under rice-fish system rice is the major component covers about 50-70% of total area of the system. Selection of suitable rice varieties, establishment of optimum crop stand and subsequent best management practices are basic needs for sustainable rice production in rice-fish system.

• Semi tall or tall, photoperiod sensitive, long duration high yielding rice varieties with stiff straw, lodging resistant and tolerance to early as well late submergence like Varsha Dhan, CR Dhan 505, CR Dhan 507 and CR Dhan 508 are preferable.

• One deep ploughing once in three years during the summer season combined with minimum tillage at the time of final land preparation followed by leveling by tractor drawn leveler or ladder which ensures uniform sowing of dry seeded rice.

• Seed bio-priming with *Trichoderma harzianum or Pseudomonas flourescens* 0.5% W.P. @ 10 g /kg of paddy seeds is helpful to keep the crop disease free at early stage of crop growth.

•Sow the treated seeds behind the plough at 20 cm apart or by drilling using seed drill at least 10-15 days before the onset of monsoon rain. A seed rate of 30-60 kg depending on varieties is sufficient to cover one hectare land.

•Apply FYM or cowdung @ 5 t/ha at the time final land preparation. A fertilizer dose of 40 kg N and 20 kg each of P_2O_5 and K_2O/ha is to be applied once at the time of sowing or transplanting in deep water rice ecology or in areas where chances of early submergence is less, the 'N' fertilizer can be applied in two splits, half at the time of sowing and rest half after first weeding at 20-25 days after sowing.

• Integrated weed control measure comprising different indirect control measures like summer ploughing, crop rotation, introduction of fishes, azolla, ducks etc. along with direct control measures are recommended to keep the weed population below the economic loss level. Pre emergence application of herbicides pretilachlor @ 0.75 kg /ha or pendimethalin @ 1kg/ha is useful for suppression of weeds in dry seeded rice. In areas where chances of early submergence are less mechanical weeding by operating a finger weeder (20-25 days after emergence) or cono weeder in line sown field at 2-5 cm water level helps to control the weeds. Release of common carp, duck and azolla helps in control of weeds at later stage of rice crop.

• The IPM practices include the following components.

Use of quality seed free from insect pest and diseases helps in to minimize the chance of invasion of insect pest and diseases. Seed treatment with biocontrol agents as already discussed helps in to keep the crop safe from disease and pest attack at early stage of crop. Use 3-4 light traps per hectare of crop. Presence of hanging platforms and other trees acts as bird perch and encourage insect pest control by predating birds.

As spraying of pesticides not feasible due to high water logging release of *Trichograma japonica* an egg parasite @ 20000 eggs/ acre to control stem borer before flowering is advocated. Spray the crop with Pseudomonas @ 5 g / litre of water at seedling or early growth stage to protect the crop from blast or sheath blight

• Rice crop is ready for harvest during the end of November to first fort night of December in rice-fish system depending on the varieties and time of sowing. Harvest the rice when 85 % of the grain tuned greyish yellow by using power operated repaor or improved sickle.

Management of fish under rice-fish farming system

•Selection of fish species and their composition, size of the fish seed, time of release of fish seed, stocking density and subsequent management practices determines the productivity of fish in rice-fish system. Some of the suitable fish species are Rohu *(Labeo rohita*), *Catla (Catla catla,),* Mrigal (*Cirrhinus mrigala*), Common carp *(Cyprinus carpio*), Silver carp (*Hypophthalmichlthys molitrix*) , Freshwater prawn (*Macrobrachium malcolmsonii) and Giant freshwater prawn (Machrobracliiitm rosenhergii)*

•Management of fish in rice-fish system includes liming, manuring, fertilization, stocking density and proportion, aeration etc. to maximize the fish yield per unit land area.

•Liming in pond refuge and trenches should be done judiciously to disinfect and correction of soil acidity suitable for growth and development of fish. Apply lime @ 200 kg/ha at least 15 days before release of the fingerlings. Calcium oxide is normally used during pond preparation whereas calcium carbonate and/or dolomite is/are used during culture operation.

