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COMMUNITY BASED SEQUENTIAL RICE – CUM - FISH FARMING IN NICRA VILLAGE JATIPURA OF PURI DISTRICT, ODISHA

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ABSTRACT

Puri, being a coastal district of Odisha is frequently affected by vagaries of nature like erratic rainfall, cyclone, super cyclone, flood etc. More than 70% of the district's geographical area are low-lying and become water-logged during monsoon season. In these areas, there is standing water of 3 to 4 feet in the crop field that greatly hinders rice cultivation during *kharif* season and it is restricted only to *rabi* season after receding of water. The study was conducted during both *kharif* and *rabi* season for the year 2021-22, 2022-23 and 2023-24 at village Jatipura of Puri Sadar block, district Puri under KVK's NICRA-TDC project. A compact patch of Rice field of 17 acres area with ownership of 17 nos. of small and marginal farmers was taken up for sequential Rice-cum-fish farming in it. Lime and raw cow dung were applied into the water after testing the water quality parameters in order to start fish farming. A total of 13,000 stunted fingerlings of IMC and Amur carp were stocked into the pond and later in another batch of 5000 numbers of Grass carp fingerlings and 3500 numbers of Scampi juveniles were released. By the end of December- 2023, a total 25q of fish and 1q of prawns of net worth Rs. 4,40,000/- were harvested from the large pond and the community earned a net profit of Rs. 2,37,200/-. People are happy to get a substantial amount of income during this fallow period. Over peripheral embankment, fruit crops like Patakapura banana varieties were planted during the year 2021-22. Due to this fish farming, the sowing window for Rice started fifteen days earlier compared to the previous practice. The nutrients from the organic matter that gradually accumulated in the soil during the previous fish crop enabled farmers for a bumper harvest of Rice crop with an average yield of 51q/ha which was 21.42% higher than previous practice. It has been ascertained that a total 225kg/ha/crop of chemical fertilizers of worth Rs.4,365/- per ha/crop was saved over previous practice.

Key words: Amur carp, Grass carp, IMC, NICRA-TDC, Scampi, Sequential Rice-cum-fish.

Introduction

In India, more than 80% of the farming community belongs to marginal and small farmers having only 32.5% of the total operational area. Odisha state derives its livelihood, food, nutritional and environmental services from 0.70M ha of upland area and 0.92M ha of alluvial plains including 0.08Mha of waterlogged soils. According to 1999-2000 estimates, Odisha had highest poverty of the country (47.15% population), followed by Bihar (42.6%) as compared to 26.1% of national average and 6.16% of Punjab. Water was declared one of the five pillars of sustainable development at Johannesburg, (WSSD, 2000). Even though it is abundant in this state, highest poverty ratio is still a unique situation. Similar is the case in many other states of eastern India. In addition to this, the combined effect of global warming and climate change frequent low-pressure conditions have been occurring over Bay of Bengal which causes erratic rainfall, untimely heavy rainfall, cyclone, super cyclone, flood, flash flood etc by Mahapatra *et al.*, (2018). Among the coastal districts of Odisha, Puri is worst affected by above mentioned climatic constraints. More than 70% of the district's geographical area are low-lying and become water-logged during monsoon season. In these areas,

water stagnates above ground for nearly six months in a year and only one Rice crop is raised in rabi season. The traditional monoculture and disciplinary approach are unable to meet the growing and changing food demand and improve the livelihood of these smallholders on a sustainable basis, Mahapatra I.C. and Behera U.K. (2011). Single commodity-based agriculture is always endangered by natural hazards such as floods, drought, and disease epidemics. During 1999-2000 in India, many cotton growers in Andhra Pradesh, Maharashtra and Karnataka committed suicide as their crops were heavily damaged by pests. Adoption of IFS would help farmers escape such situations and reduce the risk involved in crop failure by Shukla *et al*., (2002). Therefore, an integrated approach to farming is critical to sustain agricultural production, maintain farm incomes, safeguard the environment and respond to consumer concerns about food quality issues by Singh *et al.*, (2007); Yadav R.L. and Prasad K. (1998). This type of farming situation needs a farming system, which converts threats of water abundance into greater livelihood, employment generation and poverty reduction opportunities by Pattnaik *et al.*, (2021).

