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*Correct Citation :*

**Technical Bulletin No. R-40/PAT-26**

## Livelihood Improvement of Underprivileged Farming Community: Some Experiences from Vaishali, Samastipur, Darbhanga and Munger Districts of Bihar

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Published by the Director, ICAR Research Complex for Eastern Region, Patna-800 014, Bihar.
Laser typeset and Printed in The Composers Press, 2151/9A/2, Behind Shadipur Petrol Pump, New Patel Nagar, New Delhi-110 008. Tel.: 011-25707869; (M) 9810771160

## Introduction

The state of Bihar (located between 24°20′10″ N to 27°31′15″ N latitude and 83°19′50″ E to 88°17′14″ E) is the second most populous state of the country, with a total human population of 103.80 million and population density of 1102 persons/$km^2$, respectively (Bhatt *et al.*, 2011). A large section of the total population (53.5 %) lives below the poverty line (Planning Commission, 2012). The average size of the land holdings is very small, with marginal (< 1 ha) and small (1-2 ha) farmers constituting about 84.2 and 9.2%, respectively (Bhatt *et al*., 2011). The State is ranked lowest in the country in terms of per capita income. Out of the total 150 disadvantaged districts of the country, identified by the Planning Commission, 15 districts are located in Bihar. Agricultural development holds key to improve livelihoods in Bihar where over 85 per cent population depends directly or indirectly on agriculture and contributes 19 per cent to state GDP as against 14.5 per cent at the national level.

The state is endowed with rich natural resources, but its potential could not be harnessed in terms of improving agricultural productivity, poverty alleviation and rural livelihood improvement. The state has a total cultivable area of 6.64 m ha with a cropping intensity of 139.6%. Soils are mainly alluvial. Annual normal rainfall is estimated to be 1176.4 mm, with 80% of the rain occurring during four months of monsoon season (June- September), however, only 61% of the net sown area is irrigated. Annual replenishable groundwater resources of the state have been estimated as 28.63 BCM. With annual groundwater draft of 11.36 BCM, the stage of groundwater development is only about 43% (Central Ground Water Board, 2011). The frequent occurrence of flood and drought is also common phenomenon in the state, thereby, affecting agricultural production and rural livelihood.

The entire State of Bihar is divided into three distinct agro-ecological zones namely, North Bihar Plains/North West Alluvial Plains (Zone I), North Eastern Bihar Plains / North East Alluvial Plains (Zone II) and South Bihar Plains / South Bihar Alluvial Plains (Zone III). Four disadvantaged districts, namely, Vaishali, Samastipur, Darbhanga, and Munger were selected for implementing the project. The selected districts face the challenges of water resource development and management, frequent floods and water logging, and drought. Out of the four identified districts (Fig. 1), three districts, viz.Vaishali, Samastipur and Darbhanga

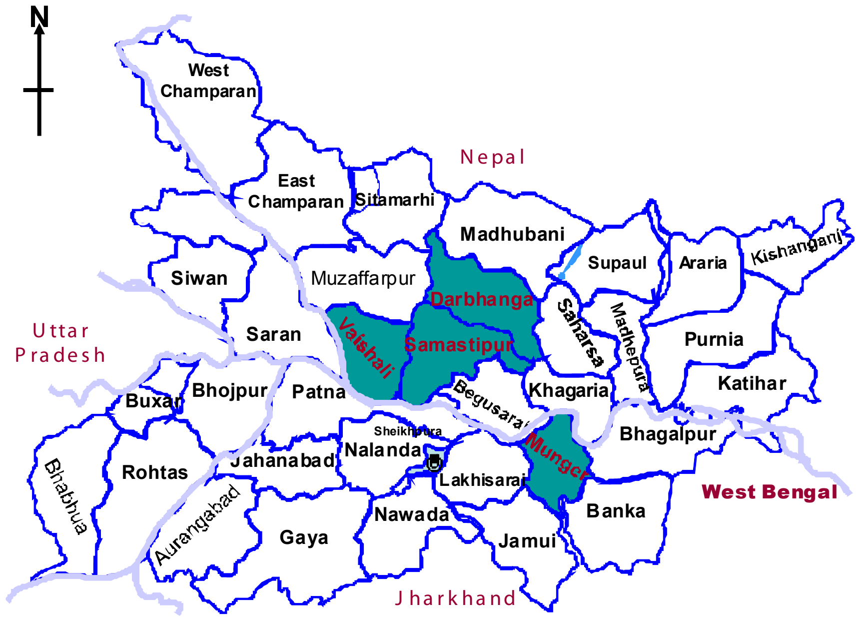



**Fig. 1. Disadvantageous districts of Bihar , selected for implementation of the project**

is the part of Northern Plains (Zone I) characterized by flood proneness, water logging and poor drainage with abundance of large water bodies like *Chaurs* and *Mauns* leading to low agricultural productivity and risk proneness. Livestock and fisheries contribute significantly towards livelihoods in these districts. Munger falls under Southern Plains (Zone III) characterized by erratic distribution of rainfall, drought proneness, rainfed farming, low agricultural productivity, and undulating/sloppy terrains including *Tals* and *Diaras*. The benchmark status of the selected districts, based on secondary data collected from different sources, are presented in Table 1.

Bihar is a true example of a 'resource rich state' inhabited by 'poor people'. Agriculture in the state is faced with major challenges like low productivity, regional disparities and low level of diversification of agriculture and allied enterprises. It is a 'high potential low productivity' state offering tremendous scope for evolving effective strategies for delivering rural services and for implementing local institutional arrangements to improve livelihoods of the rural poor through agriculture based activities. In this bulletin, an attempt has been made to present

**Table 1. Benchmark status of selected districts**

| Parameters | Districts | | | |
|---|---|---|---|---|
| | Vaishali | Darbhanga | Samastipur | Munger |
| Annual rainfall (mm) | 1234.7 | 1234.7 | 1234.7 | 1102.1 |
| Av. temp (°C) | 25.3 | 25.3 | 25.3 | 26.4 |
| Relative humidity (%) | 59-67 | 59-67 | 59-67 | 51-66 |
| Soil | Sandy loamy to loamy | Sandy loamy to loamy | Sandy loamy to loamy | Sandy loamy to loamy, clay some areas |
| Area ($km^2$) | 2036 | 2279 | 2904 | 1419 |
| Net sown area (000 ha) | 121 | 175 | 183 | 41 |
| Irrigated area (%) | 38.46 | 25.71 | 33.21 | 42.42 |
| Area under forest (000 ha) | **0** | 0 | 0 | 29 |
| Major crops | Rice-wheat | Rice-wheat | Rice-wheat | Rice-wheat |

location specific problems and constraints for agricultural development, and different technological options implemented for livelihood improvements of the farming community.

## Gaps Identified

The following technological gaps were identified in all the four districts of Bihar :

- Limited livelihood options, lack of integrated farming system models and other allied farm related income-generating activities for resource-poor farmers having small and fragmented land holdings.
- Economic scarcity of water and underutilization of the available water resources.
- Insufficient availability of quality and improved seed/planting material including fish seed in time and lack of cultivars tolerant to abiotic stresses.
- Improper nutritional management of feed and health of livestock, poultry, pig, goats and fish.
- Underdeveloped multiple uses of abundant water bodies incorporating fish, agriculture, horticulture and Makhana (aquatic crop) in irrigated and rainfed ecosystem.

- Poor utilization of flooded and flood prone areas, wetlands, *Chaurs* and *Diaras* for integrated aquaculture, agriculture and livestock.
- Lack of preparedness measures/strategies to counter the damage of natural disasters like floods and droughts by enhancing resilience of the farming systems and communities.
- Underdeveloped marketing mechanism and processing, poor value chain management of the farm produce like fruits, vegetables, makhana, maize and milk.
- Absence of agro-business and agro-industries in rural areas for employment generation and income enhancements.
- Lack of capacity and appropriate skills to undertake various activities for sustainable livelihoods.
- Lack of technological, policy and institutional innovations to reduce poverty and enhance competitiveness of small holders.
- Ineffective mechanism for technology dissemination for wider adoption of research findings and technologies, and commercialization of viable technologies through proper linkages.
- Lack of effective institutional arrangements for public - private partnerships to strengthen national and regional capacities for disseminating research results to public and private sector for information, products and services.

