# A Research Study on

# Socio Economic Benefit of Stream Tank Well Integration

# Involving Farmers Participation

## In Jhankarbahali, Budapada and Tangarjhuri villages of Western Orissa

## Final Report

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# 1. Introduction

## 1.1 **Background and justification**

Agriculture is the mainstay of the Indian economy as it accounts for about 16.1% of the GDP, 55% of the export and 65% of the employment opportunities (Economy watch-2010). Both industry and services depend strongly on the performance of agriculture, which provides raw materials, generates foreign currency for import of essential inputs and food for the fast growing population. Despite its importance for the national economy, agriculture is largely based on subsistence farming. The productivity of the agricultural sector is very low and lags behind the population growth rate resulting in food insecurity.

In the past few decades India has seen a sustainable growth in food production and incomes along with growing diversification both in consumption and production. Food security and sustainability our major goals to keep agriculture sector out of a danger zone seems to be have been fulfilled. But this feel good factor seems to be a myth as we see new and bigger challenges emerging in this most vulnerable sector. Share of agriculture in country's GDP has declined from 48.7% in 1950 to 24.4 % in 1996-97 and further 18.7% in 2007. Agriculture sector is the backbone of country's development and lifeline for 65 per cent of the population based in rural areas and approximately more than 58 percent of the population still dependent on agriculture for their livelihood. Besides this to achieve an ambitious rate of growth for the country of as high as 9-10% in the eleventh five year plan, the country needs a strong pull-up support to agriculture sector which should grow at least at the rate of 4 per cent per annum, all the more since in 2009-10 the growth in agriculture was merely 2.2% which is expected to go even negative next year.

To address this problem the Indian Government designed many programmes and strategy which aims to use agriculture as the base for the country's overall development. This strategy aims to enhance the productivity of small-scale farmers and to improve food security both in the rural and valley areas. One of the policies within this strategy is stimulate and/or support the development of small-scale irrigation. Thanks to the enabling policies, irrigated agriculture is expanding rapidly in those areas where there is access to irrigation water.

Sambalpur district in Orissa has three distinctive physiographic units such as, hilly terrain, plateau, ridges and valleys through plain table land. Sambalpur district experiences extreme type of climate with 66 rainy days and 153 centimeters rainfall on an average per annum. Most of the rainfall is confined to the months from June to October visited by south west monsoon but with long drought spell even upto 20 days at a stretch. The rainfall is highly uneven and irregular. The erraticity of rainfall and frequency of drought is obvious from the following table which depicts the rainfall in June, July and August of typical drought year, 1998 in three districts Bargarh, Sambalpur and Sudargarh adjacent to each other.

**Table-1: Erraticity of Monsoon Rainfall**

***Rainfall in mm.**

| Sl. No. | District | June | | | July | | | August | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Normal | Actual | Deviation | Normal | Actual | Deviation | Normal | Actual | Deviation |
| 1 | Bargarh | 218.7 | 181.8 | -16.9 | 469.6 | 284.4 | -39.4 | 430.9 | 209.1 | -51.5 |
| 2 | Sambalpur | 218.7 | 132.4 | -39.5 | 469.6 | 254.8 | -45.7 | 430.9 | 207.6 | -51.8 |
| 3 | Sundargarh | 250.9 | 123.4 | -50.8 | 480.2 | 219.7 | -54.2 | 458.2 | 204.2 | -55.1 |

The hilly terrain is predominant over 40% of the district mostly with tribal farmers owning small pieces of rolling land, aggregating to 100 – 200 ha in villages spaced in heterogeneous patches. Almost 50,000 ha out of the total arable land 1, 73,540 ha conform to this category. The peculiarity of the arable land is that the crop can only survive if water depth of the order of 10 to 115 mm is available at critical stages. Because the land is steep, this minimum supply in time and space is needed. In these areas conventional medium and minor irrigation schemes will not be effective because of long idle stretches and non-availability of storage sites.

The solution lies in identifying streams with good flow in the monsoon season but discharging the yield unutilized to larger stream and eventually to a river. These streams can suitability be blocked at rocky outcrops to lead the flow existing valley which flow through the small, yet fertile patches of arable land. In western Orissa natural tanks across valleys stove a part of the monsoon water from the feeding valleys which is only partially utilized for agriculture/ horticulture in the absence of a socio-economic awareness of the optimal pattern of utilization of that water by farmers who live and practice agriculture below the tanks. Essentially by capacity building and small technological intervention the existing tanks or few new tanks an effectively receive the unutilized water. The tanks in term would be able to meet the critical live saving supplementation to the arable land which otherwise suffer from acute scarcity during dry spells or when the monsoon records too early in September. The tanks would also be maintaining a high full tank level (FTL) which would allow seepage to the lower lands, where wells already exist but go dry in the absence of enough ground water recharge. This happens because the ground slope is as steep as 1 in 500 to 1000 causing almost 50% of the rain water rushing to the valleys as overland flows.

The challenge that agriculture faces in the coming years is: How to increase water productivity in the face of growing water scarcity and the limited availability of water for agriculture. Moreover, climate change may affect the amount of rainfall and its distribution. Therefore, it is important to evaluate the socio-economic performance of this surface water and ground water linked irrigation scheme which may contribute to (re)design of improved resource management options.

## 1.2 Problem Statement

The increased competition for water in the Western Orissa valleys puts a great pressure on the local hydrology and ecosystem. Tank water depletes in three ways, through evaporation, deep percolation and drawl for irrigation, of which: Evaporation cannot be avoided.

Percolation of water under the tank bed also cannot be controlled but the surface water lost through percolation can be utilized again as it recharges the ground water.

There is a high potential for ground water as a more dependable resource in the command areas of tanks. There is also a good scope to utilize this potential with a high degree of efficiency through integrated and conjunctive use. Ground water is a very valuable supplementary source of irrigation in tank ayacuts, where availability of surface water is constrained by monsoon rains.

So, the sustainability of irrigated agriculture is being questioned, both economically and environmentally. The majority of existing irrigation schemes are small, serving usually not more than 200 to 300 households. Many of these schemes are based on stream and river diversions and ground water wells, while some depend on small dams and perennial springs. Most of the schemes were designed and developed without the consent of the local communities. As a result, many of the small-scale irrigation projects have been operating below expected returns. The sustainability of small-scale irrigation projects depends on (operational) management. Many studies in India focus on technical aspects of irrigation schemes, also limited to conventional surface irrigation mechanism and very little is known of the socio-economic implications of irrigation development utilizing both the surface and groundwater as a synergy. Hence, there is a need for better understanding of the socio-economic functioning of stream tank well integration irrigation schemes, which could contribute to improvements in their performance and further scaling up. The aim of this research is to assess the socio-economic benefits of three community-based small- stream tank well integration irrigation schemes in Maneswar block of Sambalpur district, to identify operational constraints, and to identify options to improve their performance.

## 1.3 Research Objectives:

As extreme and recurrent drought (total absence of rainfall occur from mid-September to end of October) occurs subsistence cropping for the tribal farmers and protective agriculture can only be possible by demonstrating the process and effectiveness of tank/ well integration. The activity is largely a social group activity to improve water use efficiency by guidance on water need and how to meet it. The main objective of the study is therefore to ensure adequate protection of single crop, which otherwise may fail in Kharif season because of the failure in monsoon. With this study the current utilisation of the tanks is proposed to be studied and the performance evaluated for developing the integrated scheme.

The overall objective of this study is to assess the economic impact and sustainability of community-based small- stream tank well integration irrigation schemes in three selected study areas, i.e. the Jhankarbahali, Budapada and Tangarjhuri in Maneswar Block of Sambalpur District.

More specifically, the study aims to:

- ❖ Assess changes in household's socio-economic characteristics before and after implementation of the community-based small- stream tank well integration irrigation schemes.
- ❖ Analyze costs and revenues of cropping in all intervention areas.
- ❖ Identify the institutional arrangements for water management through community participation.

1.4 Research Hypothesis and research questions

Preliminary computation for water storage and utilization in Tank Well Integration. Average Monsoon rainfall over the area is 1100mm but varies in the range 600-1500 m In several valleys such as Jhankarbahali, Budapada, Kundebahal tanks varying in area was taken up for

a) Leading the water from the main valley (small perennial streams) to the tank for effectively receiving the overland monsoon flow upon minimal infrastructural improvement in the tank.
b) Improving the dug wells in their command to provide crucial supplementation to the end of Kharif to rice/ coarse cereal and for Rabi utilization (20% of light crops).
c) The incremental water availability/ vis-à-vis area to benefit will be tested for efficiency of the project.

The success of the scheme was to be inferred from empirical evidence from project areas.

Research questions:

- ❖ What are the changes in land holding size, number of livestock and farm implements before and after implementation of the irrigation schemes?
- ❖ What are the costs and benefits of irrigated crops in project areas?
- ❖ Is this kind of new technology (integration of both surface and ground water) works at field?

## 1.5 Organization of thesis report

Chapter 1 introduces the problem (problem statement), defines the objectives and specifies the research questions. Chapter 2 describes the study area and Chapter 3 explains the methodologies used for data collection, data analysis and it discusses the scope and limitations of the study. Chapter 4 presents relevant literature related to similar irrigation systems in India and other parts of the world. Chapter 5 presents the main results of the study and is the central part of the thesis. In Chapter 6 the results are discussed while Chapter 7 presents conclusions and recommendation for future development and up scaling of similar community based irrigation projects in the study area.

# 2. Description of study area

State: Orissa

District: Sambalpur

Sambalpur district lies between 20° 40' N and 22° 11' N latitude, 82° 39' E and 85° 15' E longitude with a total area of 6,702 Sq. kms. The district is surrounded by Deogarh district in the east, Bargarh and Jharsuguda districts in the west, Sundergarh district in the north and Subarnpur and Angul districts in the South. The district has three distinctive physiographic units such as, Hilly Terrain of Bamra and Kuchinda in the north, plateau and ridges of Rairakhol in the south-east and valley and plains of Sambalpur Sub-division in the south east. Sambalpur district experiences extreme type of climate with 66 rainy days and 153 centimeters rainfall on an average per annum. Most of the rainfall is confined to the months from June to October visited by south west monsoon. Mercury rises upto 47° Celsius during May with intolerable heat wave and falls as low as 11.8° Celsius during December with extreme cold. The rainfall is highly uneven and irregular.

