Impact of Some Innovative Programmes for Improving Agricultural Productivity– A Study in Arid Zones of West Bengal, India

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Abstract :

India at present faces a daunting challenge to provide food security to the burgeoning population. Rainfed areas falling mostly in arid zones accounts 60% of the total cultivated area in India. More than one-third share of the total population in the arid zone of India is below the poverty line. There is an urgent need to explore the possibilities of adopting innovative techniques of production in agriculture in the arid zones. The present paper provides some cases of innovative technologies to improve agricultural productivity in the arid zones in India. The innovative technologies that have been considered here are Happa, System of Rice Intensification (SRI), rain shelter, and mango orchard. The paper highlights the economics of these technologies for tribal households in the study area of Nayagram Block in Jungle Mahal in the state of West Bengal in India. All these technologies have been found to be economically beneficial for the farmer households in the arid zones under study.

Keywords: Innovative technology, SRI, Happa, Rain shelter, Orchard, Agricultural productivity, Arid Zone, India

INTRODUCTION

India at present faces a daunting challenge to provide food security to the burgeoning population. Rainfed areas in Indiaaccounts 60% of the total cultivated area and the majority of rural poor and marginal farmers live in these areas. Repeated droughts and erratic rainfall have severely affected the livelihood of rural people particularly those living in the arid zones where the irrigation facility is poor. More than one-third share of thetotal population in the arid zone of India is below the poverty line. A low level of income continues to be a barrier for the poor to escape the poverty trap. Poor people lack opportunities to have access to public infrastructure and income earning. A majority of the population earn their livelihood through unskilled, casual manual labor and harnessing the natural resource base. This dependence makes them more vulnerable to crises like climate shock, natural disasters, ill health, all of which adversely affect their employment opportunity and reduce their ability to move out of the poverty trap.

Mostly they depend upon agriculture for their livelihood. In this backdrop, improving agricultural productivity is an important agenda for the development of arid zones.

Nayagram Block has been selected for the study which is situated in the arid zone in the state of West Bengal in India. Nayagram Block has ST and SC population of 60.3 %. The main source of income of the community in this area is agriculture. The area mainly depends upon mono-cropping, i.e. kharif paddy is the only crop grown. The production from the agricultural land is uncertain due to erratic rainfall and occasional late onset of monsoon. Farmers cannot do timely intercultural practices and thereby production gets reduced drastically. In addition to this, a lack of knowledge on improved agricultural technology and unavailability of timely and adequate credit also plays a significant role for the poor yield. Families could somehow manage a food sufficiency of 6-8 months from their own farm production. People also migrate to nearby agriculturally developed areas of PurbaMedinipur to work as agricultural labor. The dependency of people on *babui* rope making and *sal* plate making as a secondary source of livelihood is obvious in the area. It generally acts as a source of income for these families. Farmers are generally dependent on chemical fertilizer and pesticides. It is very difficult for the community to purchase the required amount of fertilizer.

The NayagramBlock is the most backward region in PascimMedinipur as well as in West Bengal of India. In terms of HDI, Naygram is the lowest one. One of the reasons for poor economic development is low agricultural development. In cropping intensity PaschimMedinipur district is the lowest one. Agricultural productivity is also poor compared to many other blocks in West Bengal. In this backdrop, there is an urgent need to explore improving the productivity of agriculture in this area.