## Issues Addressed

Based on the technological gaps identified, and secondary data/information, expert opinion and discussion with stakeholders the following issues pertinent to agricultural development were identified:

- Livelihood of resource poor farmers with small and fragmented farm holdings.
- Low factor productivity and non-availability of suitable cultivars tolerant to abiotic stresses.
- Non-availability of timely and adequate planting material/seeds and agricultural inputs.
- Untapped potential of flooded, flood prone and waterlogged areas for fisheries and aquatic crops.
- Unexploited potential of commercialization of fruits and vegetables and lack of post harvest technology.
- Economic scarcity of water and underutilization of developed water resources.

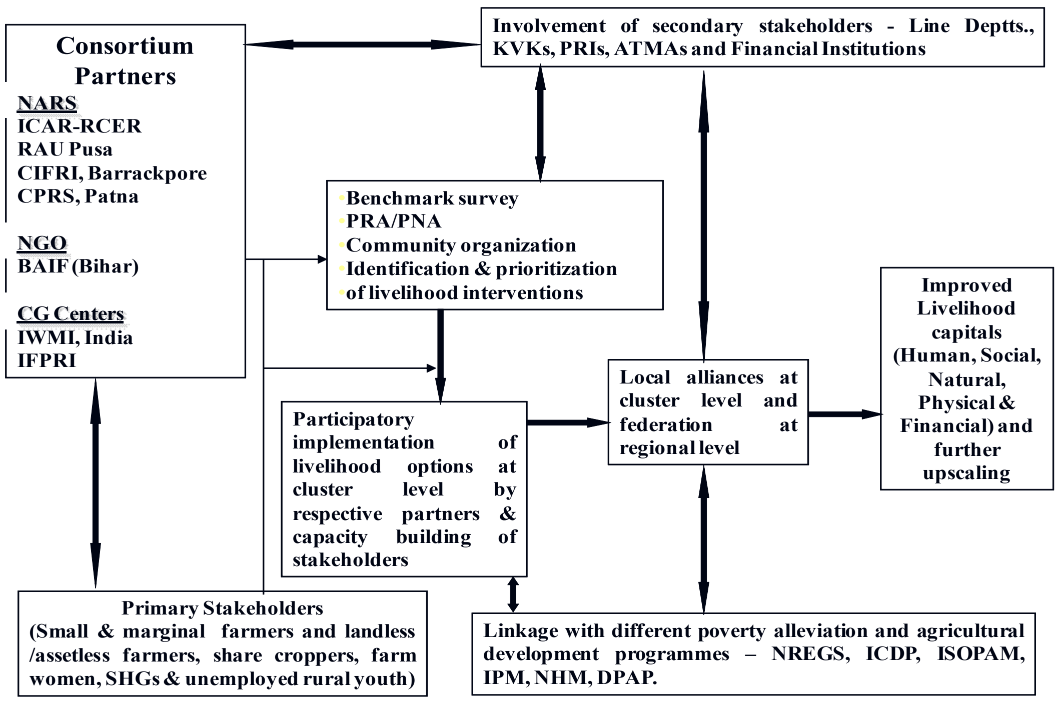
- Poor processing and marketing facilities for agricultural produce.
- Poor livestock and fish health with low productivity.
- Insufficient employment opportunities, poor skills and out-migration of rural youth.
- Inadequate extension and service delivery mechanisms and weak local institutions.
- Inadequate alliances, partnerships and linkages for research and development, technology dissemination, commercialization and upscaling.

Keeping in view the problems and potentials of agricultural development in the state, under NAIP (National Agricultural Innovation Project) Component- 3, an attempt was made to address farmers' centric livelihood security based on farmers' resources and perspective. The project envisaged to identify the target groups and to improve livelihood security of rural people through technology innovative farming systems encompassing wider process of social and economic change covering different stakeholders. The basic premise of the project was to generate knowledge and a better understanding of complex small-holding based farming system approaches in partnership with NARS (National Agricultural Research System), CG (Consortium Group) Centers, NGOs (Non-Government Organizations) and Civil Societies.The project was initiated with following specific objectives:

- Participatory development, demonstration and validation of location-specific Integrated Farming System models for livelihood improvement.
- Empowering resource poor farming community for enabling sustainable livelihood security.
- Building partnerships and linkages for livelihood improvement and upscaling.

## Methodology Adopted

The project was planned, developed and implemented in participatory mode in four selected disadvantaged districts of Bihar through a consortium consisting of ICAR-RCER, Patna; RAU, Pusa; CIFRI, Barrackpore; CPRS, Patna; IWMI, New Delhi; IFPRI, New Delhi and BAIF - a national level NGO. The community participation was ensured right from planning, benchmarking, and implementation to marketing and value addition, monitoring and impact assessment in order to make the project sustainable and acceptable to each section of society (including landless households). Special focus was given towards small and marginal farmers and landless /asset-less farmers, share croppers, farm women, SHGs and unemployed rural youth with limited skills. The schematic pathway for project implementation is depicted below:




## Current Livelihood Sources in Selected Districts

Out of the four selected districts, Darbhanga is flood prone district. Prolonged land submergence compels farmers to take photosensitive tall rice varieties with poor productivity (1.07 t/ha) as well as late sown wheat (1.8 t/ha). A total of 78.5 per cent houses are *kaccha* and 66.3 per cent population is below poverty line. High population density and low availability of food grains (65 kg/head/yr) reflect on poor health of the population. However, stagnant surface water and ground water support a high yield of boro rice. Winter crops like maize, wheat and pulses are also cultivated. Aquatic crops like *Makhana* and *Singhara* are cultivated in significant area. The livelihood is based on agriculture and the income generated by migrant labourers, working in different parts of the country and abroad.

In Samastipur, rice-wheat is the major cropping system with higher variability in yield of maize, vegetables, fruits and fisheries. Sugarcane, potato and maize (seed production) and spices are the other cash crops produced in the district. A strong crop-livestock interaction also exists. Population density is high with a population density of 1175 per $km^2$. Crop, livestock and off-farm employment are the major sources of income. The total productivity of rice- wheat system is 3.2 t/ha. Food scarcity and employment opportunities are major challenges where only 33 per cent area is irrigated and large area is flood affected.

In Vaishali district, rice-wheat is the main cropping system, followed by fruits and vegetables. Poor productivity of rice (1.05 t/ha) and wheat (2.2 t/ha) is mainly due to poor access to the available water resources (economic scarcity) with rainfed agriculture in about 61.5% of the area, flooding, water logging and soil sodicity etc. Very high population density ($1332/km^2$) with 63 per cent population below poverty line is supported by 5.6 lakhs cattle population. The milk availability is only 49 kg/head/ yr. The livelihood is mainly supported by crops, livestock, and some remittances by the migrant laborers.

In Munger, plains, *diara (riverine lands)* and plateau areas exist in close vicinities. The rice-wheat system in the rainfed area (57%) with 3.5 t/ha productivity, coupled with 3.4 lakhs livestock population and off-farm activities of the district are major sources of livelihood. The large *diara* lands have poor productivity but high potential of winter maize and summer vegetable production.

Reducing poverty and improving livelihood in the rural and peri-urban areas of selected disadvantageous districts of Bihar, inhabited by vast population of the poorest of the poor, in spite of rich natural resource endowment will require the sustainable development of agriculture and allied activities. Hence, following activities were taken up in the selected clusters:

- Focus on integrated agricultural development approach based on innovative IFS (Integrated Farming System) models integrating multiple enterprises and multiple components including processing and value addition and connecting farmers to market.
- The project shifts attention from the generation of new knowledge to the ways in which knowledge that already exits can be put to productive use through commercialization of existing knowledge so as to reduce poverty.

- Focus on participatory action research for productive utilization of underutilized/unutilized land and water endowments through multiple uses for livelihood improvement.
- Establish village/cluster level Knowledge Centers and built-in linkages to foster better rural service delivery and marketing and encourage convergence of ongoing programmes for multiplier effects and harmonizing synergies.

Based on four years study in selected clusters following technological options were developed/ implemented.

## Integrated Farming System Model for Small Holdings/Marginal Farmers (Half Acre Model)

In the Eastern Region, a sizeable populationis categorized as landless and marginal, earning their livelihood as farm labourer or other means. They possess either a small land holding or only a small hamlet, and thereby facing lot of hardships to sustain their family. Under such situations, other options such as livestock rearing, backyard poultry/duckery/ fishery or mushroom farming along with agricultural crops is need of the hour to improve upon their livelihood. Various studies on integrated farming system revealed that integration of two or more components ensured sustainability in production, economic return, recycling of wastes and livelihood improvement to the farming community over any single component (Singh *et al,* 1993; Singh *et al,* 1994; Jayanthi *et al,* 1994 and Singh *et al,* 1997). Survey on farming system in the country as a whole revealed that milching cows and buffaloes, irrespective of breed and productivity, are the first choice of farmer as integral part of farming system. Integration of crop, fish and livestock with economic benefit and employment generation over agriculture alone was reported by several workers (Jayanthi, 1995; Jayanthi *et al,* 2003, Singh *et al,* 2004, Kumar *et al*, 2011 and Kumar *et al*, 2012). Integration of crop and fish with sustainable production and economic return over arable cropping in eastern India was reported by several workers (Sinhababu and Venketswarlu 1998, and Mohanty and Mishra 2003).