•The commonly used organic manures are poultry droppings, cow dung or pig dung. It is always advisable to treat the manure with lime/disinfectant before use. The manure has to be made to solution form and the supernatant is to be spread on the water surface. The different doses of the manure are cow dung-10-15 t/ha/yr or pig dung- 3-5 t/ha/yr or poultry manure-5-7 t/ha/yr applied in 3 to 6 split doses depending on the water quality.

•Usually in single stocking and single harvesting grow out system for one-year period; the stocking density maintained is 5,000-6,000 fingerlings/ha whereas the density can be increased to 5,000-10,000 fingerlings/ha for the six months crop. Release fish fingerlings @ 1 number/ m^2 of water area during June-July depending on availability of water in pond refuge and trenches. Manuring of pond refuges should be completed at least 15 days before release of fish fingerlings to the system.

•Maintain stocking ratio 30:20:50 of surface feeder, column feeder and bottom feeder respectively. Because column feeder (rohu) does not grow properly due to short water column but

availability of sufficient foods like detritus and waste from rice plant favors growth of bottom feeder (mrigal). When freshwater prawn species is included along with the carps, juveniles should be stocked substituting 50% of the bottom feeder.

• Commonly recommended fish feed is combination of oil cake (ground nut oil cake/ mustard oil cake) and rice bran at 1:1 ratio. However, in addition to these, dried fish powder, blood meal etc also recommended when prawn is cultured along with carps in rice-fish system. The feed mixture containing 95% of (Oilcake + rice bran at 1:1 ratio) and 5% of fish meal is ideal. The feeding should be done at same time (preferably morning and evening), at the same place (feeding platform) and in the right amount (calculated from biomass of the fish through periodical sampling).

• Harvest periodically the bigger size fish from pond refuge after the harvest of rice during this period water usually recede to the trenches and pond refuge making the harvesting easy. Under optimum level of management, from 1 hectare Rice-fish culture 600-800 kg of fish can be harvested in 2-3 periodical netting.

Economics of diversified rice-fish farming system

Under optimum level of management, from one ha rice-fish farming system about16-18 t of food crops, 0.6 t of fish and prawn, 0.55 t of meat and 8000-12,000 eggs in addition to flowers, fuel wood and rice straw and for animals form one hectare of land. The system generates a net income of Rs 55000-130000 along with generation of employment of 250-300 man-days over rice farming. Thus, the system increases farm productivity by about 15 times and net income by 20 folds over the traditional rice farming. The technology validated in lowland ecosystem of Odisha and realized higher productivity and profitability over the traditional rice farming

Benefits of diversified rice-fish-horticulture farming system

▪The system is economically viable, ecologically sound and environmentally safe.

▪Synergistic effect of fish on rice could enhance the rice yield by 8-12% as compared to sole rice.

▪Higher land productivity, water productivity and nutrient use efficiency ultimately reflects in terms of enhanced productivity and farm income.

▪Increase efficiency of resource utilization; reduce investment risk through crop diversification.

▪Cost of expenditure for each crop is reduced as one crop supplements something for growth and production of other crop.

▪Better recycling of organic waste in to value added products.

▪Farmer will get income throughout the year as the harvesting time varies with crops.

▪Helps in generation employment opportunities thus keep the farmers engaged in occupation throughout the year

Constrains in adoption of rice-fish farming system

▪Non availability of fish seed of composite culture, fish feed and other inputs at reasonable rate and at appropriate time.

▪Non availability of credit facilities to meet the initial high expenditure incurred for development of the system.

▪Non availability of adequate extension facilities to train the farmers about the different technical knowledge required for successful adoption of integrated farming system.

Conclusions

Integration fish in lowland rice production system created synergistic effect and sustains food production under adverse situation. Further diversification of rice-fish system with the inclusion of other components like horticulture, duck, goat, poultry, mushroom production and vermicomposting helps in recycling of natural resources and proper utilization of byproducts results in generates additional employment, enhances farm income and provides balanced food and feed without degrading the natural bases. Rice-fish farming system has been developed and validated at different coastal districts of Odisha like Puri, Cuttack, Jagatsinhpur, Baleshwar, Ganjam and Bhadrak. Unfavorable lowland rice ecosystem of coastal districts can be converted to more profitable and sustainable farming system model for suitable food production under scenario of climate change. The system can also be adopted in hilly districts like Koraput, Malkangiri and Nabarangapur of Odisha.