Sambalpur district forms a part of North-West upland of Orissa, which is rolling and multiplying the ground slopes from a height of 776 ft. to a height of 460 ft. The district forms a part of the Mahanadi River basin. The Mahanadi, the longest river of the state, entered into the district in the north western border, where the famous Hirakud Multipurpose Dam Project is built. Other important rivers of the district are the Maltijor, the Harrad, the Kulsara, the Bheden, and the Phuljharan. The district has a total forest area of 3986.27 Sq. Kms. which is 59.46% of the total area of the district. Total land under cultivation in the district is 173540 hectares.

## 2.1 Physical characteristic of Area of Intervention

Three villages in Maneswar Block, Sambalpur District is covered in this project – Jhankarbahali, Budapada and Tangerjuri. The villages chosen for implementation of the Technology are deprived of any substantial irrigation facilities. The villagers practice rainfed agriculture and are located in drought affected area and as such loose crop every year. Economically backward, these villages have no alternative rather than to compromise with their vulnerability. As they get cudgeled through this sort of natural hazards and calamities, they need the assistance of the technology to come out of the state of vulnerability and live a dignified life.

## 2.2 Climate

Sambalpur district experiences extreme type of climate with hot and dry summer followed by humid monsoon and severely cold winter. The hot season commences from 1st week of March and lasts till the second half of June. In the month of May, temperature rises up to 46 and with 66 rainy days and 153 centimeters rainfall on an average per annum. Most of the rainfall is confined to the months from June to October visited by south west monsoon. Mercury rises up to 47° Celsius during May with intolerable heat wave and falls as low as 11.8° Celsius during December with extreme cold. The rainfall is highly uneven and irregular.

## 2.3 Agriculture

Land use is characterized by open wood land, annual crops, livestock grazing and some irrigated agriculture. Livestock, crops and forest products are the main sources of income for the farmers in rural pocket. Resource poor farmers (landless, few oxen and female headed households) earn money mainly from sales of NTFP items. During years most households depend on income from agriculture. The majority of the households engaged in conventional agriculture. Farm size and number of livestock are the main factors which determine the wealth status of farmers. Farm holding size ranges from 0.75 to 3 ha with an average size of 1.5 ha. The average family size is

5. Vegetable production is becoming the main source of income for farmers living around the cannel areas.

## 2.4 Crops

Climate and soil play vital role in Sambalpur agricultural economy. Paddy, pulses and oil seeds are mainly grown under rain fed conditions. The greatest proportion of the land is grown with paddy and grams. Though the area under agriculture increased over the period, the average crop yield remained very low. In addition to low and erratic distribution of rainfall, most farmers in the project villages are significantly constrained by available resources such as draught power and other agricultural inputs. The frequent droughts and high costs of the technologies (improved seeds, fertilizers and pesticides) causes that farmers are risk-aversive and reluctant to adopt new technologies developed for rain fed condition.

# 3. Research methodology and data sources

This study was carried out in Jhankarbahali, Budapada and Tangarjhuri, three small villages during 2009 to 2010.

The villages chosen for implementation of the stream tank well integration Technology, are deprived of any substantial irrigation facilities. The villagers practice rainfed agriculture and are located in drought affected area and as such loose crop every year. Economically backward, these villages have no alternative rather than to compromise with their vulnerability. As they get cudgelled through this sort of natural hazards and calamities, they need the assistance of the technology to come out of the state of vulnerability and live a dignified life.

## 3.1 Problem Analysis

Tank water depletes in three ways, through evaporation, deep percolation and drawl for irrigation, of which:

Evaporation cannot be avoided.

Percolation of water under the tank bed also cannot be controlled but the surface water lost through percolation can be utilized again as it recharges the ground water.

There is a high potential for ground water as a more dependable resource in the command areas of tanks. There is also a good scope to utilize this potential with a high degree of efficiency through integrated and conjunctive use. Ground water is a very valuable supplementary source of irrigation in tank ayacuts, where availability of surface water is constrained by monsoon rains.

## 3.2 The Implemented Technology:

The technology is very simple and an applied mechanics by our traditional farmers from very old time. It is to integrate surface water with ground water i.e. integration of Tank and Well. The main objective of integrated or conjunctive use of surface and ground water is to achieve optimal utilisation of the water resources and maximize agriculture production per unit of water. For a good agricultural production it is essential that the crop is supplied with requisite quantity of water at the various critical stages of its growth. Ground water lifted from wells for irrigation at some cost is better controlled, more productively used and more valuable than that from canals or tanks. With the new agricultural technology, its value has risen considerably.

The integrated use of surface and ground water can provide to the timely need of the plant during the water scarcity at the time crop reaches the sensitive stage. Often times the tank storage gets depleted by use, by conveyance and seepage losses and by evaporation and percolation.

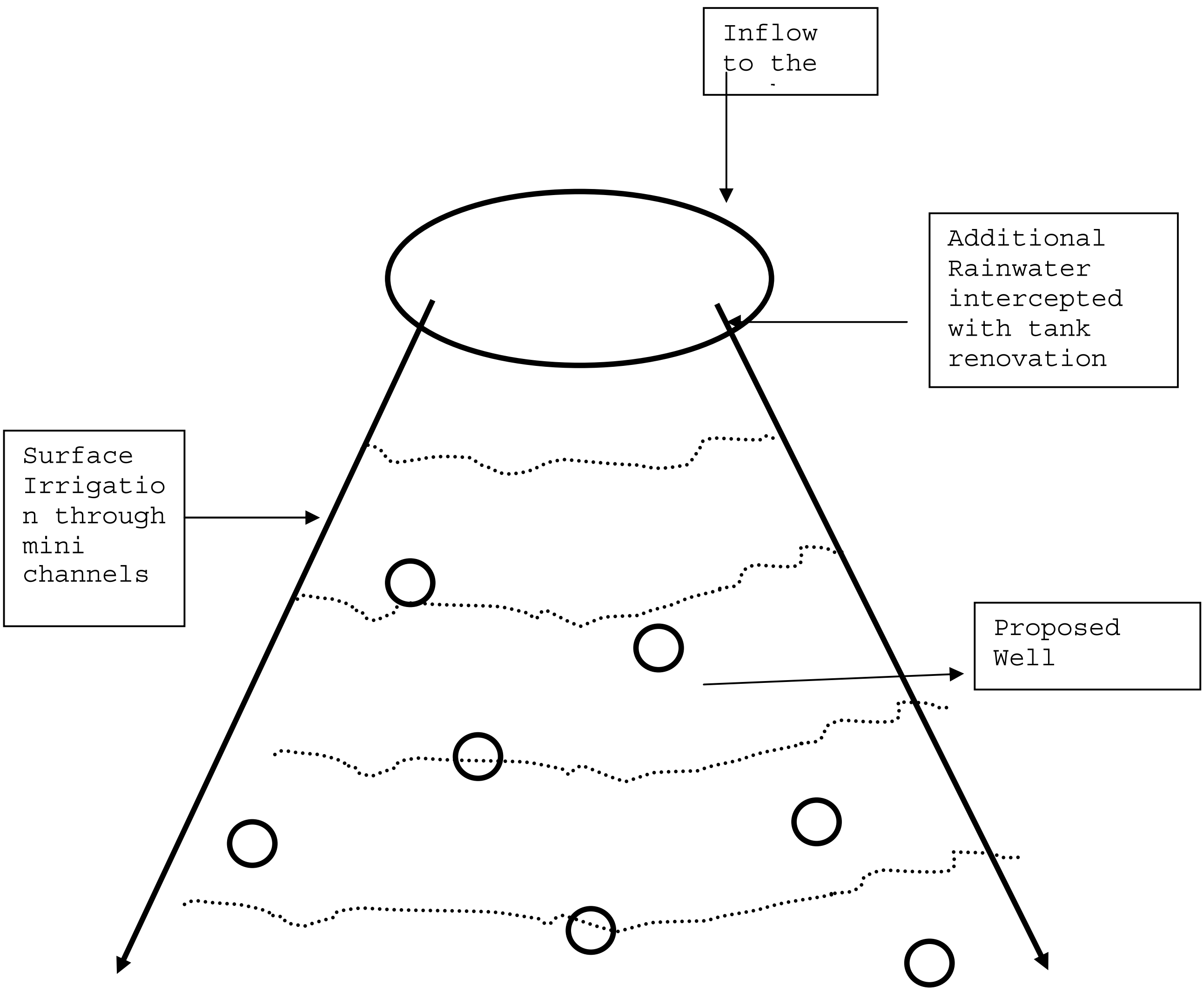
Ground water which is stored in sub surface becomes a ready source of irrigation then and it provides water according to the needs of the crop. Considering the potential of groundwater resources in the tank command which receives a good replenishment not only from rainfall and tank storage but also from the applied irrigation water, sinking community wells spaced appropriately in the tank command will be quite helpful to tide over water scarcity experienced during the end of the crop season and to provide a supplemental source of water for the poorer farmers who cannot invest on individual wells.

**Ground water in tank command as a common property resource**

Treating ground water in the command areas of irrigation tanks as a common property resource, often seen by the farmers as an attractive short term solution to water stress, which has several major long-term effects. For one, it has reduced the willingness of well irrigators to participate in tank maintenance. With a well they have their own source of water although, in fact, in most cases part or all of the ground water is due to recharge from the tank itself and a reduced short run economic incentive to help maintain the tank. Indeed, they even have the short run incentive of maximizing pumping rates in order to sell surplus water to their neighbours, often leading to monopoly sale of water. In the long run, of course, they are sawing off the limb they sit on, as degradation of the tank will ultimately affect their well yield. This privatization of common property resources provides a particular challenge to revitalizing village institutions for sustained tank managements.

Therefore it is suggested that, like tank water, ground water in tank commands should also be considered as a common property resource, as the ground water itself is mainly the percolated tank water. In areas of high ground water potential it will be advantageous to construct community wells in the tank ayacuts and practice conjunctive use of surface and ground water to stabilize tank fed agriculture and maximize crop production. Individual private wells benefit the richer farmers who can afford to invest on them, whereas community wells will benefit the small and marginal farmers who cannot make such investments.