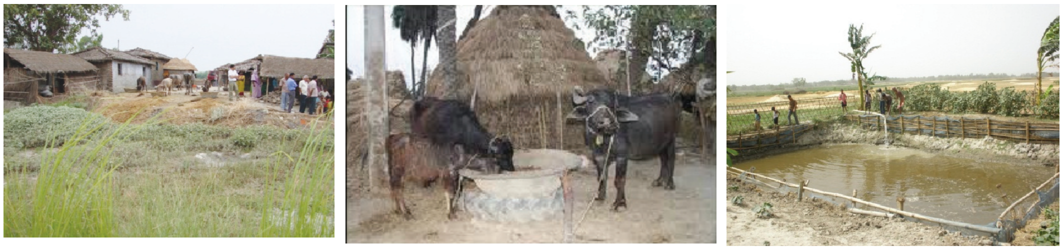
Farming system model has been developed and tested in farmers' field at Chakaramdas in the Vaishali district in participatory mode. This model included crop, livestock (buffalo) and backyard duck-cum-fish integration to obtain a sizeable income for the farm family having a small area of

**Table 2. Economic analysis of integrated farming system mode of food production system**

| Traditional System | Income from different Components (Crops+Fish+Duck+ Livestock) | Rice Equiva-lent Yield (REY) | Gross In-come (G.I.) (in ₹) | Cost of cultiva-tion (C.C.) (in ₹) | Net Income (N.I.) (in ₹) |
|---|---|---|---|---|---|
| Rice-Wheat (0.2 ha)<br>Gross Income = ₹ 11,400<br>Cost of Cultivation = ₹ 3,872<br>Net Income = ₹ 7,528<br>Labour employed= Family labour (58 mandays) | Crops<br>Rice-Wheat-Moong (0.07 ha)<br>Rice-Potato+Maize (0.07 ha)<br>Total (LR – 58 md) | 9.8 q<br>12.0 q<br>21.8 q | 9,800<br>12,000<br>21,800 | 4,200<br>5,100<br>9,300 | 5,600<br>6,900<br>12,500 |
| | Veg. & Fruits (Pond's bund)<br><br>(LR – 8 md) | Lady finger equivalent yield (L.F. E.Y.) 2.2 quintal | 2,200 | 1,144 | 1,056 |
| | Fish pond (0.04 ha)<br>Rohu+Common Carp + Silver Carp+Mrigal (300 fingerlings)<br>(LR – 15 md) | 140 kg | 9,800 | 2,064 | 7,736 |
| | Duckery (9+1) on ponds dike<br>9 female duck and 1 male duck.<br>(LR – 23 md) | 2250 egg. | 9,000 | 4,300 | 4,700 |
| | Livestock (2+2)<br>Area=0.01 ha<br>2 Buffalos & 1 calf<br>(LR – 74 md) | Milk Yield 2160 lit. | 52,840 | 22,254 | 29,586 |
| | Total | -- | 95,640 | 39,062 | 55,578 |

LR = Labour requirement, md = mandays, (1 md = 8 hrs)

2000 $m^2$. Out of 2000 $m^2$ area, different crops like rice/wheat/vegetable were grown in an area of 1400 $m^2$ and a pond was constructed in an area (low lying wasteland) of 200 $m^2$ for aquaculture purpose. The pond dike, about 1 m width, was used to grow vegetable and fruit crops. For better recycling of nutrients within the system, ten ducks and two buffaloes were also integrated in the model. Vermi-compost was also prepared with



**Fallow land selected for development** | **Crop-buffalo integration** | **Fish-duck integration**

**Fig. 2. Available resource based integrated farming system model, developed for small and marginal farmers**

the waste materials available within the system. Based on data collected from farmers' field and cost-benefit analysis showed six fold increase in income over traditional cropping system from the same area. The net return from the system was worked out to be ₹ 55,578/-. This model is suitable for popularization among small and marginal farmers having similar situations**.**

## IFS model by integration of Fish and Water chestnut (*Trapabispinosa natans*) with Makhana (*Euryale ferox* Salisb.)

Makhana (*Euryale ferox* Salisb.) cultivation is popular in North Bihar. It is an emergent floating macrophyte, commercially grown in a dozen of districts in the littoral parts of the flood plain wetlands of North Bihar. Makhana is naturally grown nutritious dry food and contains carbohydrate (76.9%), protein (9.7%), fat (0.1%), moisture (12.8%), calcium (20 mg/100 g), phosphorus (90 mg/100 g) and iron (1400 mg/100 g). In flood prone areas of North Bihar, besides makhana, water chestnut is equally popular among the fisherman communities and it grows abundantly in the eutrophic, stagnant freshwater bodies. The water chestnut fruit mainly contains carbohydrate (65-75 %), protein (13.4%), fat (0.8%), minerals (3.1%), phosphorus (0.44%) and iron (0.0024%) on dry weight basis. These aquaphytes are cultivated as a cash crop and provides nutritional and livelihood security to sizeable section of the populace involved in aquaculture operations. Makhana and singhara are widely utilized in India as non-cereal diet and having great demand on the occasion of festivals and ritualistic fast. Traditionally, makhana seeds were harvested as a mono-crop from makhana ponds. After harvesting of makhana, some air breathing fishes *viz*., Magur *(Clarias batrachus)*, *Singhi (Heteropneustes fossilis)*, Kawai *(Anabas testudineus)*, Garai *(Channa punctatus*), Trash fishes (*Trichogaster fasciatus*, *Puntius* sp.) etc. as wild fishes are also being harvested by the farmers without introducing the seeds of these fishes. Hence, there was need to develop suitable technologies for integration of makhana, fish and other aquatic crops in a system mode for enhancing water productivity as well as income of the farmers.

For enhancing water productivity, technology was developed by integrating fish and singhara with makhana in the water bodies. This technology not only enabled multiple uses of water, but also helped in generating the additional revenue and maximizing the net profit per unit area as compared to the conventional method of sole cultivation of Makhana. The different practices followed for Makhana + Fish + Singhara system were: (i) timely cleaning of pond; (ii) removal of carnivorous fishes and application of mahua oil cake (@ 2.5 t/ ha); (iii) transplanting and gap filling for optimization of crop density (@ 10,000 plants/ha); (iv) delineation of10% of the total water body area as refuge area (Fig. 3); and (v) integration of different carp species seed (@ 5000 numbers/ha as fingerlings of 10-18 g). Half of the seeds of different carp species of Rohu, Catla, Common carp, Mrigal were introduced in fixed ratio of 40:20:20:20 in March-April and rest half quantity of fish seed were introduced in the month of September after harvest of Makhana. The fishes were harvested twice : first in the month of September after the harvest of Makhana crop, and second in the month of December-January before the emergence of Makhana crop. Singhara was taken as third crop during the months of October -November.

Analysis of results from total water bodies of 50 ha (comprising of several ponds and 96 beneficiaries) exhibited fish, Makhana, and Singhara yield in the range of 0.18 to 0.4, 1.06 to 2.06, and 3.08 to 8.8 t/

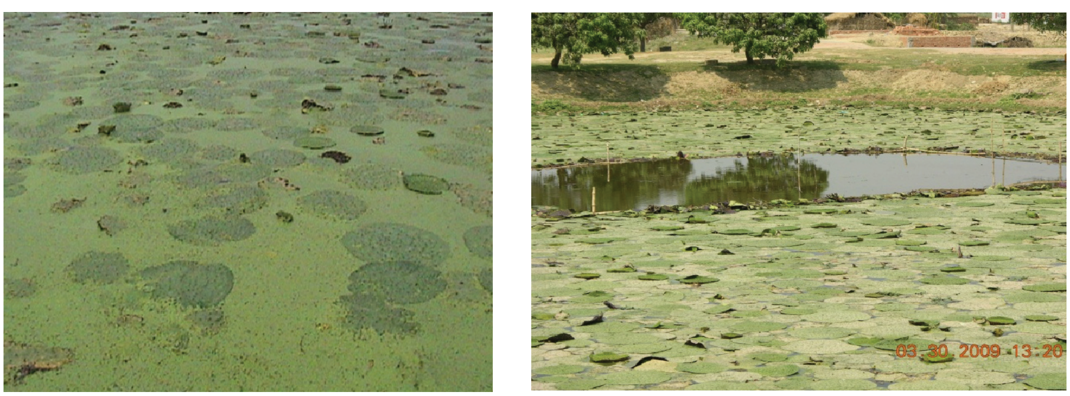



**Fig. 3. Traditional system (left panel) and integrated system (right panel) of makhana cultivation**

ha, respectively. Makhana as a primary crop showed a net profit of ₹ 20015/= per ha with an employment generation of 240 man days/ha per year. The fish as a secondary crop integrated in Makhana ponds showed an additional net income of ₹ 11806/= per ha with an employment generation of 24 man days/ha/year, whereas singhara nut, taken as tertiary crop, generated an additional net income of ₹ 13445/= per ha with an employment generation of 83 man-days per ha per year (Table 3). Thus, integrated system resulted in a benefit cost ratio of 1.94 as against 1.63 for the traditional system (makhana only).

