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Research Note

Impact of Integrated Farming of Water Chestnut and Cat Fish on Livelihood of Farmers in Seasonal Waterlogged Areas of Odisha

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Abstract

The paper has assessed the impact of integration of water chestnut cultivation with cat fish culture on livelihood of farmers in the seasonal waterlogged areas of Balasore district in Odisha. It has revealed an increase in production of water chestnut by 1.99 t/ha with an additional harvest of catfish to the extent of 0.78 tonnes, resulting in more than 50 per cent increase in the income of farmers. The study has observed that before adoption of technology, four out of five types of assets measuring the changes in livelihood of farm families were below the average level (barring social assets), which increased considerably after adoption of technology with highest gain in financial assets (41%), followed by physical assets (35%), social assets (31%) and human assets (29%). About 86 per cent farmers could be brought to above average level of living with the change in farming situation on adoption of water chestnut cultivation integrated with cat fish farming in Odisha. The developed package of practices for integrated farming of water chestnut and catfish has been adopted by the "CARE India" under their dissemination programme in tribal districts of Odisha.

Key words: Water chestnut, cat fish, integrated farming, adoption, waterlogged area, Odisha

JEL Classification: Q12, Q16, Q22

Introduction

Water chestnut (*Trapa bispinosa* Roxb.) (singhara or pani phal) is one of the few neglected but economically important aquatic crops grown in different parts of India. It is a natural crop in the areas where water stagnation above the ground persists for more than six months in a year. The 8 million ha shallow low land ecosystem in the low-lying areas of the country, of which 5.8 Mha is in eastern India, provides ideal environment for the cultivation of this crop, mainly during *kharif* season (Roy Chowdhury *et al.*, 2006).

In the eastern region of the country, the state of Odisha has about 0.085 Mha waterlogged area, where there is potential for diversification of agriculture toward remunerative crops like water chestnut (Roy Chowdhury *et al.*, 2004a). Due to its aquatic habitat, crop has resurrection ability despite exposure to brief submergence or flash flood. The crop gradually adjusts itself with the rise in water level to keep its leaf crown afloat (Roy Chowdhury *et al.*, 2003). This makes the crop flood-resilient, especially in the low-lying areas. Water chestnut fruits are generally consumed as raw or after boiling. Following sun drying of mature fruit, nut-flour is also used as a source of non-cereal carbohydrate diet (Alam *et al.*, 2001; Roy Chowdhury *et al.*, 2004b). A significant portion of the nut is processed for use as flour for food or for textile sizing.

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The low-lying waterlogged areas are suitable for the auto recruitment of native fish species and are natural habitat of captured fisheries (Kunda *et al.*, 2008). Therefore, integration of fish and aquatic crops like water chestnut is economically lucrative under the waterlogged ecosystem. The farmers are hesitant to grow fishes in the isolated water bodies due to risk of theft but integration of water chestnut with fish farming offers a surface cover protection besides diversifying livelihood options. The air-breathing fishes like catfishes fit well in such a situation due to their additional respiratory organ as well as habitat preference and nature of growth. Due to favourable factors like higher yield, production-size index and performance index, air-breathing fish culture along with water chestnut is advisable (Roy Chowdhury *et al.*, 2005).

A livelihood depends on people, their capabilities and means of living including food, income and assets. A livelihood is sustainable when it maintains or enhances the assets on which it depends. Many of the definitions of livelihood security currently in use are derived from the work of Chambers and Conway (1992). The idea of livelihood embodies three fundamental attributes: (i) possession of human capabilities (such as education, skills, health, and psychological orientation); (ii) access to tangible and intangible assets; and (iii) the existence of economic activities. The interaction between these attributes defines the livelihood strategy of a household. The sustainable livelihoods are achieved through access to a range of livelihood resources (natural, economic, human, financial and social) which are combined in the pursuit of different livelihood strategies, viz. agricultural intensification, livelihood diversification, migration, etc. (Scones, 1997). People and their access to assets are at the heart of livelihoods approaches.

In the Department for International Development (DFID) framework (1999), five categories of assets or capitals have been identified, which are: human capital (skills, knowledge, health and ability to work), social capital (social resources, including informal networks, membership of formalized groups and relationships that facilitate co-operation), natural capital (natural resources such as land, soil, water, forests and fisheries), physical capital (basic infrastructure, such as roads, water and sanitation, schools, communication avenues and producer goods including tools and equipment), and financial capital (savings, credit, and income from employment, trade and remittances). The 'rural livelihoods' are complex and wide-ranging (Ashley *et al.*, 2003). The crop diversification, farm sector diversification and livelihood diversification influence the rural economy. Therefore, rural livelihood diversification through appropriate and advanced agriculture holds the key for development of rural economy (Mehta, 2009).