The sequential Rice- cum- fish farming is a straight forward agricultural technique in which fish species are planted in flooded fields following the harvest of rice without the rice stubbles being removed. In the case of rice, the water levels were shallow, but for aquatic species, the water depth is increased. This approach of diversifying risks, self-employment, flow of income throughout the year and recycling of energy and nutrient fluxes provides sustainable resource use by Salele H.A. *et al.*, (2023). The farming systems approach is considered a resource management strategy to achieve economic and sustained productivity that meets the diverse requirements of the farm household whilst preserving the resource base and maintaining a high level of environmental quality by Lal R. and Miller F.P. (1990). This sequential Rice- cum- fish farming is also a one type of IFS. IFS provide a stable and sustainable production system through diversified crops and enterprises, which helps in risk minimization and resilience to climate change byAyyappan S. and Arunachalam A. (2014). This model has been adopted in our study area is sequence of fish and rice along with fruits and vegetable plantation in bund, portable poultry, community mushroom unit and community vermicompost unit. The model is popularly known as Jatipura Model. This model is based on multiple recycling of carbon, energy and nutrients from biomass to fishery and minimize environmental loading with pollutants. The overall system is most efficient for the absorption of inputs and production of goods and services. In these systems, waterlogged lands are brought into productive use, where the waterlogged waterbody enabled for fish farming created due to bund renovation serves as a focal point for direct or indirect links between other components. It is reported that 50 kg of fish biomass can produce enough pond humus to fertilize nearly 6500m^2 of cropland. In this system fish wastes, manures for fish farming are used to fertilize crop lands. The land in return produce crops, which serve as food for animal, fish and human beings. Keeping all these aspects in view, a sequential rice cum fish farming system developed on community basis at farmer's field of seventeen farmers was evaluated for its productivity, sustainability, profitability and also to understand the needs for further modifications. Water productivity in the sense of its multiple uses has also been attempted.

Materials and Methods

The study was conducted during both *kharif* and *rabi* season for the year 2021-22, 2022-23 and 2023-24 at village jatipura of PuriSadar block, district Puri. The experimental site comes under the agro climatic zone of east and south east coastal plain of Odisha and east coastal plains & hills of India. In the study area, there is standing water of 3 to 4 feet in the crop field that greatly hinders rice cultivation during *kharif* season. As a result, farmers sit idle for 6-8 months starting from June to November –December. Some of them are compelled to go to different cities as a daily labourer in brick kilns, construction sites, agricultural farms, hotels, spinning mills etc. to earn their livelihood.

The major contingency of the village is given in the Table 1.

Table 1: Major Contingency of the village Jatipura.

Climate vulnerability (Tick mark)	Often		Sporadic (specify month of occurrence in brackets)		Which crops are affected most
	Severe	Mild	Severe	Mild	
Drought	-	√	-	1st fortnight of April	Rice
Flood	√	-	Mid-week of August to Mid-week of September	Mid-week of July to Mid-week of August	Rice
Pests and diseases	√		Last week of February to Mid week of March		Rice
Sea inundation	√		Aug- September	-	Rice

Fig. 1: Location Map and Socio-resource map of the village Jatipura.

Based on the contingency of village Jatipura 72 house-holds have been adopted under KVK's NICRA-TDC project during the year 2021-22. Preliminary PRA survey was conducted in the village during the year 2021-22. A compact patch of Rice field of 17 acres area with ownership of 17 nos. of small and marginal farmers was identified to take up "Scientific sequential Rice-cum-fish farming" in it. This compact patch completely remains fallow during *kharif* due to waterlogging. The site is 17kms away from KVK, Puri, Sakhigopal. The location map of the project site as well as layout of the farm is given in (Fig. 1). The average annual rainfall of Jatipura for last 30 years (1990-2020) is 1436mm and the monsoon (June to October) rainfall is 1249mm, which accounts for 84% of annual rainfall. The number of normal rainy days during *kharif* was 56. It was observed that surface water ponding started from 3rd week of June and increased maximum up to 162cm in last week of August and reduced to surface level in December in the 17 acres compact patch of village Jatipura. So, there was a need to keep the water up to December, so that fish can be harvested in the last week of December and then farmer could go for rabi Rice crop. Renovation of bund up to 5ft was done by mechanical means under natural resource management up to length of 980m surrounding the compact patch of 17 acres. Then the farmers of the village engaged to prepare the bund for plantation of Patkapura variety of Banana which is suitable to the climate of the district and at the same time vegetable and floriculture crops. The weekly rainfall, surface ponding and water table depth is presented in (Fig. 2). The steep rise and fall in water table may be due to its drainage into river Ratnachira during low flow period and quick recharge of ground water during high flow period.