**Table 3. Economic analysis of traditional and integrated system of makhana cultivation**

| | Traditional system | Integrated System | | |
|---|---|---|---|---|
| | Makhana only | Makhana | Fish | Water chestnut |
| Productivity (t/ha) | 1.40 | 1.33 | 0.27 | 3.70 |
| Cost (₹/ha) | 32, 693 | 31, 058 | 11, 323 | 13,445 |
| Net Income (₹/ha) | 20, 614 | 20, 015 | 11, 806 | 20,614 |
| Labour employed (man days/ha) | 247 | 240 | 24 | 83 |
| Benefit cost ratio | 1.63 | 1.94 | | |

## Integration of fish and horticultural components for improving the productivity of Makhana (*Euryale ferox* Salisb.) ponds

Traditionally Makhana is grown as a sole crop in perennial water bodies. In case of deeper water bodies, proper agronomic management of Makhana crop is not possible and therefore the yield is very low (1.0-1.2 t/ha). Further, due to deep standing water, the cultivation of other crops is not possible in these water bodies. For effective utilization of land and water resources, a system was developed by converting nearly 20% of total makhana pond area to raised platform/embankment of 1.5 m height along the pond sides while the remaining 80% is kept as such as a pond. The pond was used for Makhana-fish cultivation while the raised platform was used to grow the horticultural plants (Fig. 4). For this purpose, in the month of March-April, Makhana was transplanted at a spacing of 1.25 x 1.25 m in the well prepared pond. During the transplantation of Makhana, nearly 10% of total water body area was left as a refuse area at the centre of the water body. The 20% raised area was used to grow fruit plants like mango (Amrapali), guava, citrus, papaya, banana and some seasonal green vegetables so as to get round the year income through the system.

In this system, the average yield of Makhana and fishes obtained were 1.2 and 0.31 t/ha, respectively. The gross and net return from the system, including horticultural crops, were estimated as 1,19,246 and 50,439 ₹/ha., respectively (Table 4).

**Fig. 4. Integration of Makhana-fish-horticulture : a vaiable option for water logged areas of Bihar**

## Evaluation of promising high yielding varieties with improved agronomical practices in participatory mode

Farmers of Chakramdas and Jandaha clusters of Vaishali were using traditional varieties which were low yielding and susceptible to insect-pest and diseases. Most of the farmers used to broadcast seeds of crops in the field with unbalanced fertilizer doses (mainly urea) in their crops, which resulted in lowest yields. Rice-wheat cropping system was the most dominating cropping system and average yield of rice was only 3.5 t/ha while yield of wheat was hardly 2.2 t/ha.

A number of improved varieties of rice, wheat, maize, potato, mustard and moong were introduced in the Chakaramdas cluster to increase the yield and income per unit area with improved cultivation practices like line sowing, use of RCT (resource conservation technology) equipment like zero tillage, laser leveler, rotavator, double and triple cropping, water management practices, balanced doses of fertilizer application along with plant protection measures. The intervention was tried in an area of 88 ha involving 359 farmers. A total of 42 nos. of improved varieties were tested in the cluster and 3 best varieties for each crop were selected (Table 5) according to their performances (yield per unit area).

Adoption of improved verities along with better management practices, resulted in rice equivalent yield of 11.0 t/ha as against 5.7 t/ha by traditional varieties. The B/C ratio of the validated technology was 1.90

**Table 4. Comparative economics of different combinations of Makhana based farming system**

| Component combinations | Total area (Ha) | Total production of different components (t) | | | | Average productivity (t/ha) | | | | Gross value of all product / ha | Net return /ha |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Makhana | Fish | Water chestnut | Horticulture components (banana/ papaya) | Makhana | Fish | Water chestnut | Horti culture components | | |
| Makhana+Fish | 20.743 | 26.39 | 5.93 | -- | --- | 1.27 | 0.29 | --- | ---- | 95,700 | 37,660 |
| Makhana+Fish+ Horticulture | 2.181(M+F 1.745) (Hort. 0.436) | 2.08 | 0.53 | -- | 6.87 (banana) 12.6 (papaya) | 1.19 | 0.31 | --- | 31.5 (banana) 58.0 (papaya) | 1,19,246 | 50,439 |
| Makhana+Water Chestnut | 0.635 | 0.84 | --- | 7.1 | ---- | 1.32 | --- | 11.2 | ---- | 1,06,035 | 41,745 |
| Makhana | 7.362 | 9.74 | ---- | ---- | ---- | 1.32 | ---- | ---- | ---- | 72,765 | 25,725 |

which was much higher than the traditional practices (1.50) followed in the cluster (Table 6). The technology has generated an additional employment of 70 man-days/ha over 310/ha as the traditional practices. This technology provided an increase in crop yield by 50-80 per cent and technology adoption rate was 70 per cent in the area.

**Table 5. Best performing varieties of different crops**

| Crop | Best performing varities |
|---|---|
| Rice | Rajendra Sweta, Pusa 44 and PNR-381 |
| Wheat | PBW-343, PBW-373 and HD-2733 |
| Maize | Shaktiman (4) – QPM maize, Deoki and Laxmi (composite) |
| Potato | K. Pukhraj, K. Kanchan, Chipsona-1 |
| Rapeseed & Mustard | Pusa Tarak, Pusa Mahak, Ankur (Yellow Mustard) |
| Moong | Pant moong-1, H.U.M.-16, Pusa Vishal |

**Table 6. Comparison of traditional and improved practices at Chakramdas, Vaishali**

| Parameters | Traditional Practices | Improved Practices |
|---|---|---|
| Productivity : (Rice-Wheat) | Rice – 3.5 t<br>Wheat – 2.2 t | Rice – 6.8 t<br>Wheat – 4.2 t |
| Income (Average) (Rice – Wheat) | ₹ 57,000/- | ₹ 1,10,000/- |
| Net income (Average) (Rice – Wheat) | ₹ 19,960/- | ₹ 50,800/- |
| Labour Employment (Man-days) | 310 | 380 |
| Benefit / cost ratio | 1.50 | 1.90 |

## Identification of location specific cropping systems

In order to increase the production per unit area, one more short duration crop was added in the prevailing cropping system (Rice-Wheat) with improved agricultural practices like judicious use of fertilizer, side placement of fertilizer, line sowing and water management. A total of 12 cropping systems viz., Rice-Wheat-Moong, Rice-Winter Maize-Moong, Rice-Winter Maize-Vegetables, Rice-Potato-Moong, Rice-Potato+Maize-Moong, Rice-Potato-Vegetables, Rice-Winter Maize-Green Manure, Rice-Lentil-Moong, Rice-Tori-Moong, Rice-Pea-Vegetables, Rice-Mustard-Vegetales, and Rice-Tori-Wheat/Potato were demonstrated and evaluated in the farmers' field in an area of 42 ha covering 234 farming families. Out of 12 cropping systems, five best cropping system, namely, Rice-Winter

Maize-Moong, Rice-Wheat-Veg., Rice-Potato + Maize-Moong, Rice-Tori-Potato+Veg., and Rice-Wheat-Moong were selected for better sustenance to the farmers. The tested cropping systems were adopted by 60 per cent of the farmers of the cluster.

With the inclusion of one more crop, cropping intensity of the area increased from 200% to 264% which resulted in increase in farmer's income by 31 to 158% and employment up to 13.7%. Out of the five cropping systems tested, Rice-Potato+Maize-Moong and Rice-Tori-Potato+Vegetable cropping systems have given higher net income and B/C ratio (Table 7).