In this backdrop, the present study was conducted to study the impact of integrated farming of water chestnut and cat fish on farming practices as well as livelihood of farmers in seasonal waterlogged areas of Odisha

Materials and Methods

The impact assessment of technology on farming situation and livelihood of farmers was carried out covering a randomly selected sample of 35 farmers adopting integration of water chestnut (WCN) cultivation and aquaculture in the Balasore district of Odisha for more than five years. The impact on the farming situation of farmers on adoption of a technology was realized through a comparison of farming pattern, acreage, production, cost of cultivation and gross income before and after the adoption of the technology. The impact on livelihoods was measured through finding comparative position of physical, social, financial, human and natural assets of the farmers before and after adoption of the intervention.

The physical assets included type of housing, sanitation, conveyance, electric, cooking and communication facilities. The social assets mainly referred to the recognition, social and political participation, active involvement in developmental works, common services used and group membership pattern. The financial assets were measured on the basis of parameters like sources of income, kinds of savings and investments, lending and borrowing. The human assets involved language competencies, education/ literacy level, management skill and mobility. The natural assets were the possession of natural resources of farm family, viz. farm size, irrigated land, livestock holding, poultry and fishpond. All the above-mentioned parameters under five types of assets were measured on the basis of responses of farmers on a 5-point continuum scale (minimum and maximum values being

1 and 5, respectively) during the interview schedule survey and focus group discussions. Overall, standard of living of farmers was assessed on the basis of their assets holding before and after adoption of the technology; thus, the value of overall standard of living ranged from 5 to 25.

Standard of living of farmer adopting the technology, $L_i = \Sigma(P_i+S_i+F_i+H_i+N_i)$

where, i indicates the number of farmers who adopted the technology; i = 1,2, …..,35

P_i (Physical assets) = $\Sigma PA_{ij}/\Sigma j$,

where, j (=1,2, ….,7) indicates the parameters measuring physical assets, viz. (1) No. of rooms in house, (2) Type of roof of the house, (3) Sanitary / Latrine condition, (4) Type of vehicles-owned, (5) Electric power usage, (6) Cooking facilities, and (7) Telephone connectivity.

S_i (Social assets) = $\Sigma SA_{ik}/\Sigma k$,

where, k (=1,2, ….,4) indicates the parameters measuring social assets, viz. (1) Respect/Recognition in village, (2) Participation in local political issues, (3) Use of common facilities at the locality, and (4) Membership in common bodies / clubs / groups.

F_i (Financial assets) =$\Sigma FF_{il}/\Sigma l$,

where, l (=1,2, ….,4) indicates the variables measuring financial assets, viz. (1) Sources of income (agriculture, agricultural labour, livestock, fish farming, business, interest from loan given, salary, etc.), (2) Kinds of savings (bank, post office, chit fund, group fund, etc.), (3) Kinds of investment (insurance, deposits in bank/ finance company, bonds, etc.), and (4) Lending.

H_i (Human assets) = $\Sigma HH_{im}/\Sigma m$,

where, m (=1,2, ….,4) indicates the variables measuring human assets, viz. (1) Communication ability, (2) Education/ literacy, (3) Management skills (ability to manage agriculture, livestock, fish farming, business, marketing, etc.), and (4) Travel / mobility.

N_i (Natural assets) = $\Sigma NN_{in}/\Sigma n$,

where, n (=1,2, ….,6) indicates the variables measuring natural assets, viz. (1) Landholding, (2) Irrigation sources, (3) Livestock holding, (4) Poultry birds holding, (5) Fish pond, and (6) Any other resource.

Results and Discussion

Table 1 presents the information on farming practices in the study area and adoption of farming practices and their integration of water chestnut cultivation and aquaculture in the Balasore district of Odisha. It reveals that planting of water chestnut is undertaken during early-June to early-July. The depth of water between 0.5 m and 1.5 m is considered favourable for cultivation and higher yield of water chestnut. A layer of 15-20 cm soft mud reach in organic matter at the bottom of water body favours better growth of water chestnut with less turbidity and near neutral pH. The farmers plant 3-4 young seedlings loosely tied at the bottom in a knot in the mud bottom of water with gentle push by toe maintaining the

Table 1. Impact of integration of water chestnut and cat fish (Magur) on farming practices in seasonal waterlogged areas of Odisha (Farm size = 3.30±1.39 acre, N=35)