LITERATURE REVIEW

Styger et al (2010) found that in 2007, Africare undertook the first test of the System of Rice Intensification (SRI) in Goundam circle and found 9 t/ha of paddy in SRI plot compared with 6.7 t/ha in the control plot. Rao (2011) studied on economic analysis of SRI in Andhra Pradesh for the period 208-09 and found that BCR is higher for SRI (1.76) than traditional (1.25) methods. Ghosh and Chakma (2015) in a study in West Bengal found that BCR in SRI practice is significantly higher than the conventional method of rice cultivation. Field experiments conducted by Hameed et al (2011) in southern Iraq reveal tahtthe SRI methods had favorable and significant impacts on plant height and panicle length and showed significant differences in the yield components of grain number. According to Gujja and Thiyagarajan (2009), innovative rice cultivation practices like SRI not only enhance rice production and their net income but also to solve the water crisis. Another study Chapagain et al (2011)found that net returns increased approximately 1.5 times for SRI-organic management regardless of the added labor requirements for weed control. Dahal (2014) attempts to succinctly review the present situation of SRI in Nepal and its benefits, along with its limitations and criticisms. Arayaphong (2012) quantifies and compares the costs and benefits of SRI and the conventional system of rice cultivation in Thailand.. Pathak (2013) examines the farm-level performance of SRI method of paddy cultivation as against the traditional method of paddy cultivation in the state of Gujarat. According to Reddy and Shenoy (2013), the profit was higher in SRI paddy cultivation compared to Traditional paddy cultivation. The study of Lybbert and Tescar (2013) in Haiti found that SRI is touted as a high-yielding low external input rice cultivation method that can increase rice yields and improve household welfare. Nakano et al (2014) in Tanzania found that the training effectively enhances the adoption of improved rice cultivation practices, paddy yield, and profit of rice cultivation by small-holder farmers. According to Dhakal (2005), yield increases with the SRI method were recorded up to 90% more than the traditional method in the Hindu Kush-Himalayas. The study of Anne et al (2014) found thatthat SRI yield compared to traditional rice cultivation was more than double in Tanzania, Zambia, and Malawi. based on the study in southern Africa, According to Rappocciolo (2012), challenges for disseminating SRI includes resistance by farmers who hold on to their traditional ways; geographical and infrastructure constraints ; inadequate access to inputs such as seeds, organic fertilizers, and mechanical tools; and a need for extra labor . Adhikari et al (2010) report data and experience from Himachal Pradesh, Uttarakhand, Orissa, and West Bengal.andthe capacity of SRI methods to buffer adverse climate effects is particularly important in such settings. According to Mahendra Kumar et al (2013), in the SRI method, using less water to produce rice can help overcome water shortages in the future. Ibrahim (2014)find that SRI practices in Malaysia paddy cultivation have resulted in the increase in yield as well as superior quality paddy because of its shorter crop cycle, less need for seeds and fertilizer, less chaffy grain because of higher percentage grain filling. According to Kumboj et al (2012), the conventional system of rice production in South Asian countries is basically water, labor, energy-intensive, adversely affecting the environment. Productivity gains of SRI have also been discussed by Barison and Uphoff(2011), Basavaraja et al, (2008), Sarala &Chellappan, (2011), Senthilkumar et al (2008), Sinha, &Talati, (2007), Thomas&Ramzi (2011), Uphoff et al (2011), Jana et al (2016) According to Palada et al (2003), the production of tomatoes during the hot-wet season in tropical and subtropical climates is limited by unfavorable conditions. These conditions can significantly reduce tomato yields. Rain shelters protect tomato plants against the impact of heavy rainfall and prevent frequent periods of leaf wetness. Phiri (2011) found that the Rain Shelter technique is transmitted to other communities within the district in Japan due to the high yield of tomato, simple and low cost of the technique. The advantages of irrigation through happa has been discussed by Jana (2011) and Jana (2017).

Research Objectives

The broad objective of the study is to evaluate the economic impacts of the innovative schemes used in agriculture in the selected arid Zone in the state of West Bengal. The major objectives of the present study is to (i) assess the social and economic impacts of innovative agricultural techniques, (ii) Scope of different innovative agricultural technologies to improve agricultural productivity in the zones.

STUDY AREA

The state of West Bengal is one of the 29 states and seven union territories in India. The present study has been conducted in the Nayagram Block of Jhargram District of West Bengal. It is part of ‘western tract’ of West Bengal lying at 22°01′55″N 87°10′41″E. The region is characterized by water to the extent of hindering or preventing the growth and development of plant and animal life. The arid climate hinders the growth of vegetation with low agricultural productivity. As *Chota Nagpur* Plateau gradually slopes down, it creates an undulating area with infertile lateritic rocks and soil which has direct bearing on the soil characteristics of the area. The Block is mostly (about 90%) is characterised by the lateritic soil and the rest is alluvial. The region is drought prone.

The study area (Figure 1) belongs to four villages in Nayagram block which is situated in the western part of Paschim Medinipur district, West Bengal. There is a specific geographical concentration of backwardness in these regions of the district. The backwardness can be explained through the lack of access to natural resources like water.

Figure 1: Study Area

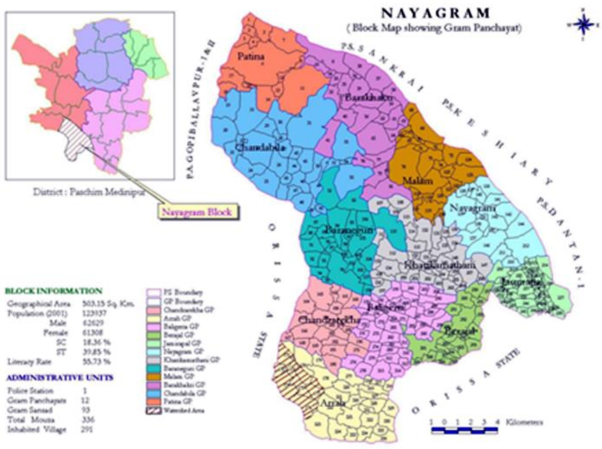


Table 1 shows the General Information of Nayagram Block. In Nayagram Block, there are 12 GPs, 381 Mouzas. The total population of the block 1.42 lakhs with the literacy rate being 47.56.