**Table 7. Performance of selected croppying systems**

| Parameters | Rice Equivalent Yield, t | | Gross Income, ₹ | | Net Income, ₹ | | Labour employed, man-days | | B/C (ratio) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Traditional Practices | Improved Practises | Improved | Traditional | Improved | Traditional | Improved | Traditional | Improved | Traditional |
| Rice- Wheat | 5.7 | 11.0 | 57,000 | 1,10,000 | 19,960 | 50,860 | 310 | 380 | 1.5 | 1.9 |
| Rice-Winter Maize-Moong | -- | 17.5 | -- | 1,75,000 | -- | 101,200 | -- | 396 | -- | 2.3 |
| Rice-Wheat-Veg. | -- | 16.6 | -- | 1,60,000 | -- | 85,600 | -- | 428 | -- | 2.1 |
| Rice-Potato+ Maize-Moong | -- | 23.8 | -- | 2,38,000 | -- | 1,40,770 | -- | 440 | -- | 2.4 |
| Rice-Tori-Potato-Veg. | -- | 23.5 | -- | 2,35,000 | -- | 1,40,780 | -- | 458 | -- | 2.5 |
| Rice-Wheat-Moong | -- | 15.5 | -- | 1,55,000 | -- | 80,800 | -- | 382 | -- | 2.1 |

## Backyard livestock and poultry farming for income generation of landless women

Livelihood development of resource poor farmers, particularly of women is a major issue in eastern region and can be improved through backyard livestock and poultry farming. Higher age at first egg laying, low production and low growth rate are the main constraints in backyard poultry and duck rearing with indigenous breeds, while purchase of concentrate and fodder are the other major issue for landless families to rear a dairy animal.

For the improvement of livelihood and household nutrition of economically poor farmers, 14 female and two male Black Bengal goats were distributed among 12 landless families. Goats were reared on common property resources (5-6 hours grazing) with feeding of tree leaves and local grasses. Similarly, 180 numbers of Gram Priya varietiy of poultry were distributed among 26 landless women @ 6 birds/ family for rearing in backyards under low input system. Birds were reared on scavenging system. Poultry started laying eggs at the age of 18.45 ± 0.25 weeks and body weight of 1.27 ± 0.03 kg. The fowl laid 148 ± 7.31 eggs per year under low input system. On an average, a family got 590 eggs per year and consumed 288 eggs and a family earned ₹ 1800 per year from one unit (6 birds). Mortality of birds was observed to be 15%, mainly due to attack by predators.

Forty three Khaki Campbell ducks were distributed among 10 landless women farmers @ 4 ducks/family for backyard rearing in the community ponds (Fig. 5). A low cost night shelter with bamboo, straw and mud was prepared. During day time, ducks were kept on foraging on community ponds, canal etc and left over food, grains were supplemented in the evening. Ducks started laying eggs at the age of 22.0 ± 1.42 weeks and body weight of 1.39 ± 0.08 kg. During one year, a female bird laid 165.0 ± 6.90 eggs under low input system. On an average, a family consumed 190 eggs per year and earned ₹ 1830 through sale of 305 eggs.

**Fig. 5. Backyard poultry and duck farming : a potential livelihood option for landless farming community**

## Pen Culture for Increasing Productivity of *Chaur* (Wetlands)

Realization of potential of wetlands, despite being the highly productive ecosystem, remains poor or suboptimal. Siltation and installation of various flood control devices in the link channel prevents auto-stocking of these resources with carp seeds resulting into low productive system.

Interventions like stocking enhancement with appropriate seed of various species of required size and quantity at appropriate time would be the key to fisheries management for yield and livelihood improvement in natural open water resource, particularly in *Chaurs* of Bihar.

Wetlands in Bihar, locally called *Chaurs*, have potential for high fish yield and can support livelihood and nutritional security of the people inhabiting the catchment. The *Chaurs* of Bihar, by nature, being shallow and low water holding capacity are however, vulnerable to vagaries of nature, such as flood and drought.Annual floods, presence of predators, uncontrolled growth of aquatic plants are the major environmental and biological deterrents to fish production leading to poor productivity and unsecured livelihood. Social factor such as multiple ownership of the resource and ignorance of technology are also responsible for low fish yield. In such ecosystem, short duration intervention such as seed production using pen culture technique is the most appropriate, simple and inexpensive technique for enhancing water productivity and improvement of livelihood.

Pen culture is a technique of culturing aquatic organisms in a secured enclosure while maintaining a free exchange of water. A pen is "a fixed enclosure with sides of netting or bamboo, in which the bottom is the bed of the water body". The pen may be square, rectangular or circular with size varying in the range of 0.05- 0.2 ha. Conventionally, the pen walls are constructed using split bamboo mats.

A strong and thick HDPE net with 3.3 feet height and 3 mm mesh was used for making under-water part of pen wall. HDPE rope of 4-5 mm and 3-4 mm thickness was tied to the bottom and head line of the net, respectively. Loops at an interval of 3-4 m in the foot rope were given for fixing with the cleft of the bamboo pole which was driven into the mud vertically. A thin net was stitched to thick net which were also provided with bottom and head line of 3-4 mm thick HDPE net.

The pen area was made free from aquatic macrophytes, predators and competitors. Liming was done @ 250-300 kg/ha depending on the pH of water. For producing advanced fingerlings of carp (>10 cm), fish fries (40-50 mm) belonging to Indian Major Carp like Catla, Rohu and Mrigal; and exotic fishes like Grass Carp, Silver Carp, Common Carp were stocked @ 2,50,000/ha. In addition to natural food, supplementary feed in the form of dry pellet or moist ball containing boiled mustard/ground nut oil cake, rice/wheat/maize bran, lentil/Bengal/black gram dust fortified with fish meal, soya meal, Vit-Min. mixture was used for better and faster growth of fish. Supplementary feed @ 5-10% of live weight was given in a tray or porous bag twice daily. Fish growth (length and weight) and health was monitored periodically (Fig. 6 and 7).

## Details of demonstrations/ adoption of intervention/technology

Three HDPE made pens (2 rectangular one circular) were installed at the project site for the demonstration of fingerling production. Realizing the potential of the technology, one progressive farmer in the neighbouring Mahua block installed two pens each of 0.1 ha in Telaur *Chaur*. A farmer group in neighbouring village Dulaur also adopted the technology in a big way and prepared a pen of 1 ha size for table fish production in *Baraila chaur*. Previous year's left over (stunted) seeds of Indian major carp and exotic carp (grass carp and silver carp) were stocked at a density of 12000/ha after prophylactic treatment of lime (200 kg/ha) during last week of February, when water temperature was recorded at 25°C. Excellent performance of the stocked fishes was recorded and a yield of 1.5 t was observed in 6 month grow out period (Fig. 8).

**Fig. 6.** ***Chaurs*, dominated by large predatory fishes (pre-adoption)**

**Seed stocking in pen** **Pen and cage culture** **Pre-stocking management (weed clearance)**

**Fig. 7.** ***Chaur* area rehabilitation by stocking of quality yearlings**

**Fig. 8. Pen culture in *Baraiila Chaur,* Bihar**

## Economics of technology/intervention

Economics of seed rearing in pen was worked out considering the cost price prevailing in Jandaha (Vaishali). Two crops of advanced fingerlings could be produced in the first year and three crops in the following years. The capital cost estimated for a pen of size 0.1 ha was ₹ 11,350/- and recurring cost of ₹ 35,720/- was involved for the 1st year. Minor repair and maintenance cost involving man and material will be additional cost in the 2nd and 3rd year. The net benefit of ₹ 29,688/- was earned in the 1st year while ₹ 58,957/- in the 2nd and 3rd year. The B:C ratio of pen culture operation for seed production was found to be 1.93.

## Grow-out culture of exotic catfish, *Pangasius sutchi* in polythene lined pond during the drought period

Fishermen of Jandaha cluster were earlier involved only in capture mode of fisheries. There was no practice of aquaculture. Income from this mode of fisheries was very low, uncertain and very difficult to earn livelihood. During drought years, all the open water resourses of the area are completely devoid of water, affecting the livelihood of fishermen. So appropriate technology was needed to provide job to fishermen during the drought periods.