Farming practice	Farming situation before technology adoption				Farming situation after technology adoption			
	Area (acre) Mean±SD	Production (t) Mean±SD	Cost of cultivation (₹/acre) Mean±SD	Gross income (₹/acre) Mean±SD	Area (acre) Mean±SD	Production (t) Mean±SD	Cost of cultivation (₹/acre) Mean±SD	Gross income (₹/acre) Mean±SD
Paddy	1.65±0.87 (52.72%)	1.12±0.63 (56.25%)	4165±2409 (57.84%)	8118±4551 (56.06%)	1.63±0.86 (52.76%)	1.49±0.70 (46.98%)	6891±4106 (59.58%)	14057±6460 (45.96%)
Water chestnut	1.53±0.95 (62.09%)	5.23±2.31 (44.17%)	19794±9473 (47.86%)	50735±24451 (48.19%)	1.66±0.93 (56.02%)	6.45±2.70 (41.86%)	24000±11277 (46.99%)	68143±25079 (36.80%)
Fish	1.15±0.69 (60.00%)	0.22±0.15 (68.18%)	2324±1626 (69.97%)	6235±4308 (69.09%)	1.59±0.93 (58.49%)	0.58±0.27 (46.55%)	4914±2331 (47.44%)	21757±9983 (45.88%)

Notes: SD stands for standard deviation. The figures within the parentheses indicate coefficient of variance.

spacing of about 1.5 m × 1.5 m. About 4400 to 4500 bundles of seedlings (3-4 seedlings in each bundle) are required for 1 ha area. The farmers apply compost manure of about 7-8 t/ha to the water body during the last week of May or early June, before the arrival of monsoons. Although N:P:K fertilizers are recommended @ 40:40:60 kg/ha in three splits, the farmers in general do not strictly follow the recommended dose.

The environment suitable for water chestnut cultivation is also conducive for rearing of air-breathing fish, and farmers prefer to grow Magur (*Clarias batrachus*) species because of its relatively high market price (₹ 40/kg approx.) along with water chestnut. The identical habitat preference of water chestnut and Magur has provided an opportunity to the farmers for the integrated farming with better income. The farmers release the air-breathing fish (Magur) during mid-August when the water chestnut crop establishes itself with full canopy growth. The release of fish during the period of crop establishment may affect the crop growth. The farmers release the fingerlings of about 15-25 g mean body weight @ 7500-10000/ha after the establishment of the crop. Even though fish feed @ 3 per cent of mean body weight twice-a-day is recommended, the expensive nature of fish feed, does not allow the farmers to follow the recommendation entirely, they rather provide the feed as per their affordability and availability to reduce the cost of production compromising with the poor growth.

The farmers perceive that the fish (Magur) gets natural food from this integrated eco-system as the water chestnut provides huge detritus food, weed associated fauna, benthic organism and insects that reduce 25-30 per cent feed requirement. The co-production of Magur and water chestnut also reduces the problem of water chestnut beetle (*Galerucella birmanica*) as Magur being carnivorous consumes it. Thus, the coproduction system of Magur and water chestnut provides congenial environment for the fish in terms of natural food availability, water quality, benthic population structure, and lower degree of cannibalism. It also results in an increase in gross and net water productivity. The harvesting of water chestnut fruits is generally done during the months of November and December, after which the crop gradually decomposes and fish is also harvested.

The status of farming before and after adoption of the technology is presented in Table 1. It is revealed that integration of water chestnut (WCN) cultivation and fish (Magur) was adopted by the farmers in about 50 per cent area, while paddy crop was grown in rest of the area, though with low yield. Although there was not much change in the acreage of paddy, its production had increased. As the low lying areas are suitable for auto recruitment of native fish species and natural habitat of captured fisheries, few farmers used to capture fishes in a portion (1.15 acre out of 1.53 acre) of water chestnut growing area with relatively low fish yield.

The adoption of integration of Magur fish with water chestnut in most of the areas (1.59 acre out of 1.66 acre) provided more than double fish yield. The average production of water chestnut was increased by about 1.16 t/ha (from 8.55 t to 9.71 t) with additional fish harvest of 0.43 t/ha. The integration of aquaculture with water chestnut increased the average income of farmers by ₹ 33,000/acre as compared to pre-adoption situation. The total average income of the farmers from the farming was increased by more than 50 per cent after adoption of this technology. The variations among the farmers with respect to acreage, production, cost of cultivation and gross income were reduced after adoption of the technology, as reflected from the values of coefficient of variance.