A Schematic Diagram for Integration of Ground Water with Surface Water




## 3.3 Data collection methods

### 3.3.1 Primary data

Primary data collection was started with a reconnaissance survey of project villages and discussions with relevant governmental and other line departments. Primary data collection consisted of key informant interviews, semi-structured interviews, focus group discussions, direct observations and structured questionnaires for household surveys. Key informant interviews have been made with our experts, PRI representatives, village farmer's committee members to improve understanding of the institutional and technical functioning of the new projects, water management within the scheme, input use, resource use conflict resolution mechanisms, and to gain insight in their perception on the importance of irrigation for local food security and other issues like market conditions.

Semi-structured interviews were made with irrigation committee members, farmers, PRI electives, Block level facilitators, irrigation and agronomy experts of the state Agriculture University, Chipilima. Structured questionnaires were used for collecting quantitative and qualitative data from selected households. The household survey covered demographic characteristics, household socioeconomic factors, plot characteristics, water management practices, yields at plot level, and labor requirements. Focus group discussions were conducted in all three villages with selected elder community water user associations (WUA) members, president and Panchyat leader. Six and eight people participated in the focus group discussion in villages. The prices of inputs were from the office. Qualitative observations were made on soil conditions of irrigated plots, water use and deforestation.

### 3.3.2 Secondary data

Literature on socio-economic impact of small-scale irrigation, irrigation scheme management, and institutional arrangements for irrigation schemes, environmental regulation policies, and development plans of the State and other studies were collected from BISWA library, District Development Agency, District Agricultural Office, Minor Irrigation Office, Agriculture Collage, Chipilima, OUAT and Sambalpur University to supplement the primary data collected through the survey.

## 3.4 Method of data analysis

### 3.4.1 Calculation of costs and revenues

To estimate the financial costs and revenues of irrigated crop activities information was collected on the type of crops, crop yields, quantity of inputs (seed, fertilizer, fuel, labor, insecticides and fungicides) and input and output prices. Crop yields, output prices and labor data were collected at farm household level while input use and input prices were collected at District level. The local wage rate was used as the opportunity cost for labor. Results and data used for cost and revenue analysis were standardized for 0.25 ha in all project areas. Costs of pump operation and maintenance and equipment depreciation are not included in the analysis. The net revenue obtained by farmers at project level is calculated as:

$$NR = \sum_{i=1}^{4} \left[ y_{i,n} * p_{i,n} - q_{i,n} * r_{i,n} - l_{i,n} * w \right]$$

Where =NR Net revenue from sales of different crops

y= Total yield from crop i in one growing season (in kg/0.25 ha)

Pi= Sale price of crop i

i= Different crops

q= Quantity of different inputs used for production of crop i

l= Total amount of labor used for production of crop i (in man days)

r= Price of different inputs used for production of crop i

w= Local wage rate which is the same for all households and all crops

n=Different households

The average crop productivity per 0.25 ha in the schemes for the sample households is calculated as:

$$AP_{i,H} = \frac{\sum_{i=1}^{k} y_{i,n}}{k}$$

The average production cost per 0.25 ha in the schemes for the sample households is calculated as:

$$APC_{i,H} = \frac{\sum_{i=1}^{k} \left[ q_{i,n} * r_{i,n} + l_{i,n} * w \right]}{k}$$

Where, k = Total number of producers in each scheme

To study the socio-economic impact, various households socio-economic characteristics 'before and after' the implementation of new technology were compared. Data were collected on land holding size, number of livestock, number of farm tools and family food security conditions at household level 'before and after' the implementation.

### 3.4.2. Statistical analysis

The quantitative and qualitative data collected from the primary and secondary sources were analyzed using qualitative methods and descriptive statistics. Statistical Package for Social Sciences (SPSS) software was used for the analysis of quantitative data. Data collected from key informant interviews, group discussions and observations were qualitatively assessed. Finally, outputs of the statistical analysis were discussed using tabulation, cross-tabulation, means, frequencies and percentages.

### 3.5 Scope and limitations of the study

Because of budget and time constraints the study has the following limitations:

- Soils were not analyzed to assess the impact of irrigation on soil properties because of lack of time and lab facilities.
- The analysis is limited to 1.5 year due to the lack of time series data.

## <u>Literature Review: Studies on Integrated Use of Water Sources</u>

According to the studies conducted under the All India Coordinated Water Management Research Project sponsored by the Indian Council of Agricultural Research in Tamil Nadu, 30 percent of the applied irrigation water to the rice crop in tank command contributes the ground water recharge. During the main rice cropping season i.e, North East Monsoon period, the water table in the open dug wells rises to ground level and flows out of the wells by gravity on to the agricultural lands below. This water if utilized for irrigation can save that much water in the tank for later use. Lowering the water table during such periods would also prevent water logging of the cropped tank command area. Ground water is conserved more efficiently than surface water, since it is not subjected to evaporation as in the case of surface water.

As a part of an action research study conducted by the Center for Water resources, Anna University, Chennai, 'Integrated use of Surface and Found waters in an irrigation tank command' was compared with 'Surface water irrigation' alone during the post monsoon season, for crop yields obtained from irrigated rive. The total command area of the tank was 238.41 ha and there were 38 wells in the command area (19 open dug wells and 19 shallow tube wells) at the time of intervention. Five years after the tank was renovated, the number of shallow tube wells in the command area increased from 19 to 28 making the total number of wells to 47. The area irrigated by the wells was 94.37 ha during the post monsoon season. The breakup was 72.47 ha of area in well owners lands and 21.90 ha of area in the neighbors' lands. The neighbors purchased the water to irrigated their crops from the well owner. The others had access only to tank water and not to any well water. Of these, the integrated use of surface and ground water or otherwise was monitored in 40 land holdings covering a total area of 15.41 ha as detailed in the table below.

**Table: 1. Particulars of area cultivated, water used and crop yield of paddy grown by conjunctive use and by tank irrigation alone during the second crop season in the tank**

| Sl. No. | Particular | Farmers owning wells | Farmers who purchased water | Farmers who did not have access to well water | Total |
|---|---|---|---|---|---|
| 1 | Area cultivated (ha) | 8.27 | 4.05 | 3.09 | 15.41 |
| 2 | No. of land owners | 7nos. | 21nos. | 12nos. | 40nos. |
| 3 | Effective rainfall | 1.46 | 1.46 | 1.46 | 1.46 |
| 4 | Water released from tank (cm) | 42.34 | 64.46 | 65.66 | - |
| 5 | a. Well water used (cm) | 57.04 | 21.16 | - | - |
| | b. No. of irrigations given from wells | 4 to 9 | 1 to 6 | - | - |
| 6 | Total water used (cm) | 100.84 | 87.08 | 67.12 | - |
| 7 | Crop yield (kg/ ha) | 3705 to 4817 | 1482 to 3385 | 741 to 1853 | - |

**command.**

The research study clearly shows that the farmers who practiced integrated or conjunctive use of surface (tank) and ground water (well), benefited most by way of high crop yield ranging from 3.7 to 4.8 tons of paddy per hectare.

The farmers who did not have wells but still practiced integrated use by purchasing well water from their neighbouring well owners obtained crop yields ranging from 1.5 to 3.4 tons per hectare. The constraint from them was that they had to purchase water to overcome the moisture stress faced by their crops and so they could not fully meet the crop water needs during its critical growth periods.

The farmers who did not have wells and could access only the meager rain and tank water alone suffered most with a very poor crop yield of 0.7 to 1.9 tonnes per hectare.

The water use efficiency of integrated use of surface and ground water was also similar. The productivity of crops ranged from 36.75 kg to 47.77 kg of paddy per cm depth of total water applied to the crop for farmers who practiced complete integrated use. For the others who purchased well water and practiced partial integrated use, the crop yield ranged from 17.02 kg to 38.87 kg per cm depth of total water applied. For the third category who depended only upon rain and tank water, the productivity ranged from 11.04 kg to 27.61 kg per cm depth of water applied.

In another study made in six different villages, it was found that during a particular year (2000 - 01) the farmers could cultivate paddy crops successfully only in the ranks which had community/ individual wells, as they facilitated practicing integrated use of surface and ground waters. In the adjoining villages and tanks where there was no well in the tank command, the entire command area was not either cultivated for want of adequate surface water in the tank or wherever the farmers risked to raise a crop, it failed and they could not get any grain yield. The particulars of tanks, the no. of wells each tank had, the area cultivated and the crop yield obtained from them are presented in the table below. Here also the crop yield is very high ranging from 2.9 tonnes to 4.9 tonnes per hectare, mainly because of their practising integrated use of surface and ground water.

**Table: 2. Particulars of area cultivated with integrated use of tank and well water, no. of farmers benefited.**

| Sl. No. | Name of the Tank | No. of Community well | Area cultivated (ha) | No. of Farmers benefited | Crop yield/ ha | Comparison of crop yield with tank water only |
|---|---|---|---|---|---|---|
| 1 | Kumarasamuthram | 1+1 well | 9.31 | 17 | 55 bags/ ha | No yield |
| 2 | Malayappankulam | 1 | 8.90 | 25 | 70 bags/ ha (3 irrigation) | No yield in other tanks in the surrounding villages and tanks |
| 3 | Navithan Chinnandikulam | 1 | 0.86 | 7 | 75 bags/ ha | Not cultivated due to inadequacy of water |
| 4 | Varilovankulam | 1 | 1.17 | 5 | 45 bags/ ha | -do- |
| 5 | Nagamangalam | 12(IW) | 29.04 | 80 | 60 bags/ ha | -do- |
| 6 | V. Pudur | 1 | 7.41 | 22 | 65 bags/ ha | -do- |

1 bag = 65kg of paddy, IW = Individual Wells

Observations of the behaviour of the water table made just prior to the advent of monsoon season indicate that the tank storage can be advantageously depleted and adequate aquifer space is made available to receive the recharge from the next rains. Water required during this period for raising paddy nurseries which are scattered all over, can be met from the local ground water. The demands of crop in an area in the monsoon season should be covered fully by surface water supplies through the canal or tank system. During the dry months, irrigation coverage should be provided to the crops by ground water to the maximum extent possible. Such sequencing offers the advantage of quicker replenishment of ground water through recharge during the next rainy season by the help of surface irrigation network.