As a measure of contingent plan for drought period, culture of exotic catfish, *Pangasius sutchi,* was attempted in the rearing pond (140 $m^2$) of the carp hatchery complex of NAIP project Site, Sakri Chaur, Jandaha (Vaishali). The pond bottom was dressed evenly and lining with low cost polythene (HDPE) sheet was done to prevent leaching loss. The plastic sheet was covered by a layer of 4-5 inch soil. Lime (3.5 kg) was applied @ 250 kg/ha and cow dung (140 kg) was used @ 10.0t/ha. The rearing pond was filled with pumped ground water. After 15 days, pond was stocked with fingerlings (210 no.) of *Pangasius sutchi*, which can sustain low water depth, high temperature and high stocking density. The stocking density was 15,000 fingerlings per ha. They were fed with a commercial floating pellet @ 5% of live weight. This innovation indicated encouraging results. After 6 months, 120 fishes (60% survival) corresponding to 61 kg were obtained. The final average length and weight of fish was 37.5 cm and 510 gm. Thus in a pond of one hectare, a total of 9000 fishes with a total weight of 4.59 t could be obtained (Fig. 9).

**Polythene lined tank prepared for rearing of exotic catfish**

**Stocking of exotic catfish**

**Harvesting of exotic catfish**

**Fig. 9. A view of exotic catfish (*Pangasius sutchi*) rearing**

## Seed Plot Technique for Potato Seed Production

Potato is the fourth major food crop after rice, wheat and maize in Bihar and occupies about 5% of the net sown area. Being a short duration crop, it has special significance as it gives exceptionally high yield per unit area, energy and protein to sustain burgeoning population and ward off hunger and malnutrition and providing food and nutritional security to ever increasing population. Besides, potato is a highly remunerative cash crop. Potato processed products also have very good demand in the market. Hence, scientific cultivation of seed and production of processing grade potato have a significant role in enhancing the socio-economic status of the farmers. Shortage of quality seed is, however, recognized as the single most important factor inhibiting potato production and productivity. Seed village concept needs to be adopted for multiplication of potato seed by providing breeder seed and scientific technological inputs. Considering this, demonstration of seed plot technique for quality seed production was carried out at Chakramdas cluster of district Vaishali.

### Details of demonstrations/ adoption of intervention/technology

Potato was grown in 2 ha area in Chakramdas village with variable plot sizes each year. Upto 2012, seed production was undertaken in 8 ha area involving 114 small and marginal farmers. Sowing was done within prescribed period of 25$^{th}$ October to 10$^{th}$ November. Well sprouted whole tubers were used for planting. Fertilizer application was done in furrows. Nitrogen @ 150 kg/ha was applied in two split doses, half at planting and half at earthing up time. Full dose of phosphorous @ 60 Kg and potassium @ 80 Kg/ha was applied at planting time. Soil insecticide like Thimet 10 G @ 10 kg/ha was added along with fertilizer mixture at planting time and @ 7 kg/ha at earthing up (30 days after planting). Initial earthing up at planting was moderate to help in early emergence. Light irrigation after planting was applied which helped in quick emergence (this is generally avoided by the farmers). Roguing was done at least three times at 25-30 days, 50-60 days and before dehaulming. Use of systemic insecticides as foliar spray in the first week of January was carried out to check the damage caused by aphids. Irrigation was stopped one week before dehaulming. Dehaulming of crop was done by 20$^{th}$ January to avoid infestation and thereafter, sorting and grading was done before seed treatment. Seed treatment with 2.5% boric acid was carried at a relatively cool place. Treated seed, bagged in hessian bags, were kept in cold storage by 15$^{th}$ March (Fig. 10).

**Sprouted tuber for planting**

**Potato seed crop**

**Rouging of diseased plants**

**Seed treatment with boric acid**

**Fig. 10. Potato seed production through seed plot technique**

### Impact of technology/intervention

A total of 203.2 t of foundation seed was produced in a span of four years. The average yield of seed was about 25.4 t/a. Part of the produce was sold after harvesting @ ₹ 800-1000/q and the remaining kept in cold store for further sale and use as planting material during next season. The average net returns of ₹ 1,94,000/ha were obtained from the seed crop.

## Agro-Technique for Production of Processing Grade Potato: A Success Story

There is tremendous scope of potato processing since the quality of potatoes produced in state is of high quality because of the inherent climatic advantage. Ideally potatoes for chip making should have more than 20% dry matter and sugar content below 250 mg per 100 g fresh weight. Potatoes produced in Bihar successfully qualify for these parameters. In 80% of potato growing areas of the state, planting of crop is done after 3rd week of November after harvesting of paddy. This results in exposure of potato crop to late harvesting around late February to mid March. The relatively warmer night temperatures during late phase of crop growth and crop maturity results in more accumulation of starch thereby more dry matter. Such favourable temperature conditions also cause accumulation of lesser reducing sugars. The over production and glut situation can be meaningfully addressed by diverting the produce to processed potato chips. This will arrest the downfall of prices and thus protect the interest of farmers.

## Description of technology

Potato varieties developed and released exclusively for processing purposes are Kufri Chipsona-I, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Chipsona-4 and Kufri Himsona which have excellent chip colour and productivity (32-34 t/ha) compared to other cultivars of the region. Planting was done at wider row spacing of 67.5 cm and plant to plant spacing of 20-25 cm. Higher dose of fertilizers were applied for increasing the longevity of the crop and also to increase the size of tubers. The dose of nitrogen, phosphorous and potassium was 270, 80 and 150 kg/ha, respectively. Duration of crop was 100-110 days. Application of irrigation was stopped 10 days prior to harvesting. The harvesting was done when the skin of tubers get matured. After harvesting tubers were kept in heaps in cool place for curing of skin. The produce was sorted and graded as per the requirement of chip/french fries.

## Details of demonstrations/ adoption of intervention/technology

For use of improved agronomic practice for cultivation of processing potatoes, a total of 117 small and marginal farmers were selected. The crop was grown in 2 ha area in variable plot sizes each year and an area of 6 ha was covered in three years. Potato varieties Kufri Chipsona–1, Kufri chipsona 2, Kufri Himsona and Kufri Kanchan were used for demonstration. The farmers were imparted with the knowledge of scientific agro-practices for growing of above varieties through live demonstrations and made aware of the important steps of potato cultivation (Fig. 11).

## Impact of technology/ intervention

A total of 194 tons of potato was produced from 6 ha area in three years. The average yield of processing variety was 32.32 t/ha, giving a net return of ₹ 1,66,000 /ha. An employment of 400-450 mandays/ha was also generated for the cultivation of seed and processing potato in the area.

**Fig. 11. Processing variety (K. Chipsona-1) of potato in farmers' field (left) and its various products (right)**

## Development of IFS Model for Maun Areas

The flooded and flood prone areas are characterized as tal, diara, chaur and mauns in North Bihar. Mauns or oxbow lakes are cut off portions of meandering rivers. These lands offer great potential and challenge for their productive utilization through appropriate farming system including fisheries following multiple water-use and farming system approach. For productive utilization of maun land in the Samastipur district, a sugarcane-fish based farming system model was developed and demonstrated.

Three hectare maun at Kalwara of Rosera, District Samastipur was converted into fish pond by making two dams on two sides with outlet-inlet facility. Total 6 ha land was used and comprises of 52 beneficiaries. On pond dyke, mango (Amrapali, Maldah and Mallika) was planted and pigeon pea was taken as intercrop. High yielding Sugarcane varieties such as BO-147, COP 9702, COLK 97184 for seed production was also introduced. Thirty thousand fingerling of common carp was added into the reshaped 3 ha fish pond which yielded 1.2 t and fetched ₹ 2,04, 000/= to farmers by selling fish @ ₹ 170/kg (Table 8, Fig. 12).

**Table 8. Economics of fish production in the Maun area**

| Parameters | Traditional | Improved practice |
|---|---|---|
| Productivity | 58.82 kg fish/ 3 ha | 400 kg fish/ ha |
| Income (₹) | 10,000/ ha | 68,000/ ha |
| Labour employed (mandays) | Nil | 87 mandays/ha |
| Cost/ Benefit Ratio | 1:1.5 | 1:16 |

**Fig. 12. Three hectare Maun of Rosera reshaped for fish production (above) and establishment of high density mango orchard on pond dykes (below)**

## Income Generation through Mushroom Production

### Brief description of innovation

Mushroom can be an alternate income generating activity for the landless women. The intervention was adopted in three villages (Bhadurpur, Thahra Gopalpur and Malpur) in Pusa cluster by 160 landless families. Eight Farmers Interest Groups (FIG), comprising of 20 landless women from three villages were formed. The groups were given on and off campus training for Oyster & Button mushroom production. The FIGs were also trained for bamboo bed formation in three tier, compost formation, casing and picking techniques after flush of mushroom.