The total area of the system was 17 acres with ownership of 17 small and marginal farmers. Since area remained completely fallow due to waterlogging, it was

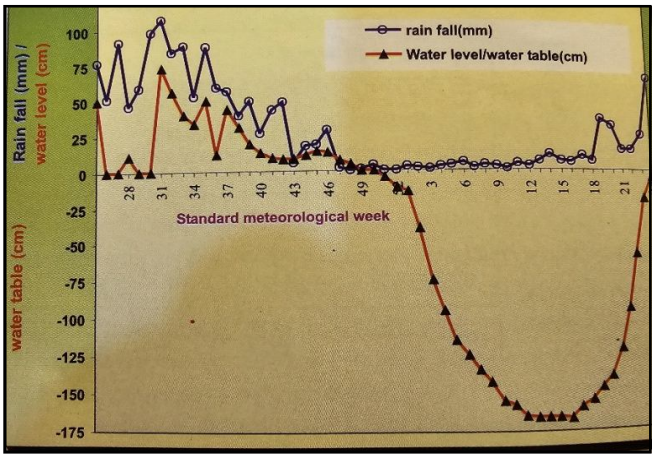

Fig. 2: Weekly rainfall, surface ponding and water table depth of the project site.

Table 2: Crop Calendar for Sequential Rice-cum-Fish Farming @ Jatipura.

MONTH ACTIVITIES	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Fish Fry/Fingerlings stocking in farm ponds				**Fish Stocking**								
Fish Grow-out operation & Table –size Fish harvesting							**Fish Grow-Out**			**Fish Harvesting**		
Rice crop cultivation	***Rabi Rice***											

a main concern for the villagers. Considering all the pros and cons of suggested cropping system by agricultural scientists, finally sequential Rice- cum-fish farming approach was adopted by converting the area enabled for fish farming by raising the bund height. As a result raised bund obtained used for farming. Embankment was planted with Banana, Radish, sweet corn, Okra etc. Again a community mushroom unit and community vermi compost unit was established in the embankment area. Poultry and duckery was also introduced to be reared in portable unit to give protection against flood. The bund area was 0.25ha, dimension of the compact patch was 389m × 175m. and the depth of pond was 2.0m. The compact patch has twosmall nursery ponds (total 0.2ha) for rearing fingerling to advanced fingerling stage of Indian major carps.

Results and Discussion

Fish Farming

The crop calendar for sequential Rice -cum-Fish farming is given in Table 2.

Table 3: Annual operational cost and net return of the 5.6ha pond system (year 2023-24).

Input material	Quantity	Total Input Cost (Rs.)
Cost of fingerling production for stocking @Rs2/- per fingerling	51000	102000
Cost of ploughing by tractor @Rs.500 per hour	14h	7000
Cost of cow dung@ Rs.1300 per tonne	6tonne	7800
Cost of lime @ Rs.10 per kg	800kg	8000
Cost of pellet feed @Rs10per kg	6tonne	60000
Labour cost @Rs.100 per man day	180 man days	18000
Total cost		202800
Yield (q)		
Carp fish	21.8	348800
Weed fish	3.2	51200
Scampi	1.0	40000
Selling of fish	25.0	400000
Selling of Prawn	1.0	40000
Gross return		440000
Net return		237200