## 5. Results

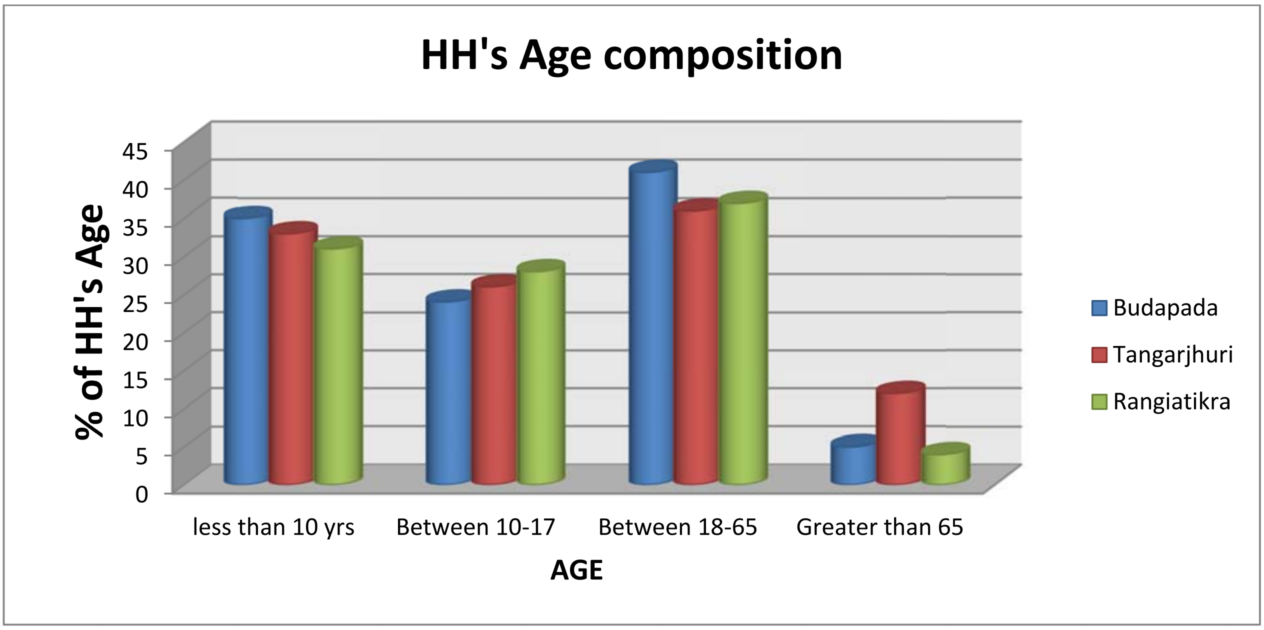
The first part of the analysis compares the household's socio-economic characteristics before and after implementation of the project in three selected villages. The second part focuses on the analysis of qualitative information obtained through qualitative household surveys, interviews and group discussions. It describes the institutional arrangements of the tank stream well integration project. The third and last part describes in short the environmental impacts of the project.

### 5.1.1 Socio- economic characteristics of the study areas

The total populations of three project villages are:

| Village | Number of Household | Male | Female |
|---|---|---|---|
| Budapada | 34 | 77 | 80 |
| Tangarjhuri | 46 | 100 | 106 |
| jhankarbahali | 85 | 202 | 190 |

Among these 35, 21 and 27 household heads are direct users of the new irrigation schemes in Budapada, Tangarjhuri and Jhankarbahali, respectively. From the selected household heads in both irrigation schemes 91% are male. The average family size of the sample households was 5 and 7.2 with a standard deviation of 1.9, 2.1 and 2.8 in Budapada, Tangarjhuri and Jhankarbahali project villages, respectively. The average family size in all three villages was not statistically significant at 5% probability level. The average family size of the Maneswar is 5. The mean age of the sample households was 35 and 44 with a standard deviation of 11.1 and 13.4 years at Jhankarbahali and Budapada, respectively. The average age of the sample households was highly significant at 5% probability level. The minimum and maximum age of the sample household heads was 23 and 60 in Budapada, 22 and 76 in Jhankarbahali and 31 and 68 in Tangarjhuri, respectively. Family age composition is shown in Figure 1.




Among others, the educational level of farmers is considered important for technology adoption. According to the survey, 4% can read/write, 58% have attended primary education and, 28% have secondary education in Budapada (Figure 2). There is no illiteracy among the respondents in Tangarjhuri, and they have had at least informal education. In Jhankarbahali village 29% of the respondents is illiterate, 15% can read/write, 48% have had primary education and only 8% have had secondary education suggesting a lower level of education.

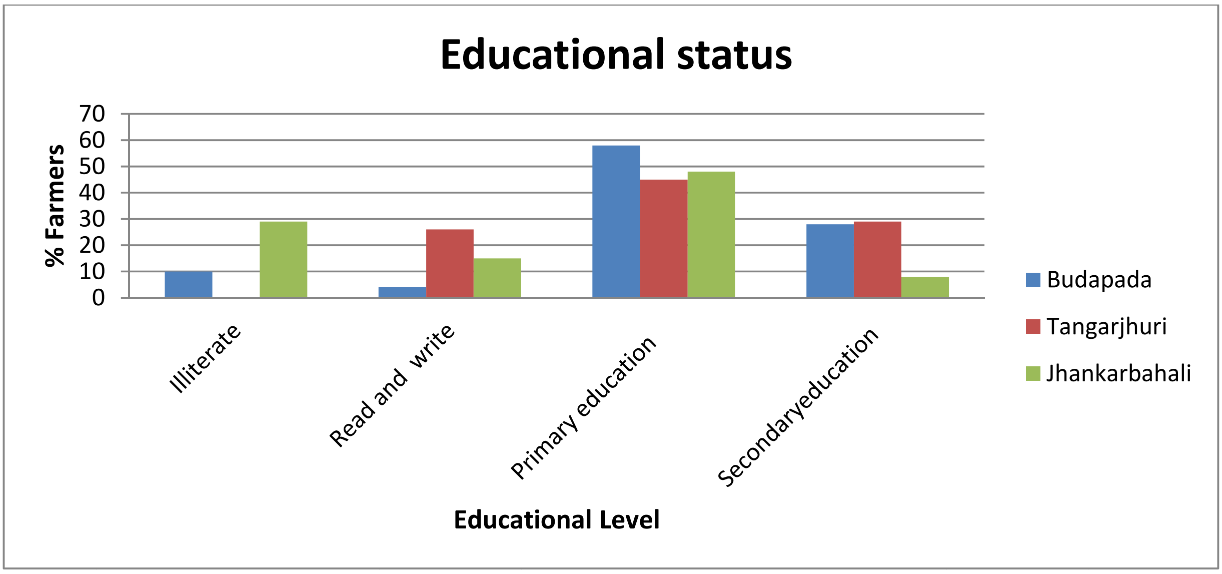



Figure 2: **Educational status of sample household heads**

### 5.1.2 Farming system, land holding size and cropping pattern

All farmers in project areas have mixed systems consisting of crops and livestock. The livelihoods of the farmers in both peasant associations depend on rain fed crop production and livestock rearing. In Tangarjhuri, only 20% of the farmers are member of the Stream Tank Well WUG and the land allocated for irrigated crop production is small compared to the total land size of the other villages. Except for paddy, which is grown both under rain fed and irrigated conditions all other cereals cultivated are produced under rain fed conditions only. The greatest proportion of the land is allocated to paddy. Onion, tomato, grams, green bean and cabbage are produced under irrigation.

Before implementation of the project, the farm sites were owned by few farmers. After establishment of the farmer's committee, its members agreed to exchange their land, i.e. those with more than 0.5 ha in the scheme sites exchanged their land with other members without land in the project areas. In Budapada, after this land reallocation the target site was divided into different small blocks and allocated to members on lottery basis to avoid possible conflicts due to differences in soil fertility and access to water and every beneficiary has a plot in each block, facilitating equal access to water and practicing crop rotation on block basis. However, in Jhankarbahali individual land holdings vary from 0.25 to 0.5 ha.

In project villages the land holding size increased after implementation of the irrigation scheme due to long-tem lease constructions. There are mainly two land lease systems in the area: The

first one is leasing land for short periods, i.e. less than 10 years and mostly for 2-5 years. The other one is long-term lease which is equal to selling of land, although formally selling is prohibited in villages. Farmers lease their land for longer periods. The size of the irrigated plots per household remained the same since implementation of the irrigation projects. Taking into account that irrigated crop production requires large amount of inputs (labor and agrochemicals) and to ensure equity, BISWA has designed this small-scale irrigation schemes with a maximum plot size of 0.5 ha.

| Ownership status | 2007-08 | 2009-10 | Changes in land holding |
|---|---|---|---|
| Own land | 2.67 | 3.61 | 0.49 |
| Rented in | 0.06 | 0.01 | -0.05 |
| Rented out | 0.49 | 0.36 | -0.13 |

**Table 2. Average land holding size before (2001) and after (2009-10) implementation of the irrigation project**

Table 3 shows average yields of different crops under irrigation in Budapada, Tangarjhuri and Jhankarbahali. All respondents in rotate crops (e.g. onion followed by paddy and tomato). However, the farmers do not follow strict crop sequences and there is no fixed schedule for planting the crop in all project villages. The farmers grow crops throughout the year based on the availability of water. They plant usually paddy in April and June, onion in December, July and August; green bean/ cabbage is mostly planted in January, while tomato is planted in April.

**Table 3. Yield ranges in** Budapada, Tangarjhuri and Jhankarbahali

Implementation of the irrigation schemes has increased the cropping intensity per year in all study villages (Table 4). Before farmers were dependent on rain fall and only one crop per year was grown**.**

| **Crop type** | **Once per year** | **Twice per year** | **Thrice per year** |
|---|---|---|---|
| **Onion** | **23** | **65** | **12** |
| **Tomato** | **46** | **42** | **12** |
| **Paddy** | **92** | **8** | **0** |
| **Green bean / cabbage** | **77** | **23** | **0** |

**Table 4. Cropping intensity in Budapada village**

### 5.1.3 Livestock holding

Major animal types in all villages are cattle, goat, and sheep. Oxen are used as draught power for ploughing and threshing, manure for fuel and for fertilizer. The economic contribution of livestock to households is milk and meat. Sheep and goats are also used as a source of cash income in time of need. Bullocks are widely used to transport agricultural products, fuel wood, and water and to transport agricultural products to the markets. About 16, 23 and 43% of the sample households did not have cattle, oxen and goats in project areas before implementation of the project, (Table 5). After implementation of the scheme these numbers decreased to 12, 4, and 39% respectively.