### Comparative performance

On campus and off campus training on mushroom production to 3 women FIGs, enabled each member of the group to practice Oyster and Button mushroom production in a common mushroom hut (40′×30′) at each selected village. Each women of the group produced 50 bags of oyster, which enabled them to earn ₹ 3150/- per month by selling the mushroom @ ₹ 70/kg. By selling button mushroom @ ₹ 100/kg, each woman of the group earned ₹ 1350-1570.

Engagement in mushroom production also led to employment generation @ 135 mandays/yr/household which resulted in slowdown in migration of women labours. Based on training and practice, the leadership in some of the FIG also emerged who took the lead to act as master trainers & women FIGs increased from 20 to 58 in Thahra, and 22 to 82 in Bahadurpur, indicating the entrepreneurship development in women folk. Some of the women leaders called herein as Mushroom leaders Sudha and Gayatri had established a spawn production lab with knowledge &support gained under the project (Table 9 and Fig. 13).

**Table 9. Economics of mushroom cultivation**

| Parameters | Production and profitability |
|---|---|
| Productivity | Oyster- 700-800 g/kg substrate (straw)<br>Button- 120-180 g/kg compost |
| Income (₹) | 3150/month per women by Oyster<br>1530-1630/month per women by Button |
| Labour employed (mandays) | 135 mandays/yr/household |
| Cost/Benefit ratio | 1:4.2 |

## High Value Vegetable Cultivation Under Multitier System

High value vegetable cultivation under three tier systems was introduced at Bahadurpur and Thahra of Pusa Cluster. Under this system, three models were introduced and farmers were able to grow three different vegetables on the same piece of land at a time (Table 10). In this system, bamboos and nylon strings were used to make 6′ high frame to support tendril/stem of climbers like bitter gourd, pointed gourd and pumpkin etc. Crops like Amranthus, Okra, Elephant foot yam etc were grown in the lower portion (bottom layer). At the middle layer, crops such as Okra, Cow pea and Cucumber are cultivated.

**Table 10. Three tier model used for high value vegetable cultivation**

| Model | Upper | Middle | Lower |
|---|---|---|---|
| I | Bitter gourd (Palee) | Cow pea (Pusa Komal) | Elephant foot yam bean |
| lI | Pointed gourd (Dandari) | Cucumber (Kareena | Okra (Parbhani Kranti) |
| III | Pointed gourd (Dan-dari) | Okra (Anamika) | Amranthus |

**Fig. 13. Different steps of mushroom production during off Campus Training (Malpur village) (Top), boiling of straw for sterilization (middle) and beneficiaries with oyster mushroom production at their home (bottom)**

Realizing the benefit of multitier system, the farmers started growing other vegetables like sponge gourd, bottle gourd etc. along with palak, dhaniya and tomato. The net monetary return of ₹ 3,60,000/- from Model I, ₹ 2,29,300/- from Model II and ₹ 2,25,100/- from Model III have been realized (Table 11 and Fig. 14).

**Table 11. Comparison of traditional and three tier method for vegetable cultivation**

| Parmaeters | Traditional practice | Improved practice | | |
|---|---|---|---|---|
| | | Model I | Model II | Model III |
| Productivity | Bitter gourd / Pointed gourd (yield 1.25-1.50 t/ha) | Upper 27.3t/ha + Middle 12.0 t/ha + Lower 35.0 t/ha | Upper 19.5 t/ha + Middle 13.5 t/ha + Lower 11.3 t/ha | Upper 20.3 t/ha + Middle 12.1 t/ha+ Lower 7.7 t/ha |
| Net income (₹) | 45,000 -50,000 /75,000-1,00000 | 3,60,000/- | 2,29,300/- | 2,25,100/- |
| Labour employed (mandays) | 180 | 580 | 580 | 580 |
| Cost-Benefit ratio | 1:1.28 -1:1.57/ 1:1.5 -1:2.00 | 1:3.78 | 1:3.22 | 1:2.53 |



Vegetable production system

Guava with pheromone trap

Low cost polytunnels

Mango tree with pheromone trap

**Fig. 14. Multitier production system in the farmers' field**

## Income Generation through Vermicompost Production

The vermi-compost production was carried out in different types of pits, i.e., bamboo made pit and concrete pit. The pit was filled with partially decomposed (30-45 days) cow dung and organic waste mixtures in the ratio of 3:2. The optimum temperature (< $35^{o}C$ ) and moisture (65-75 % W/W) favours the decomposition process. Suitable strains (*Eisenia foetida*, *Eudrilus eugeniae*, *Perionyx excavatus*) of earthworms @ 1500-2000 numbers per cubic meter of waste were used.To avoid rain and wind, a polythene sheet or temporary shed at a height of about 5 feet above the ground was used to cover the pit (Fig. 15).

At three villages of Pusa block, a total of 105 vermicompost pits of 4 mx 1 m x 0.75 m were constructed. In each cycle, 700 kg vermicompost is being produced with annual production of 2100 kg per pit. A total of ₹ 8400 was earned per pit per year with input cost of ₹ 1800 per year

**Training on vermicompost**

**Construction of bamboo pit**

**Low cost brick vermipit**

**Vermipit with vermicompost**

**Fig. 15. Different steps involved in vermicomposing**

and cost benefit ratio of 1: 4.66. Total employment generation per pit per year was recorded to be 53 mandays.

## Improvement in Milk Yield Through Crossbreeding and Fodder Production

In Munger district of Bihar, farmers were raising mostly Non-Descript (ND) indigenous cattle and buffaloes which were yielding very less quantity of milk (1-4 kg/d or less than 1500 kg/lactation). Farmers were dependent on local bulls for insemination which resulted in inbreeding problem and thereby poor milk yield. Moreover, there was acute shortage of green fodder in the area which influenced adversely the milk production. Traditionally, local varieties of Jowar and Maize were cultivated as green fodder for feeding of cattle and buffalo. Since, yield of these fodders is low (35.0-40.0 t/ha), it was not sufficient to accomplish the nutritional requirement of livestock round the year in spite of the fact that round the year availability of green fodder is necessary to increase the milk production as well as to minimize the expenditure on fodder and thereby the cost of milk production.

In order to increase the family income by producing surplus milk, an attempt was made to bring awareness among farmers about the importance of crossbreeding for genetic up-gradation, and production of high yielding green fodder for balanced feeding. For this purpose, 55 small and marginal household/families were identified in two villages of Munger district and crossbred cows were provided partly with project support (₹ 10,000/ family) and partly with their own contribution. For production of green biomass, planting material of Sudan and Hybrid Napier (BHN 10 variety) was provided to the farmers (Fig. 16).

As a result of introduction of crossbred cows and feeding of green fodder, the milk production increased from 1-4 kg/d to 8-10 kg/d beside improvement in the age of 1$^{st}$ calving from 46 months to 28 months. By the sale of surplus milk, a family earned ₹ 14000 to 24000 per year from a single lactating crossbred cow. A family also earned ₹ 10000 to 15000 by the sale of female calf. However, disposal of male calf had a problem.

Due to introduction of two varieties of high yielding fodder, i.e., Sudan and Hybrid Napier, total green biomass yield increased from 240.0 t/ha to 447.5 t/ ha per year. The yield of BHN 10 and Sudan was recorded as 130.0-150.0 and 100.0-120.0 t/ha, respectively. So far as economics of fodder is concerned, a farmer can earn ₹ 18000 to ₹ 32000 per ha per year.


**Crossbred cow rearing at the project site**

**Sudan cultivation at farmer's field**

**Growth of BHN-10 in farmers' field**

**Fig. 16. Crossbred cattle rearing and quality fodder production for higher milk yield**

## Improvement of Black Bengal Goats through Selective Breeding

During the pre project period, farmers were acustomed of raising Black Bengal goats of lower body weight and reproductive efficiency. The poor performance of this breed was mainly due to continuous inbreeding. To avoid this problem, superior quality (higher body weight) bucks were distributed among farmers.

To avoid the inbreeding problem in the existing stock, 22 superior quality (higher body weight and reproductive efficiency) goats were selected from Bankura district of West Bengal and distributed among 35 farmers in 3 villages of Munger district. All the goats were vaccinated against infectious diseases and dewormed at 4 months interval. After one year of intervention, a family earned ₹ 1872 per year through sale of kids. Average meat production per goat was recorded at 8-10 kg at the age of 16 months (Fig. 17).

### Outcome/impact of the technology

(1) 169 kids born through selective breeding.
(2) Total meat production of 1690 kg/yr was gained worth ₹ 1.96 lacs.