The gross and net economic index of water productivity of the above co-production system evaluated by Roy Chowdhury *et al.* (2005), revealed the gross water productivity to be ₹ 5.20, ₹ 6.00 and ₹ 12.90 per cubic metre of water for water chestnut, fish, water chestnut+fish, respectively; the net water productivity reported to be ₹ 2.80, ₹ 3.40 and ₹ 7.90 per cubic metre of water for water chestnut, fish, water chestnut+fish, respectively. After the complete harvest of fish and water chestnut in December – January, the available water can be used for supplementary irrigation to crops like green gram, black gram in the adjacent fields that would further increase the gross and net water productivity up to ₹ 19.70 and ₹ 10.90 per cubic metre of water, respectively. However, in the present study none of the selected farmers had total holding at one place due to fragmentation; and therefore, they grow water chestnut + fish (Magur) in the seasonal waterlogged areas and cultivate paddy in the fields not affected by waterlogging problem. Thus,

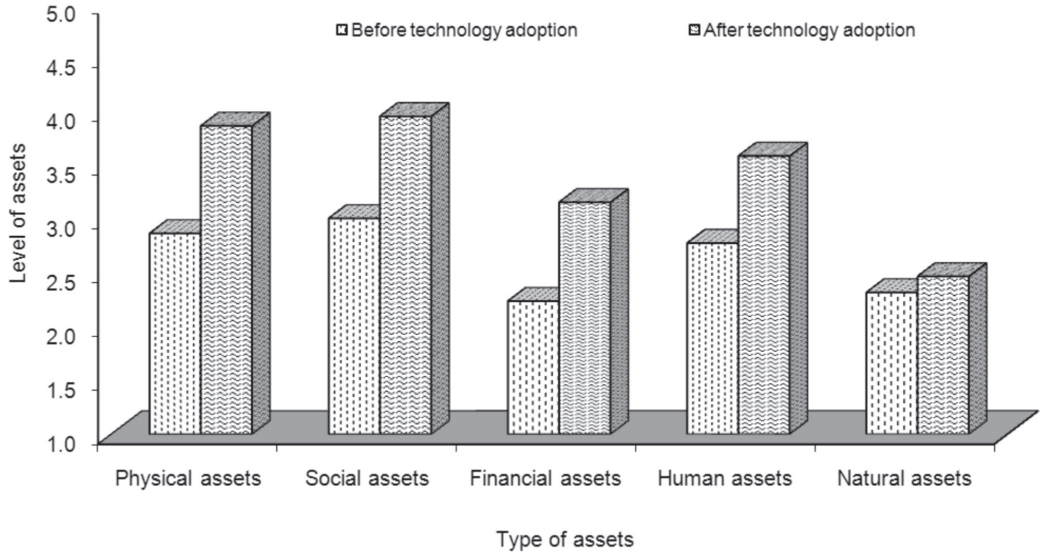

Figure 1. Change in average level of different types of assets measuring livelihood of farmers after adoption of water chestnut and cat fish (Magur) integrated farming in seasonal waterlogged areas of Odisha

they could not use the left-over water after harvest of water chestnut + fish by December-January to raise the pulse crops for providing supplementary irrigations.

The variables under five types of assets measuring the changes in livelihood of farmers were assessed on the basis of their responses on a 5-point continuum scale (minimum and maximum values being 1 and 5, respectively) and the mean values were derived for each type of asset. It is evident from the Figure 1 that there was improvement in all the five types of assets measuring the changes in the livelihood of farm families during post-adoption period. Four out of five types of asset holdings, barring the social asset, were found to be below average before adoption of the integrated farming of water chestnut and cat fish (Magur) culture technology. The gain was found maximum in the financial assets (41%), followed by physical assets (35%), social assets (31%) and human assets (29%). Except natural asset gain (7%), all other assets holding of farm families increased considerably and came at above-average level. The high improvements in financial and physical assets indicate the betterment of living as well as economic conditions.

The increased income on adoption of technology even motivated the farmers to invest and intervene further leading to the growth in physical and financial assets. Social recognition was also reflected with higher mean values of both social and human assets holdings of the farmers. The low growth in natural assets (land, water resource and livestock holding) was due to the fact that their growth generally requires a longer time as compared to other types of assets.

The overall standard of living of farmers was assessed through summing up of the mean values of all five types assets holdings of sample farmers before and after adoption of the technology. It is presented in Figure 2. A perusal of Figure 2 reveals that living standard of only 3 out of 35 farmers was above the average level prior to adoption of the technology, but after adoption of technology, 30 out of 35 farmers came above the average level of living. The mean value of overall standard of living of all the technology-adopting farmers derived through addition of the mean values of five assets, indicated it to be in the range of 10.60 to 15.65 during pre-adoption and it increased to 13.55 to 20.95 during post-adoption period (minimum and maximum values being 5 and 25, respectively).