The mean number of animals in Budapada was higher than in Jhankarbahali before implementation of the irrigation schemes (Table 6). But after implementation the number of animals per household increased in Jhankarbahali whereas it decreased in Budapada. The farmers in Jhankarbahali gain more than in Budapada from irrigation and therefore they are able to invest more in livestock. There were no statistical significant differences in the number of animals before and after implementation of the projects. However, the reported numbers of animals by farmers are likely underestimated because farmers are generally reluctant to tell the size of their herd as they present their capital. So, the actual number of animals might be more than the survey result in the irrigation schemes.

| Type of livestock | **Holding category** | **Before implementation of project** | | **In 2009-10** | |
|---|---|---|---|---|---|
| | | **Budapada** | **Jhankarbahali** | **Budapada** | **Jhankarbahali** |
| **Cow** | **0** | **15.4** | **14.8** | **11.6** | **22** |
| | **1-5** | **69.2** | **59.2** | **61.6** | **63** |
| | **6-10** | **15.4** | **24.1** | **23** | **15** |
| | **>10** | **0** | **1.9** | **3.8** | **0** |
| **Oxen** | **0** | **23.2** | **22** | **3.8** | **20.3** |
| | **1-5** | **73** | **72.3** | **92.4** | **76** |
| | **6-10** | **3.8** | **3.8** | **0** | **3.7** |
| | **>10** | **0** | **1.9** | **03.8** | **0** |
| **Sheep** | **0** | **80.8** | **77.5** | **73.3** | **72.2** |
| | **1-5** | **19.2** | **14.9** | **22.9** | **22.2** |
| | **6-10** | **0** | **1.9** | **3.8** | **3.7** |
| | **>10** | **0** | **5.7** | **0** | **1.9** |
| **Goat** | **0** | **53.9** | **46.1** | **38.9** | **29.4** |
| | **1-5** | **26.9** | **20.5** | **38.3** | **50.1** |
| | **6-10** | **15.4** | **25.9** | **15.2** | **18.6** |
| | **>10** | **3.8** | **7.5** | **7.6** | **1.9** |
| **Poultry** | **0** | **57.8** | **64.5** | **38.5** | **59** |
| | **1-5** | **15.4** | **13.1** | **26.9** | **18.6** |

| | | | | | |
|---|---|---|---|---|---|
| | **6-10** | **15.3** | **16.7** | **26.9** | **20.5** |
| | **>10** | **11.5** | **5.7** | **7.7** | **1.9** |
| **Buffalo** | **0** | **34.6** | **38.9** | **27** | **35.5** |
| | **1-5** | **50** | **48** | **57.7** | **50.3** |
| | **6-10** | **11.6** | **11.2** | **15.3** | **12.3** |
| | **>10** | **3.8** | **1.9** | **0** | **1.9** |

**Table 5. Livestock holding in Budapada and Jhankarbahali**

| **Type of livestock** | **Budapada** | | | **Jhankarbahali** | | |
|---|---|---|---|---|---|---|
| | **Before** | **After** | **Change** | **Before** | **After** | **Change** |
| **Cow** | **3.31** | **3.85** | **0.54** | **4.07** | **2.74** | **-1.33** |
| **Oxen** | **1.81** | **2.35** | **0.54** | **2.11** | **1.67** | **-0.44** |
| **Sheep** | **0.73** | **1.08** | **0.35** | **1.50** | **0.94** | **-0.56** |
| **Goat** | **2.88** | **3.96** | **1.08** | **4.81** | **3.30** | **-1.51** |
| **Poultry** | **4.54** | **4.31** | **-0.23** | **3.41** | **2.94** | **-0.47** |
| **Buffalo** | **2.85** | **2.85** | **0.00** | **2.69** | **2.30** | **-0.39** |

## 5.1.4 Farm implements

Farm implements are used for different production activities and or facilitate transportation and marketing of farm products. In project areas the number of farm implements increased after the intervention of new the irrigation scheme (Table 7). In Budapada the percentage of farmers who own a watering can increased from 4% to 94% whereas in Tangarjhuri it increased from 6% to 59%. The ownerships of tiller increased from 35 to 50% in Budapada and from 22 to 41% in Tangarjhuri.

| Type of farm implements | Budapada | | | Tangarjhuri | | |
|---|---|---|---|---|---|---|
| | Before | After | Change | Before | After | Change |
| Shovel | 0.58 | 1.62 | 1.04 | 0.41 | 1.46 | 1.05 |
| Cart | 0.35 | 0.88 | 0.53 | 0.23 | 0.46 | 0.23 |
| Watering can | 0.04 | 1.35 | 0.07 | 0.76 | 0.76 | 0.69 |
| Sprayer | 0 | 0.04 | 0.04 | 0.04 | 0.09 | 0.05 |

**Table 7. Mean farm implements per household in Budapada and Tangarjhuri before and after (2009-10) implementation of the irrigation projects.**

Bullock carts are very important farm implements to transport inputs to the field and products from the field to home stead or market place. During market days the cart is also used as a source of income for the households as it is used to transport products and people from village to town areas near Dhanupali.

### 5.1.5 Labour input

Labour is one of the major inputs used in small-scale irrigation projects. Trained and experienced labour is an essential production factor. Family labour is the major source of labour all project areas except during peak production period, i.e. transplanting, weeding and harvesting when farmers hire additional labour. The wage rate in the area ranges from Rs.70-100 per day depending of the production period. During peak periods wage rate increases due to shortage of labour. Both male and female labourers are involved in the production activities. Male labours are involved in all production activities whereas females are mostly involved in planting, weeding, and harvesting. Labour data of different production activities are indicated in Table 8.

| Village | Production activity | Labour requirement | | | |
|---|---|---|---|---|---|
| | | Onion | Tomato | Paddy | Green bean/ cabbage |
| Budapada | Land preparation | 5 | 4 | 4 | 4 |
| | Planting | 9 | 5 | 4 | 7 |
| | crop protection | 4 | 4 | 1 | 4 |
| | Irrigation/ watering | 17 | 15 | 14 | 12 |
| | Cultivation | 24 | 16 | 8 | 17 |
| | Harvesting | 17 | 33 | 5 | 61 |
| Tangarjhuri | Land preparation | 4 | 4 | 3 | 4 |
| | Planting | 12 | 6 | 4 | 8 |
| | crop protection | 4 | 4 | 1 | 4 |
| | Irrigation/ watering | 17 | 15 | 11 | 11 |
| | Cultivation | 21 | 15 | 7 | 15 |
| | Harvesting | 16 | 36 | 5 | 57 |

**Table 8. Amount of labour used for different field operations in onion, tomato, paddy and green bean in Budapada and Tangarjhuri (in man days per 0.25 ha).**

Labour requirements for onion, tomato, and paddy and green vegetables production are statistically the same in Budapada and Tangarjhuri (Table 8)

| Type of crop | Project Village | | Significance |
|---|---|---|---|
| | Budapada | Tangarjhuri | |
| Onion | 94 | 93 | NS |
| Tomato | 96 | 93 | NS |
| Paddy | 45 | 42 | NS |
| Green vegetables | 117 | 109 | NS |

NS= non-significant, * significant at P<0.05 significant at P<0.01

**Table 9. Mean total labor used for production of different crops in Budapada and Tangarjhuri (in man day per 0.25 ha).**

### 5.1.6 Average costs and returns

The net production cost for the different crops in the project areas are summarized in Table 10 and indicates no significant differences in individual crop production costs between Budapada and Jhankarbahali schemes at 5% probability level.

| Type of crop | Project Village | | Significance |
|---|---|---|---|
| | Budapada | Tangarjhuri | |
| Onion | 6266 | 6195 | NS |
| Tomato | 6099 | 6007 | NS |
| Paddy | 2609 | 2596 | NS |
| Green vegetables | 5991 | 5787 | NS |

NS= non-significant, * significant at P<0.05 significant at P<0.01

**Table 10. Mean total production costs of different crops in Budapada and Jhankarbahali**

Mean yields of onion, maize and green beans are significantly higher at 1% probability level in Budapada (Table 11).

| Type of crop | Target project area | | | | Significance |
|---|---|---|---|---|---|
| | Budapada | | Tangarjhuri | | |
| | Yield range | Net yield | Yield range | Net yield | |
| Onion | 1000-6400 | 3462 | 500-6000 | 2379 | ** |
| Tomato | 600-4200 | 2796 | 500-5000 | 2483 | NS |
| Paddy | 200-4000 | 1416 | 200-2000 | 729 | NS |

| | | | | | |
|---|---|---|---|---|---|
| Green vegetables | 1200-4900 | 2227 | 500-4200 | 1596 | NS |

NS= non-significant, * significant at P<0.05 significant at P<0.01

**Table 11. Average productivity of different crops in Budapada and Jhankarbahali (in kg/0.25 ha).**

The net revenues obtained from onion, paddy and green vegetables is significantly higher in Budapada at 1% probability level but not significant for tomato (Table 12). Although net revenues of most households are positive some farmers produced with loss. In Budapada project 4% and 9% of the farmers produced tomato and green bean with financial losses, respectively, whereas 4, 29 and 17% of the farmers produced onion, paddy and green bean with losses in Jhankarbahali, respectively. In Budapada, 16% of farmers produced paddy with losses. The loss range and average loss per crop in the schemes are indicated in Table 13. The standard deviation in net revenue is very high within and between both project villages.

| Type of crop | **% of farmer with positive revenue** | | **Revenue range** | | **Net revenue** | |
|---|---|---|---|---|---|---|
| | **Budapada** | **Jhankarbahali** | **Budapada** | **Jhankarbahali** | **Budapada** | **Jhankarbahali** |
| Onion | **100** | **96.3** | **5112-45635** | **156-45220** | **21579** | **13987** |
| Tomato | **88.5** | **88.9** | **1416-27851** | **209-30671** | **15721** | **12672** |
| Paddy | **80.8** | **59.3** | **1283-17192** | **114-6642** | **4398** | **1717** |
| Green vegetables | **100** | **79.6** | **466-21645** | **16-7539** | **6015** | **3660** |