**Fig. 17. Distribution of Black Bengal goat among farmers**

## Formation of Farmers' Interest Groups for Sustainable Production System: A Success Story

In the year 2010, based on farmers' interest and needs, the groups were formed for rice-wheat seed production, fisheries, vermicomposting and mushroom production and mobilized in Vaishali and Jandaha cluster (Fig. 18). Most of the group members were marginal and small. One seed interest group of 13 members produced 5.4t and 4.1 t of rice and wheat seed, respectively, during the year 2011. Fishery interest group of nine members worked on the principle of division of labour. They apply feeds on 8 ponds on rotation basis. The group producing vermicompost earned ₹ 7500/ in the year 2011 from the sale of vermicompost. Presently, six farmers interest groups (two fishery interest group, two vermicomposting interest group, one mushroom interest group and one seed production interest group) are operational. Group members of these groups organise meeting at least once in a month to discuss the activities by the group members. The group provide loans to needy members either to meet out their urgent needs or for the purchase of agricultural inputs. A critical

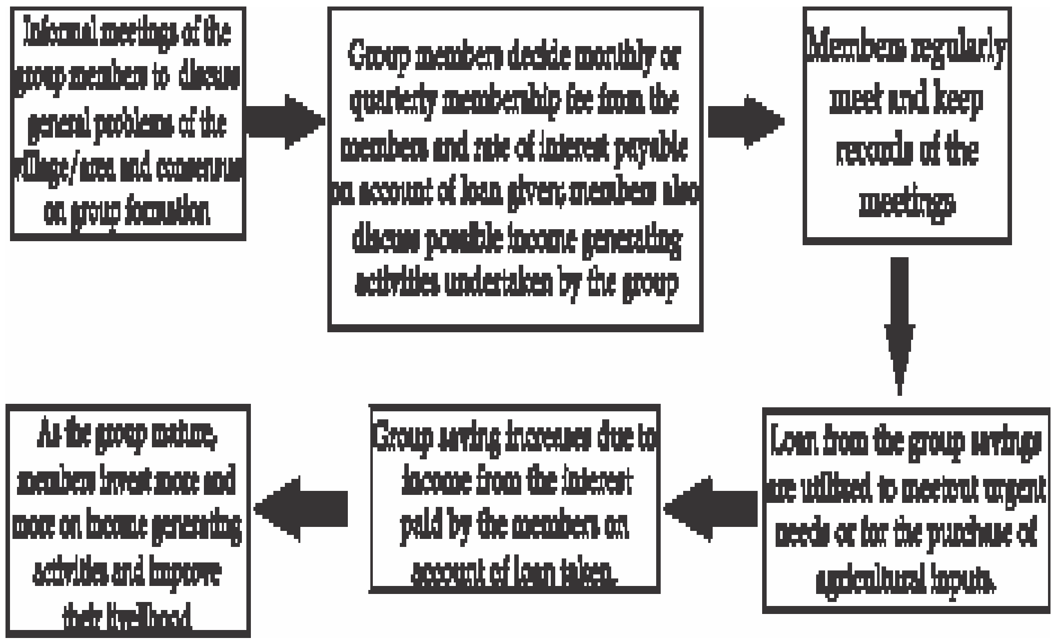



**Fig. 18. Group formation process**

analysis of flow of investment of savings by group members revealed that members invested 63 per cent of group savings in agriculture and allied activities indicating the members see agriculture as viable enterprises for increasing their income and livelihood (Table 12). Farmers of Vaishali and Jandaha cluster has established a deposit of 3.0 lakh as sustainability fund that has been created for post project sustenance of the project activities like maintenance of irrigation pumps, hatchery, village resource centre etc.

**Table 12. Impact of the various technologies implemented**

| Sl. No | Name of Technology | Area (or Number) covered under NAIP | Expansion in Area (or number) | Yield improvement | | Income ₹ /ha/year (or ₹/hh / yr, specify) | |
|---|---|---|---|---|---|---|---|
| | | | | Pre intervention | Post intervention | Pre intervention | Post intervention |
| 1. | Alternate income generation through mushroom production | 3 FIG each of 20 women group in three village | 562 | 0 | Oyster Mushroom 700-800 g/kg of subtract (straw) | 0 | ₹ 3150/ month/woman by oyster mushroom |
| 2. | Alternate income generation through vermicompost production | 3 FIG each of 20 women group in three village | 279 | 0 | 2100 kg/pit/year | 0 | ₹ 8,400/pit/ year |
| 3. | Three tier system of vegetable production | 72 | 220 | Bitter gourd 12.5-15.0 t/ha by conventional method | Model I- Upper 27.3 t/ ha+ Middle 12.0t/ha+ Lower 35.0t/ha, Model II- Upper 19.5 t/ha+ Middle 13.5 t/ha +Lower 11.3 t/ha, Mode lII-Upper 20.3 t/ha+Middle 12.1 t/ ha + Lower 7.7 t/ha | 45000/= and 50,000/= | Model I- 3,60,000/= Model II- 2,29,000/= Model III- ₹2,25,000/= |
| 4. | Reshaping of Chaur/Maun into fish pond | 03 ha | 3 ha (52 beneficiaries) | 176.46 kg/3 ha/yr. | 1.2 t/ 3ha/ year | 30,000/= | 2,04,000/= |
| 5. | Seed production of potato | 6.5 ha | 6.5 ha | 150.0 t/6.5 ha | 1.6 t/6.5 ha | 7,50,000/= @ ₹ 500/q | 21,12,500/= @ ₹ 1300/q |
| 6. | Varietal replacement for increasing productivity of different crops | 20 ha | 12 ha | Rice- 3.5t/ha, Wheat-2 .2t/ha, Maize-4.1 t/ha, Rape seed & Mustard-1.4t/ha, Moong-1.3 t/ ha, Lady finger-11.0 t/ ha Cow pea- Nil and Urd- Nil | Rice-6.8t/ha, Wheat-4.2t/ ha, Maize-6.8 t/ha, Rape seed & Mustard-2.2t/ ha, Moong-1.9t/ha, Lady finger-14.5t/ha, Cow Pea-9.5 t/ha and Urd-1 .1t/ha | ₹ 57000/ ha/year | ₹ 1,10,000/ ha/yr |

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|---|---|---|---|---|---|---|---|
| 7. | Integration of Makhana + Fish system in flood prone ecosystem | 50 ha | 96 beneficiaries | 1.4t/ha (Makhana only) | 1.4t/ha (Makhana), .27 t/ha (Fish), 3.7 t/ha (Water chest nut) | ₹ 20,614/ha/yr | ₹ 53,034/ha/yr |
| 8. | Seed plot technology for quality seed production of potato | 6 ha | 6.5 ha | 11.2 t/ha | 25.1t/ha | ₹ 25,000/ha/yr | ₹ 49,500/ha/yr |
| 9. | Cultivation of processing type potatoes | 6 ha | 2 ha | 11.2 t/ha | 28.6t/ha | ₹ 25000/ha/year | ₹ 42,500/ha/yr |
| 10. | Line sowing & earthen-up of maize | 68.5 ha | 15 ha | 2.4-3.2 t/ha | 3.2-4.8 t/ha | 19,600 | 30,000 |
| 11. | Line sowing of wheat | 44.25 ha | 8 ha | 1.6-2.4 t/ha | 4.0-4.8 t/ha | 21,000 | 48,400 |
| 12. | SRI Method of paddy cultivation | 59.75 ha | 16 ha | 1.6-2.4 t/ha | 4.2-4.8 t/ha | 23,000 | 51,750 |
| 13. | Cucumber cultivation | 8.75 ha | 2.75 ha | 4.0-4.8 t/ha | 6.0-7.5 t/ha | ₹ 19200 / ha/yr | ₹ 27000 /ha/yr |
| 14. | Introduction of cross bred cows | 55 hh | 14 hh | 2-8 lit/hh | 8-12 lit/hh | ₹ 22400/hh/yr | ₹ 36000 /hh/yr |
| 15. | Water resource management | 5 | 2 | 0 | 13.5 ha | 0 | 12,000 |
| 16. | Azolla farming | 10 hh | 5 hh | 0 | 0 | 0 | ₹ 4,320 /hh/yr |
| 17. | Green fodder cultivation | 5.375 ha | 2 ha | 300.0 t/ha | 450.0 t/ha | 3,000 | 4,500 |
| 18. | Introduction of Black Bengal goat | 139 Goat (22 hh) | 15 Goat (3 hh) | 0 | 25 | 0 | ₹ 1,872 /hh/yr |

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