By the end of July-2021, the 17 acres patch was impounded with sufficient rain water and the water depth was 3 – 5 feet level (due to undulated bottom). The water quality parameters were tested and accordingly reclamation was done by application of lime. After 5 days of lime application the water was manured with 8 tractor trips (around 2000 kg) of raw cow dung. In 2021-22, two nos. of 'Farm ponds' of total WSA 0.3 acres were present within the selected patch. The farm ponds were made dewatered, exposed for sun- drying, filled up with water, fertilised and stocked initially with 4000 nos. of Jayanti rohu stunted fingerlings. In the year 2022-23, During July and August the two farm ponds were phase-wise stocked with 10000 nos. of GI catla, 8000 nos. of Jayanti rohu and 10,000 nos. of Amur carp fry. A total of 13,000 fingerlings of IMC and Amur carp were released to the pond in the month of July & August, 2023. Again in the month of August 5000 numbers of Grass carp were released. But in the year 2023-24 along with 5000 numbers of grass carp and 3500 numbers of Scampi fingerlings were released. Grass carp juveniles were stocked to control luxuriant growth of emergent weeds (*Nymphaea*). From first week of October-2023, fishes were served with artificial floating feed on daily basis. During mid-November-2023, the large pond was applied with 800 kg lime as winter disease prophylaxis.Annual operational cost and net return of the 5.6ha pond system for the year 2023-24 is given in the Table 3.

Prior to stocking, the main waterlogged area is treated following the standard pond preparation procedures such as drying, ploughing, liming (@200kg ha^{-1} as basal), fresh cow dung (@7000 kg ha^{-1} as basal), SSP @ 25kg ha^{-1} as basal). However, periodic liming @ 25kg ha^{-1} is carried out at every 15 days interval to maintain desired water pH and plankton density.

During stocking, a density of 7500 fingerlingsper ha is maintained in the main pond with a species composition of 30:40:30. In addition to this prawns are also stocked the main pond for poly culture with IMCs @15000 $ha^{-1.}$ High energy pelleted feed is given twice (1:1) a day @2.5%of mean body weight throughout the culture period. Since cow dung is given as basal. The average feed conversion ratio during 3 years was 1.22. Glimpses of step wise procedures followed in Jatipura village for

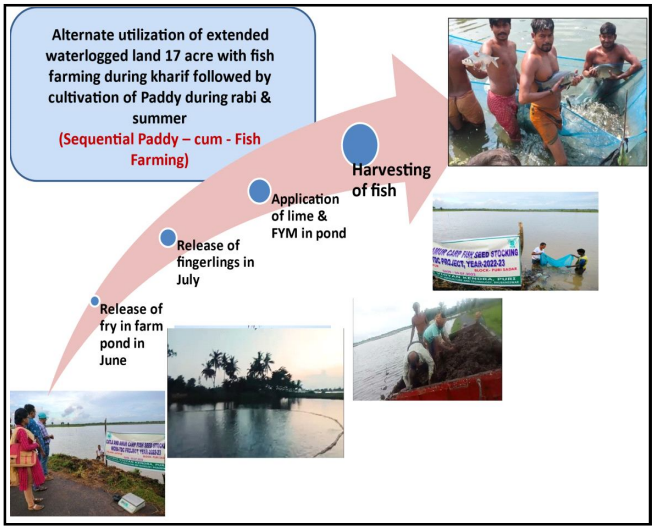

Fig. 3: Glimpses of step wise procedures followed in Jatipura village.

implementation of sequential Rice-cum- fish farming are shown in (Fig. 3).

The manure loaded fish ponds can be considered as a system to which mineral rich organic matter was added in the form of manure and produce fish biomass. Maximum amount of organic waste loading was maintained within 120-200 kg ha^{-1} day^{-1} (dry weight) or 72-130 kg ha^{-1} day^{-1} of organic matter. The estimation of waste loading rate squarely depends upon the rate kinetics of decomposition process and utilization of degraded products in pond eco-system, which is very much influenced by temperature, dissolved oxygen and intensity of solar radiation. Regular monitoring of dissolved oxygen and pH are therefore, very important from waste loading point of view. Further, to maintain a cleaner aquatic environment, regular water exchange was carried out which corresponds to 2-3% day^{-1}.

Poultry & Duckery System

Eight numbers of low-cost portable two stored poultry units were constructed to provide the 17 farmers to operate them on community basis. The dimension of these poultry units were 1.8m × 1.5m each and 60 birds were reared in each unit. So total capacity of birds was 480. 500 numbers of poultry birds of breed kadaknath, Vanaraja and Rhode Island Red and 1000 numbers of White pekin & Khaki campbell were provided during the year 2021-22, 2022-23 and 2023-24 respectively. Starter feed were also supplied by KVK for initial feeding of birds. Time to time vaccination was done by KVK in association with VAS, Puri Sadar. Trainings on poultry bird rearing was imparted to the farmers of the NICRA village by KVK scientists. Theselow cost portable units have been provided to give protection against flood. So in the event of a climatic emergency these units can be transferred to a safe place. Economic analysis of day old poultry bird is given in the Table 4.