**Table 12. Net revenues, range of net revenues and percentage of farmers with positive revenue for different crops in Budapada and Jhankarbahali irrigation projects**

| Type of crop | **% of farmer with positive revenue** | | **Revenue range** | | **Net revenue** | |
|---|---|---|---|---|---|---|
| | **Budapada** | **Jhankarbahali** | **Budapada** | **Jhankarbahali** | **Budapada** | **Jhankarbahali** |
| Onion | **0** | **3.7** | **-** | **672-1053** | **-** | **955** |
| Tomato | **3.8** | **9.3** | **2337** | **606-1365** | **2337** | **1069** |
| Paddy | **15.4** | **24.1** | **13-1368** | **11-1844** | **471** | **860** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Green vegetables | **0** | **16.7** | | **445-2191** | | **1249** |

**Table 13. Loss ranges and net loss from production of different crops in Budapada and Jhankarbahali**

## 5.1.7 Households' food security

The development of this new irrigation projects in the targeted areas has increased cropping intensity and crop income. According to the survey results and group discussions with farmers their income has increased as compared to the situation before implementation of this irrigation interventions. Before implementation of the irrigation schemes, farmers used rain fed production both for home consumption and to cover other household expenses (school, cloth, health care) together with income from livestock. The farmers indicated that the income from crop sale and livestock was not sufficient for home consumption to cover these household expenses. As a result they faced shortages in food, seeds for the next season and cash to buy inputs. Implementation of the irrigation schemes helped them to diversify crops and income sources. The majority of the households currently use rain fed staple production for home consumption and income from irrigation to cover the household expenses and for saving. In Budapada, 39 and 61% of the respondents uses irrigated products for market and both for market and home consumption purposes, respectively (Figure 3). In Jhankarbahali 6% of the households use irrigated products only for home consumption, 20% for market purpose and 74% for both purposes.

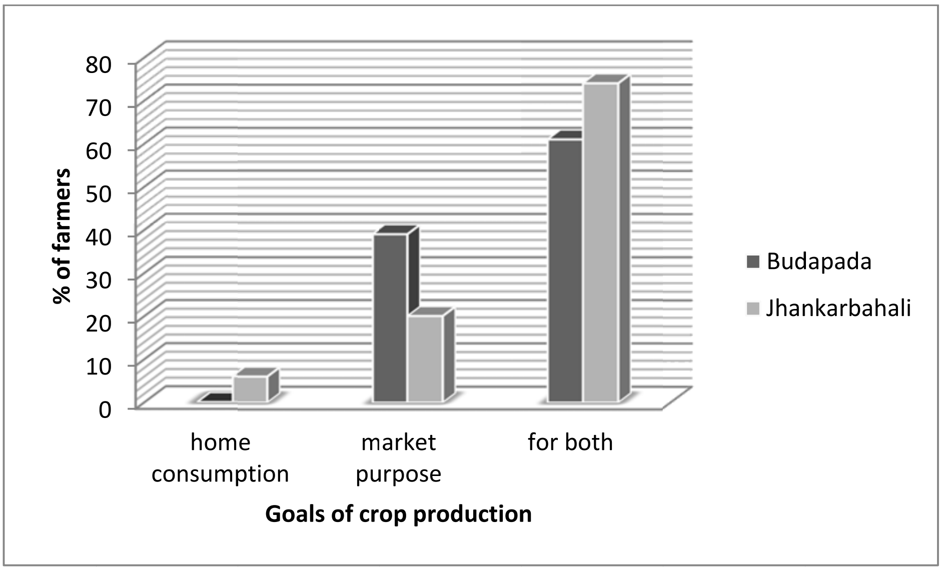



**Figure 3: Production goals of irrigated crops**

The major area of concern among the rural farming community is the availability of food at household level. In Budapada, 35% of the respondents have secured their family food consumption year round, 61% has a surplus for market purpose and 4% indicated a worsening of their family food security after the implementation of the irrigation scheme (Figure 4). In Jhankarbahali, 19% of the respondents produced sufficiently to secure their family food consumption, 38% produced a surplus for market purposes, 17% had no change in family food security level as compared to implementation of the irrigation scheme and 26% faced a decrease in food security.

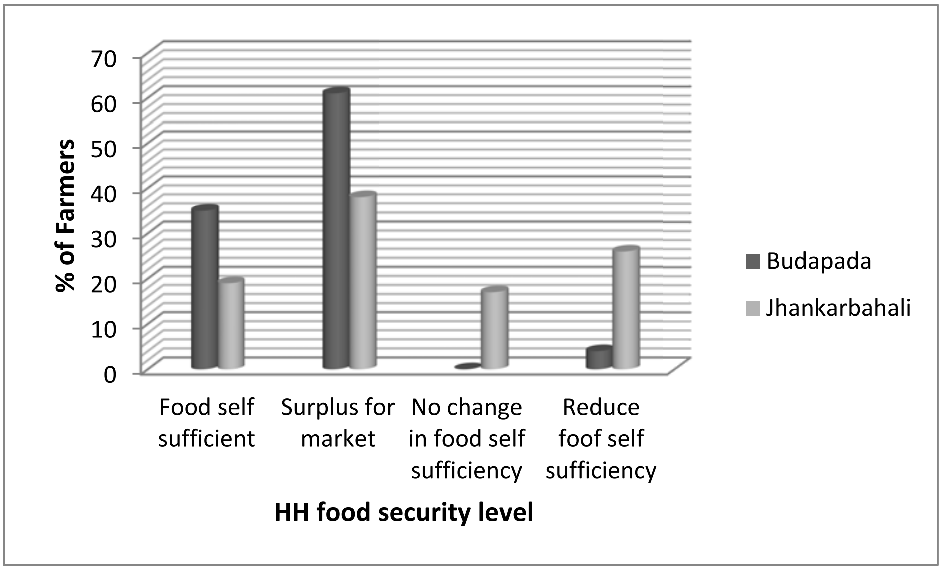



**Figure 4. Perception of household's food security after implementation of the irrigation projects**

## 5.1.8 Linkages of irrigation

Access to and reliable supply of water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. This may open up new employment opportunities, both on-farm and off-farm, and can improve incomes, and the quality of life in rural areas. The farmers were interviewed about the different linkages to identify spill-over effects of this irrigation project.

BISWA identified five key dimensions of how access to good irrigation water contributes to socioeconomic uplift of rural communities and alleviate poverty: production, consumption, employment, food security, and other social impacts contributing to overall improved welfare. There are various linkages that connect different fields of activities in the form of backward and forward linkages Forward linkages are essentially facilitators and they increase the viability of other economic activities from the supply side. Backward linkages increase the demand for the product of another sector. In the study area four types of linkages have been identified although the levels of linkages are low. These are production linkages, consumption linkages, investment linkages and employment linkages.

Production linkages can be either backward or forward. Forward linkages relate to marketing and processing industries while the backward linkage to input and resource suppliers. Implementation of the irrigation project in the study area facilitated the intensification and diversification of crop production and allowed the farmers to grow several crops per year on the same plot of land (Table 4). Implementation of the irrigation project also enabled to diversify from low yielding and low profitable crops to new high yielding and more profitable crops. Before implementation of the project the farmers grew paddy. Now the production has shifted to high value and high yielding paddy variety and vegetable crops (onion, tomato, green bean and cabbage). The intensification and diversification of crop production also facilitated the linkages between farmers and input suppliers. The increase in farm income created high demand for modern agricultural farm inputs such as improved seeds, fertilizers and pesticides. Thus, irrigation development has lead to higher production, which implies increased consumption of inputs, as well as higher production receipts for the farmer.

Apart from production linkages there are also consumption linkages because of the higher income from irrigation agriculture. Crop intensification, diversification, and market-oriented production provide food to producers as well as to consumers. The forward consumption linkage is the increased supply of products for the local and national markets. In the study areas paddy is produced for home consumption and local market in Sambalpur and Bargarh. Onion and tomato are mostly produced for markets such as Dhama and Sahaspur. Only the low grade products are used for home consumption and local markets. Green bean is produced for export markets (mostly Jharsuguda and Rourkela). In most case farmers sell tomato and onion before the harvest. Green bean is sold to the private farms found in the locality of the Block Head quarter that export it to Sambalpur and near by town market. As a backward linkage, irrigation has increased the household's income and as a result increased the consumption of industrial products like cloths, food oil, kerosene, sugar, etc.

The benefits of higher yields and income increased the savings of households in the study area. At the end of each cropping season the farmers save 5-10% of their total sales. It is clearly explained the relationship between saving rate and investment: the higher the saving rate the greater the investment potential and the higher the growth rate. Various investments by farmers were observed in the project areas. About 31% of the sample respondents in Budapada built/ renovate their house in their village after implementation of the project. Some farmers opened shops in Sahaspur. In Tangarjhuri, farmer also has started investing in improved dairy cattle. Tractor and other farm machinery ownership have increased after intervention of the irrigation project. The intervention of the irrigation schemes in the study areas showed more positive implication on the backward investment linkage through investment in small businesses. The investment expenditure in local kiosks, local drink houses, shops etc. increased in nearby Baduapali and Sahaspur. According to owners of local shops the development of irrigation schemes created favorable conditions for the expansion of their businesses.

The labor-intensive nature (increased cropping intensity, cropping area and crop diversification) of irrigation development has increased the employment opportunity both on-farm and off-farm. The irrigation farmers cultivate both rain fed and irrigated land. As a result, family labor is not sufficient to support all production activities. This has created employment opportunities for local landless poor and others. Irrigation development has also created additional employment opportunities outside the project areas through increased demand for inputs and increased supply of outputs. Off-farm employment opportunities created due to the irrigation interventions include local traders, brokers, whole sellers, and loaders of products.