Being a dynamic process, the livelihood diversification depends on many factors having spatial and temporal variations. This process of change varies from farmer to farmer and over the space and time (Ghosh *et al.*, 2011). Therefore, the adoption of any technology is not exclusive, but one of the factors influencing the changes in livelihood of farmers. The rural livelihoods are also wide-ranging (Ashley *et al.*, 2003). Both crop diversification and farm sector diversification lead to livelihood diversification influencing the rural economy; therefore, the adoption

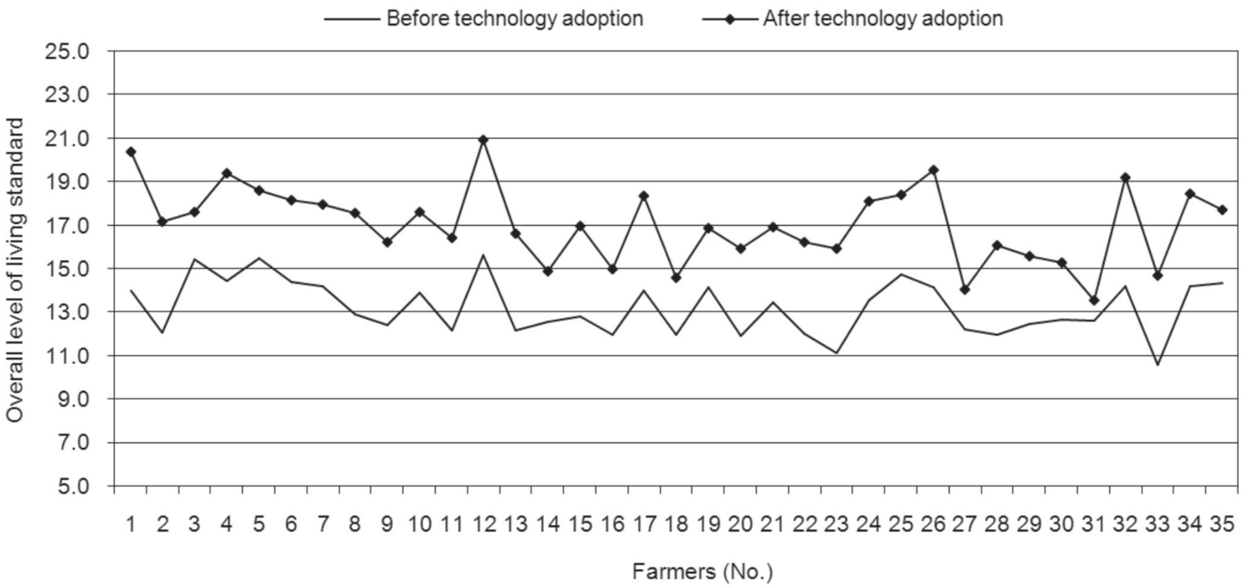

Figure 2. Overall standard of living of farmers before and after adoption of water chestnut and cat fish (Magur) integrated farming in seasonal waterlogged areas of Odisha

of appropriate agricultural technology holds the key for development of rural economy (Mehta, 2009).

Concluding Remarks

There is market demand for both cat fish (Magur) and water chestnut; therefore, growing water chestnut in combination with Magur could provide good income to the farmers of seasonal waterlogged areas in the Balasore district of Odisha. Moreover, options of post-harvest processing of nut to flour could potentially avoid distress sale of excess harvest as well as provided better market price. Growing fishes in isolated water bodies has always been vulnerable to theft/poaching and farmers are hesitant to invest in fisheries away from their homestead. The integration of water chestnut with it could offer a surface cover protection besides adding income. This shallow waterlogged areas of eastern India, where surface drainage is not possible, and water stagnates with depth of more than 0.50 m for a period of about six months, this technology is farmer-friendly and a cost-effective option.

In this study, the impact assessment of technology on farming situation and livelihood of farmers has been carried out covering a sample of 35 farmers adopting integration of water chestnut (WCN) cultivation and cat fish culture. The smothering effect given by water chestnut crop over water body could deter the pilferage of fish cultivated below. The potential of this technology has been reflected through the growth of overall farming system and provision of better earning and living to the small and marginal farmers of the waterlogged ecosystem. The integration could supplement fish feed requirement. Under the ICAR-CARE collaboration on "Dissemination of Inland Water Management Technologies", the developed package of practices for water chestnut cultivation has been adopted by "The CARE India" under their dissemination program in three tribal districts (Bolangir, Phulbani and Gajapati) of Odisha. The successful implementation of the technology has led to the spread of water chestnut cultivation technology in the tribal districts of Odisha.

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