Table 4: Economic analysis of poultry system.

Sl No	Item	Price (Rs)
1.	One day old Chick cost	30/-
2.	Feed cost per bird	60/-
3.	Medicine cost per bird	10/-
4.	Maintenance cost per bird	10/-
Total expenditure incurred per bird		110
Per bird yield 1.8kg @Rs.130.00 per kg		234
Net profit per bird		124

Bund Plantation

Eight hundred numbers of Banana variety Patkapura were planted along the 1.0 kilometer renovated bund. This Patkapura variety is a climate resilient variety and it can withstand moderate wind velocity. Sweetcorn, lady's finger, radish, cowpea and marigold were taken as inter crop in the bund. Excepting lady's finger all other intercrops were very much successful in local market. Total net returns from vegetables alone were Rs. 33,600/- in the first year. The detail year wise input and returns from the pond as well as bund system (Sequential Rice-cum-fish farming system) is given in Table 5.

Community Mushroom & Vermi Composting Unit

Mushroom farming has emerged as a climate-resilient

Table 5: Details of year wise expenditure and return of the integrated farming system (5.8ha of pond + 0.25ha bund).

Components	A : Input Cost (Rs)			B: Gross Return (Rs)			C: Net Return (Rs)		
	2021-22	2022-23	2023-24	2021-22	2022-23	2023-24	2021-22	2022-23	2023-24
Bund renovation	96000	-	-	-	-	-	-96000	-	-
Horticultural crops	130000	136000	262169	208000	258400	549490	78000	122400	287321
Fishery	180000	228530	202800	270000	414575	440000	90000	186045	237200
Poultry	55000	110000	214000	117000	220000	544000	62000	110000	330000
Duckery	7600	8800	NIL	13800	17600	NIL	6200	8800	NIL
Mushroom	40000	80000	129000	69400	140400	279900	29400	60400	150900
Vermicompost	4350	26100	26100	5000	36000	54000	650	9900	27900
Rice	313200	301600	291015	522440	542880	563760	209240	241280	272745
Total (Rs)	826150	891030	1125084	1205640	1629855	2431150	379490	738825	1306066

crop that aligns with sustainable agricultural practices by minimizing environmental impact, conserving resources, and promoting biodiversity. With its low requirements for land, water, and chemicals, mushroom cultivation supports soil health and enhances biodiversity through mycorrhizal associations by Smith S.E. and Read, D.J. (2020). Both Rice straw and oyster mushroom cultivation, along with vermicomposting from spent mushroom substrate was carried out in bund area. Seventeen farmers participated in both mushroom cultivation and vermicomposting. Economic performances of both interventions were given in the table. Resource recycling, particularly using Rice straw waste for vermicomposting, was emphasized. Over the last three years (2021-2023), Puri Sadar Block in Puri district, Odisha, has experienced favourable conditions for mushroom cultivation, with summer temperatures ranging from 31°C to 39°C and winter temperatures between 16°C and 25°C. The monsoon season recorded temperatures from 26°C to 34°C,

creating an ideal environment for the growth of mushrooms like Rice straw and oyster varieties. Consistently high humidity, especially during the monsoon months (80% to 97%), along with moderate humidity in other seasons (45% to 82%), provides optimal moisture levels essential for successful mushroom farming, supporting both growth and productivity. These conditions are ideal for cultivating Rice straw and oyster mushrooms, which thrive on agricultural by-products, sequester carbon, and aid in bioremediation, making them an environmentally beneficial and sustainable agricultural choice by Liu *et al.*, (2018); Singh H. and Sharma S. (2021). Both the mushroom and vermi compost unit were constructed by community with the technological backstopping given by KVK scientists.