### 5.1.9 Commercial aspects

**Input source and utilization**

Proper utilization of modern inputs such as improved seeds, chemical fertilizers, pesticides and fungicides are basic and essential to any farm enterprise especially in the production of high value horticultural crops. However, the efforts to develop efficient and effective technologies have achieved limited success in the case of small-scale farmers who are often regarded as resistant to changes. All farmers apply fertilizers and pesticides DAP and urea is the major fertilizers used. Depending on the availability of fertilizer farmers apply 25-50 kg/0.25 ha DAP and 25 kg/0.25 ha urea. The types o f insecticide used in all our study areas are Selecron, Karate and Mitga. Fungicide used in the schemes is Kocide, Bayleten, Pencozeb, Ridomil and Bumper. Among these chemicals Selecron, Kocide, Pencozeb and Ridomil are mostly used chemicals in the study areas. Often two or more chemicals are applied together depending on pest and disease pressure. Farmers use the same type of insecticides and pesticides for tomato and onion. Apart from lack of cash or credit services, high prices of these input and timely availability of inputs are reasons for underutilization of farm inputs. The amount of inputs distributed by the association does not meet the demand of farmers resulting in yield reduction. Some farmers also apply manure to increase soil fertility of their plot.

High yielding seed varieties are another important input that contributes to high output, but access in the study area is very low. The sources of seeds are private shops, individual seed producers and local open markets. Due to the high price of seeds in private shops as compared to open markets and individual seed producers most of the farmers buy seeds from local open markets and local seed producers. The quality of seeds from local open markets is often low which affects yield negatively. Seeds from local open markets is of unknown purity and usually susceptible to disease, pests and low yielding. There is no government institution responsible for multiplication and distribution of vegetable seeds in the study area. Therefore, farmers use mainly low yielding local crop varieties. Recently, the number of private farmers producing vegetable seeds is increasing in the CRV. However, the irrigation schemes have no experience in vegetable seed production. The sources of other agro-chemical inputs (fertilizer, pesticides and fungicides) are unions and private shops.

## Out put marketing

As horticultural crops have a short shelf-life marketing is a central issue in their production process. Household decisions and responses are governed by markets and related institutions. The price of horticultural crops fluctuates from year to year, season to season, from day to day and from market to market. Therefore, profitability of horticultural crops depends on marketing skills and getting good market information rather than production expertise. The great variation in prices makes horticultural crop production potentially very profitable but also very risky. The study areas are found near the main highway from Sambalpur to Sonepure via Dhama and are easily accessible to whole traders from Sambalpur, Sundargarh, Jharsuguda and Sonepur. Although, marketing is one of the crucial components of agricultural development, it is not well addressed by extension agents. For example agricultural extension does not deliver market information to farmers as it is outside its mandate. But under our project farmers have received training on facilitating market services. Access to market information enhances their bargaining power and enables them to negotiate the prices given by traders.

### Credit and saving services

Credit service is very important for capital intensive farming like horticulture. In the study areas, there are no well-established credit services for farmers. Particularly, in Jhankarbahali, production activities are highly constrained by the lack of credit services. But after irrigation intervention, farmers receive credits from Banks to buy the necessary inputs for crop production. This saves 5-10% of their total sale at the end of each cropping season and uses these savings for pump maintenance and buying inputs.

## 5.2 Institutional arrangement

### 5.2.1 Organization of the irrigation schemes

### Formation of Water User Groups:

BISWA has thrust on enhancing the capacity of local leaders and farmers on water scheme management skills so as to enhance operation and maintenance of the hardware systems created under the project.

### Notable Community Participation

Participatory method was followed by BISWA in identifying the natural leaders, volunteers and farmers to form water users group (WUG), a village level institutions for management of the scheme.

### Significant Participation of Indigenous Peoples

The project will benefit the natives of the project area, so BISWA ensured the participation of indigenous peoples in the WUG and enhanced their capacity in sustainable management of the water resources.

## Capacity - Building Component:

(1) Participatory approach: BISWA focused to train community and WUA members on proper water management, operation and maintenance of the check dams and irrigation canals constructed under this project.

(2) Training: Training is investment in human capital- The envisaged training has been imparted to the community to make them acquire knowledge and skills which have created a long term effect and promote sustainability.

## Promoting Public Awareness on Global water crises and sustainable natural resource management:

Public awareness meetings on the importance of improved agriculture, conservation of water resources and prevention of land degradation have been conducted by BISWA. Farmers have also learned different Morden agricultural practices through exposure visit and capacity development programmes.

It is come out of the study that farmer groups or Water User Groups are the most frequently recommended organizational form for management of this irrigation scheme. WUGs are legal entities which are supposed to have full control over the irrigation infrastructure in their respective villages. Establishing a strong irrigation organization is one of the major aspects for a successful and sustainable irrigation management .Sustainable management of farmers-managed irrigation systems requires well established rules that ensure the interest of all farmers. The structure is developed by BISWA for modern small-scale irrigation schemes in Orissa. Certification is important to get legal access to credit services from governmental and non-governmental organizations. They can also legally enter into different agreements with different unions, governmental and non-governmental organizations. Uncertified WUGs have not such legal rights.

### 5.2.2 Irrigation scheme management

All management activities in the intervene irrigation projects are carried out by the WUGs. The main activities include repair, maintenance of canals, and supervision of water distribution, settling any conflicts and raising internal resources to sustain the WUG. Where farmers cultivation adjacent plots using common pumps, certain tasks and activities should be properly coordinated to smoothly run the irrigation scheme and avoid possible conflicts. In the following the management performance of the irrigation schemes is described based on the qualitative survey, interviews and group discussions.

### 5.2.3 Water distribution and management

There are two major water distribution systems, i.e. free irrigation and scheduled distribution. The choice between both distribution systems depends on the availability of water. The former distribution system is used when there is sufficient water available whereas the later is used when water is scarce. In all villages pumps are owned by the groups, which need scheduled water distribution to avoid potential water conflicts. The presidents of the respective WUGs are responsible for the proper distribution and allocation of water according to the schedule of the water committee. Based on the interviews and group discussions it became clear that there are no major problems with respect to field water management. However, water losses occur due to rodents and lack of proper clearing of weeds and other grasses in the canal lines. About 85% of the respondents in Budapada indicated to receive enough irrigation water. In contrast, 80% of the households in Jhankarbahali receive to little irrigation water.  Due to the lack of coordination, pump failure and or low pumping capacity and lack of fuel and oil, water is not received when it is needed by the farmers. The severity of these problems is less in Budapada since it has more wells and the management of the scheme is better organized.

### 5.2.4 Transaction costs in irrigation scheme management

The net revenue differences between Budapada and Tangarjhuri for onion, tomato, Paddy and green bean are 2560, 655, 1266 and 1210 Rs/0.25 ha, respectively. These differences can be considered the transaction costs associated with poor irrigation intervention organization and management, lack of credit facilities, lack or absence of supervision in Tangarjhuri.

## 5.3 Environmental impacts small-scale irrigation

Although irrigated agriculture in the study area has contributed to increased food production and to over all socio-economic development, irrigation in general has been subject to increased criticism over the past decades, including the concern on socioeconomic inequality, social disruption and environmental degradation. During the field survey physical observation on soil erosion and deforestation was made. Also information was collected concerning land use change, plot fertility and human and animal disease occurrences due to implementation of irrigation schemes in the area. According to the information from farmers, there is no pressure on the surrounding forest trees. But ultimately this project brings positive impact on the income level of the farmers. Therefore, the dependency on income from charcoal and fuel wood during bad years has decreased. About 69 and 78 % of the respondents indicated that there is no land use change at either of the villages, Budapada and Tangarjhuri respectively. There is no soil erosion observed due to the implementation of the irrigation schemes.

However, the increase in the irrigated area especially around Baduapali village has a considerable effect on the ground water level the minimum, maximum and average levels of ponds and reservoirs were increased since implementation, which is associated with an increase in the surface water and ground water availability. The sample households have different opinions regarding fertility of their plots, i.e. 65, 24 and 11% of the respondents in Budapada and 54, 23 and 23% in Jhankarbahali stated that it increased, decreased and showed no change after the implementation of the irrigation schemes, respectively. The use of manure and chemical fertilizers were mentioned as reason for increased soil fertility while the continuous cultivation is mentioned as a reason for decreasing soil fertility. Sample respondents did not indicate an increase of human or animal diseases after implementation of the irrigation schemes.

## 6. Strategy adopted by BISWA:-

The impact of the efforts by BISWA has given enough reason to believe that we were right in stressing on a participatory approach. And this brings us to the solution strategies we used to address the problems discussed earlier.

## Organising people:

We used the strategy of motivating resource-poor farmers to form Water user groups (WUG). There are now 3 such groups in 3 villages with a member of 15 each as the core committee. Water management and irrigation development activities were taken up for discussion at their credit group meetings. This also became the forum for initial planning and budgeting. In Budapada these groups have continued to serve adequately for planning, executing, and managing all water storage activities, and task-related sub-committees were formed for various works. In all the villages, there was a gradual realisation of the need to integrate other farmers who were not in the WUG. This has led to the formation of a people's managed water management committee.

## Motivating People:

Helping them form groups and establishing a water management system helped. This was followed up with intensive awareness building efforts, training programmes, and exposure visits to other successful projects. BISWA also assisted the villages in other need based programmes such as health care, veterinary care, drinking water, working capital loans (through SHG groups) for income generating programmes, etc., The people were also assured of BISWA's continuous presence and support for agricultural development activities.

One strategically important effort was that BISWA did not go to the people with a pre-formulated, prescribed package of activities; rather, we facilitated many participatory discussions, provided a lot of explanations, incorporated many of the people's own suggestions and traditional practices into the action plan, and enabled the people to see their development holistically.

## Reducing Dependency:

We can claim to have reduced but not entirely eliminated dependency, particularly on rain water dependency. The following actions have helped in this process:

* Participatory analysis, planning, budgeting, implementation, and management of all activities.
* Full involvement of people in decision making and quality control.
* Detailed analysis of available resources and prioritization in resource allocation.
* Inculcating cost consciousness due to participatory analysis.
* Fund management by the people, including making all payments (financial assistance from BISWA goes to the group account operated by selected group members in rotation. Payments are made by the group after verifying the quantity and quality of work done).
* Encouraging at least 30% contribution from the people for works done on their lands (this has worked with greater success in Budapada than in Tangarjhuri and Jhankarbahali).
* Periodic participatory evaluations.

## Increasing People's Knowledge of Farming Technologies:

External science-based information and technical guidance was mobilized from several sources:

a) BISWA involves technically qualified staffs who are available to the people at all times.

b) BISWA seeks and obtains expert advice from Agriculture Universities and scientists whenever required, on a consultancy basis.

c) The information thus obtained is not only used in discussions but also integrated into farmers' training programmes.

## Financing Agriculture development programmes:

To a large extent, the financial support has come from BISWA which, in turn, mobilises funds both from the government and from external aid agencies. However, local contributions are also insisted upon, to the extent possible and this has taken several forms:

| | |
|---|---|
| Work on common lands & large structures such as check dams | : Mostly grant funding. People's contribution is in the form of free labour for approximately 2 day in a week. All benefitting families have to arrange for free labour as agreed in the group / watershed association meeting. |
| Work on individual lands | : a. The concerned families have to contribute free labour or work at lower wage rates for a specified number of days.<br><br>b. An agreed amount is paid by the concerned families as financial contribution. This may either be financed from BISWA or treated as a loan, or the families may straight away borrow from other sources to pay for a part of the works.<br><br>Often, BISWA finances the WUGs on a loan basis again the group advances (a part of) the money to farmers on a loan basis. The surplus recovered amount is kept in a separate fund and used to undertake maintenance and repair works. |

## Increasing the rate of adoption of technologies:

All the above factors have succeeded in promoting the adoption rate of different agriculture management technologies. However, the financial factor is the most crucial factor in translating motivation into action. Willing and motivated farmers are still constrained by their inability to make the necessary investments on the full basket of necessary technologies. An equally crucial factor is the control of finances. Full participation is possible only when the farmers understand how the various parts of the irrigation development scheme interact with one another, the role of the different technologies proposed, and when they are involved in planning as well as budgeting for the proposed works, and not just in their execution.

## Management of Common resources and equitable sharing of benefits:

Continue to pose the most difficult management problems; BISWA has experienced as many failures as successes. Large communities, heterogeneous populations, and the presence of powerful farmers with vested interests make it very difficult to arrive at decisions that are acceptable to all. Projects planned and executed entirely by the people have shown a better rate of success. However, BISWA's experience has been that each situation has to be separately dealt with. The most obvious problems (e.g. digging of canal on common lands and distribution of irrigation water) have to be addressed and resolved even before any work is begun or any investment is made. The decisions on how to manage have to be arrived at by the people themselves, and responsibilities have to be clearly defined and allocated, with penalties for violation.

### Involving Women:

By making it compulsory for Water user groups to include the representation of women, BISWA has successfully created conditions for women to be present at meetings where decisions are being taken and responsibilities are being discussed. However, partly because most of the land is owned by men, and partly because men are generally expected to do outdoor work, conduct land-related negotiations, and engage in financial transactions, the role of women has still not developed to the ideal extent.

### Livelihoods for landless people:

BISWA has been sensitive to the problems of the landless poor. However, under this programme it is a fact that the majority of the benefits go to landowners. BISWA's efforts up to now with regard to the landless families have been:

- To protect their access to common resources such as grazing lands, and to ensure that they have a share in the benefits if any, accruing from common resources.

- To create wage earning opportunities by undertaking agricultural works.
- To create alternate, non-land based income earning opportunities for them (e.g. petty businesses, skill training, etc.), and give priority to the landless in non-farming activities.
- To make efforts to secure land for the landless where surplus lands - government and/or private - are available, and help them develop these lands for productive use.

To conclude are a few principles on which BISWA now bases its water management and agriculture development programmes:

1. The micro- approach: People must be able to see their own area development, appreciate how the different parts of area interact with one another, and understand how the different activities impact on one another to increase the life and productivity of the area as a whole.

2. Budgeting for enough time and manpower: Participatory processes are time consuming and labour intensive; nevertheless, they are the only means to ensure sustainability. Meeting people at a time of their convenience (generally after 7.30 p.m.), organizing them into groups and water users associations, interacting with them on a daily basis, conducting training programmes and exposure visits, being present at the times when conflicts have to be addressed - have all to find a place in the management plan.

3. There is no shortcut to consultations with the people and participatory planning, implementation conflict-resolutions, monitoring, and evaluation. Participatory Rural Appraisal (PRA) techniques are effective in getting this process started, but are by no means the end of the process. PRA techniques have to be followed up with building and strengthening grassroot level institutions that have a major role to play in agriculture development (e.g. water user groups).

4. Keeping aside some provision for other need based programmes: Poor people who are lacking in other basic requirements such as drinking water, health facilities, timely credit, etc., will involve in agriculture activities much better if such other basic concerns are addressed on priority. It is necessary to make budgetary provisions for such eventualities.

6. The question of acceptance and adoption of technologies requires a separate and special mention. In a recent exchange of experiences at BISWA's stream tank well integration Project it

was possible to isolate some of the most crucial issues that have to be addressed with regard to the promotion of physical structures relating to check dam development (since they generally constitute the major and most expensive part of the basket of technologies) and ensuring farmer participation with regard to the same:

a. Awareness of the need among farmers for treatment measures to manage water and soil.

b. The types of measures to control soil erosion and water run-off.

c. The actual design of the structures.

d. The skills required to construct the structures.

e. The materials required to construct the structures.

f. The cost of the structures.

All of the above have to be understood by the farmers, acceptable to them, and affordable in terms of maintenance costs.

Farmers are also inventors, experimenters, builders, and managers. They hold opinions and also have a wealth of practical experience.

## 7. Discussion

This chapter discusses the main findings presented in Chapter 5 and our personal observations during the interviews, group discussions and field visit.

### Main findings Households' income situation and food security condition

This study shows that this irrigation interventions increased average households' income compared to before implementation of these schemes. Irrigation increased crop diversification, cropping intensity from one crop to two or three crops per year, production volume, households' income and consumption and employment. Access to irrigation water created the opportunity for the households to diversify their income base and reduced their dependency on rain fed agriculture and livestock. This reduced their vulnerability to the seasonality of agricultural production and external socks. About 70% of the household respondents secured their family food consumption through increased income from irrigation.

## Extension service provision

Horticultural crop production is knowledge intensive and requires careful crop management starting from nursery to post-harvest handling and marketing. Therefore, education and training of farmers is extremely important. Educated and trained farmers can use information from different sources i.e. folders, posters and information on input packages. In Tangarjhuri most farmers have attended primary and secondary education and this might have contributed to the better field management observed and to higher profits. Moreover, education is an important factor for WUGs since the entire management is done by the committees elected by its members. In particular financial management (book keeping of input prices, input use, yields and revenue distribution) needs good book keeping procedures to guarantee transparency and to avoid possible conflicts within WUGs. The provision of agricultural extension services in both irrigation schemes is very low.

During field visits it was also observed that many agronomic practices are according to the recommendations. Plant spacing, threshold level for applying agrochemicals and the amount of irrigation water are based on farmers' knowledge. The other problem, especially in jhankarbahali is product marketing. Most of horticultural growers follow a similar cropping calendar and the seasonality of production results in a high supply of the same product and consequently low prices. About 81% and 77% of tomato and onion around Baduapali are traded at farm get level, respectively .Since the WUGs have little market information their bargaining power is low and makes them price-takers instead of price setters.

## Environmental impacts of the project

This new technique of irrigation facility was popularized because of their potentially lower negative environmental impacts, low investment cost, ease in maintenance, and low management requirements. Environmental problems associated with this irrigation schemes appear low. However, further study is needed to identify the impacts of this  irrigation schemes on soil quality and ground water quality.

## 8. Conclusions and recommendations

To enhance the productivity of the agricultural sector and to improve food security, BISWA designed this strategy to stimulate and/or support the development of tank stream well integration small-scale irrigation projects. This aims to increase agricultural production and to contribute to improved food security through improving income of participating farmers and optimized surface water and ground water utilization. Based on this study, various lessons can be learned for improving the sustainability of such irrigation projects:

The analysis of the costs and revenues of various production activities indicates positive crop revenue. The net revenue of four different crops (per 0.25 ha) ranged from 7040 to 33298 in Budapada and from 609 to 31040 Rs in Tangarjhuri. Except for tomato the net revenues from three different crops (onion, paddy and green bean) are statistically significantly higher in Budapada at 1% probability level. Although mainly assessed qualitatively, irrigated farmers perceived their food security condition better than compared to the situation before implementation of the irrigation schemes. In Jhankarbahali, land holding size and number of animals decreased whereas the number of farm implements increased.

In all project areas there are no location-specific recommendations for input use and, therefore the farmers apply different rates based on the availability of inputs. Improved management recommendations and better skills of farmers to apply inputs can improve the yield performance in study areas considerably.

WUGs committees are in charge of the coordination and management of irrigation schemes. The institutional performance has a great impact on the profitability of projects. In Budapada committees and farmers cooperate well and WUG committees are transparent creating trust between farmers and committee members. Members are actively participating in the management of their scheme.

Among others, one of the benefits of this irrigation schemes is their potentially lower environmental impacts compared to large scale schemes. Soil erosion was not observed in project sites and according to farmers water level is increased which enhances the year round water availability.

Based on this study, the following recommendations may contribute to a sustainable development of stream tank well integration irrigation schemes:

- Better training of farmers on improved agronomic practices, crop protection aspects, book keeping, irrigation practices, and product marketing is required to increase crop productivity, price bargaining power and profitability of this irrigation scheme.
- The District Agricultural office could support this previous recommendation through setting up farmers training center.
- Strengthening or establishing institutions for input supply, output marketing and credit service to allow rapid progress in the introduction and adoption of productivity improving technologies and farming practices.
- The WUGs should find ways to better match the production plan with market demand.
- The WUGs should form producer unions and focus on the production of high quality products so as to compete with other producers and to increase their bargaining power.
- The WUGs should be involved in seed multiplication programs to reduce seed costs and to improve access to high quality seed.
- The WUGs should be supported and encouraged to strengthen their own credit systems to reduce dependency on other institutions.
- Training, capacity building and encouraging development agents and WUGs committee members are essential to build the local understanding and management capabilities to effectively support farmers.

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