Rice cultivation

After the fish and prawn harvest in late December, pre germinated rice seeds of variety Bina Dhan 11 were



broadcasted directly onto the same land. The above said variety is a climate smart stress tolerant high yielding rice variety with saline tolerant (EC up to 12 ds/m) and submergence tolerant up to 20 - 25 days, Sultana *et al.*, (2019). This makes it as a best choice by the farmers for *rabi* season. The field, left puddled post-fish farming, minimizes the need for additional land preparation. This reduces costs associated with rotavator hiring by approximately Rs.2500 per hectare, as the puddled soil is ideal for rice cultivation without extensive modification. The fish farming process enriched the soil with FYM and fish biomass, which produced pond humus. This natural fertilization significantly reduced the requirement for synthetic fertilizers, leading to further cost savings and promoting sustainable agricultural practices. The cycle of this farming system model is given in (Fig. 4).

Water Productivity of Sequential Rice- cum- Fish farming

The water productivity of the sequential Rice- cum- fish farming system was estimated as the ratio of pond output in rupees to the volume of pond water for the year 2023. The total volume of water available in the pond assuming average depth of 1.5 m, is 86660 m^3. Annual water exchange is approximately 68,461 m^3. No bund



renovation was required during second and third year *i.e.* 2022-23 and 2023-24. During 2023-24, farmers showed no interest towards duckery due to heavy feed requirement. The total returns from the pond system alone were Rs. 4,40,000 in the year 2023. This corresponds to a water productivity of Rs.2.83 per m^3.

The net return per hectare from this sequential rice-cum-fish farming system over an area of 6.05ha (including the bund area) was Rs.62, 726/- in 2021-22, Rs. 1,22,120/- in 2022-23 and Rs. 2,15,879/- in 2023-24. The average net return per hectare per year on 3 year basis from this farming system was Rs. 4,00,725/-.

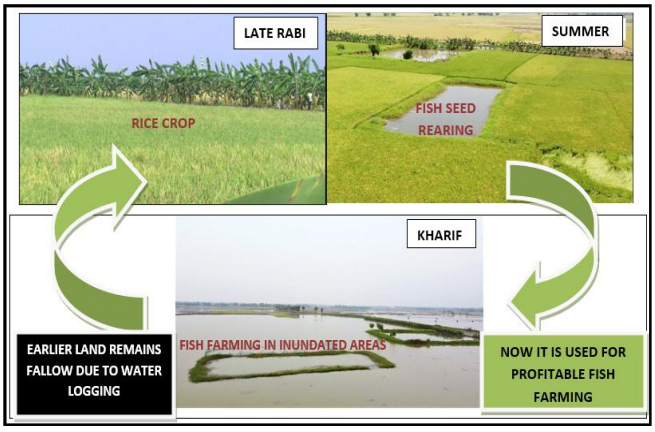

Fig. 4: Cycle of Sequential Rice- cum- Fish farming.

Conclusion

The adoption of sequential Rice-cum-fish farming in Jatipura village of the Puri Sadar block under the NICRA -TDC project has provided a good livelihood to farmers who previously remained idle during the *kharif* season. The successful implementation of this farming systems has effectively addressed critical challenges faced by smallholder farmers in resource utilization. This sequential Rice-cum- fish farming system of Jatipura village is recognized as "Jatipura model" by the district administration and farmers across the state. This technology combines the benefits of rice cultivation with aquaculture, optimizing land and water resources for higher productivity, cost savings and environmental sustainability. By adoption of this system apart from fish farming, rice was sown 15 days earlier than previous practice. Nutrients from organic matter accumulating in the soil during the previous fish crop enable farmers to harvest a bumper Rice crop with an average yield of 51q/ha by first week of May-24, which was 9q/ha higher yield than previous practice without much application of manures & fertilizers. It has been ascertained that a total of 225kg/ha chemical fertilizers worth Rs.4,365/- was saved over previous practice. Due to fish farming, an adjacent 70 acres area came under wet direct seeded rice due to availability of soil moisture. The total net return from the sequential Rice-cum- fish farming system on 6.05 ha, including bund plantation, was Rs.24,24,381/-. Notably, it has been established that for a system to be sustainable, farmers' participation is essential, and pisciculture is feasible in seasonally waterlogged areas. To enhance sustainability, farmers' paying capacity must be increased. The impact of this technology is evident in the form of sensitization of district administration, reduced migration of farmers and labourers over the past three operational years. The fish traders are now providing advances and sensitizing PRI members for promoting similar projects in water logged areas of Brahmagiri, Gop and Kanas block of the district. Recently, two other farmers have adopted this successful sequential Rice-cum-Fish farming system in the locality.

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