Table 1: General Information of Nayagram Block

Sl.No		Number
1	Gram Panchayat (GP)	12
2	Mouza	381
3	Gram Sansad	90
4	Total Population (2011 Census)	142145
5	Area (Sq. Km.)	503.15
6	Total Literacy (%)	47.56
7	Bank	9
8	Post-Office	24
9	Co-Operative Society	73
10	Villages Having Drinking Water Sources	335

Source: Census, 2011

Demographic Characteristics: Some demographic characteristics of the Nayagram Block are presented in Table 2. According to the 2011 Census Report, the total population of the Block is 142145. Tribals including *Santal*, *Munda* and *Bhumij*occupy an important place in

Nayagram. Out of the total population, 40 percent schedule tribe and 20 percent schedule caste. The percentage of BPL households in Nayagram is 69.2% compared to 45% in the district. There are different tribal groups e.g. santal, munda, bhumij etc.

Table 2: Demographic Characteristics of Nayagram

Block	Nayagram	PaschimMedinipur
House-holds	24954	1009891
Total Population	142145	5193411
% of SC to the Total	20.3	18.05
% of ST to the Total	40.0	14.87
% of Minority Population	19.41	15.23
% of BPL	69.26	45.11

Source: Census, 2011

Human Resources in Nayagram Table3 presents types of workers in Nayagram block.Out of the total population, the percentages of different types of workers are as follows: Main Worker -21.9%, Marginal Workers – 27.4% and Non-Workers – 50.7%.

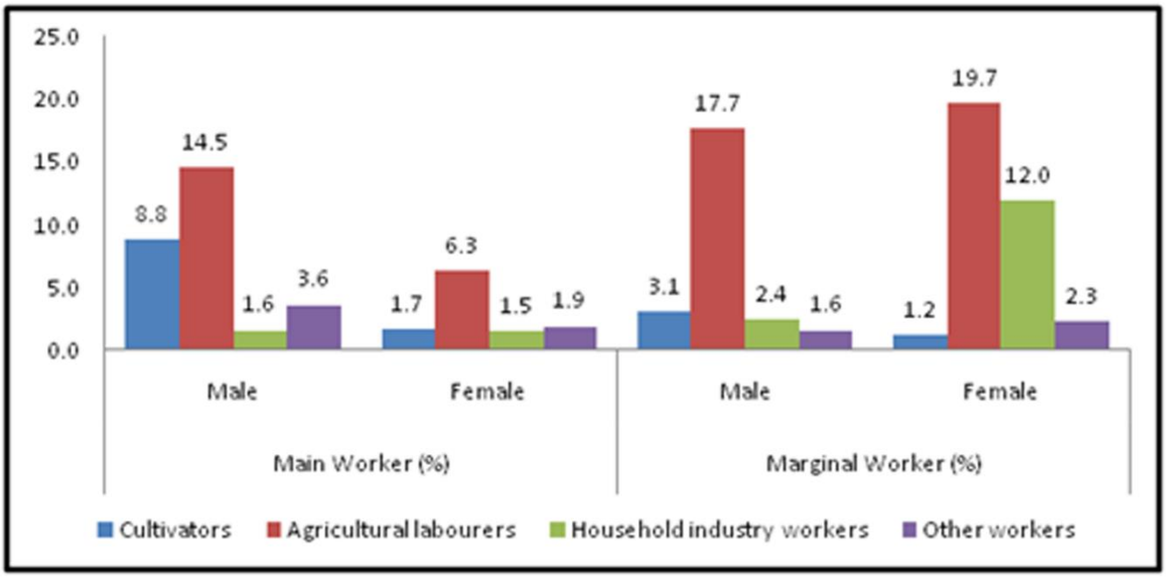
Table 3: Types of workers in Nayagram Block

	Number	Percentage of Total population
Total Population	142145	---
Main Worker	31089	21.9
Marginal Worker	38965	27.4
Non-Worker	72145	50.7
ST Main Worker	12141	8.5
ST Marginal Worker	18192	12.8
ST Non-worker	26554	18.7

Source: Census, 2011

The worker distribution in Nayagramis shown in Figure 2.

Figure 2: Distribution of workers in Nayagram



Land resource in Nayagram

The land types in the area are of three categories: (i) Fallow Uplands (called *Dahi*): These are at the top of the terrain having thin topsoil and very low capacity of water-holding. (ii) Medium uplands (called *Danga*): These lands soils are with sandy and sandy loam and shallow having low moisture-holding capacity and low organic matter (iii) Low Lands (called *Sole*land): These lands are more loamy than baid/danga and are most advantageously located in terms of water availability and these lands get additional water (Table 4).

Table 4: Slope and Water holding Capacity of land in Nayagram

Category of land	Slope (% age)	Water holding capacity*
Dahi(Up Land)	1-2 %	Low
Danga(Medium Land)	1-2 %	Moderate
Sole(Low Land)	0.5-1%	Good

Source: PRADAN, Nayagram

Table 5 shows the land use pattern of the area in a different category of land. As there are hardly any irrigation facilities in the area almost all these lands under cultivation are single cropped and rain-fed.

Table 5: Use of land in Naygram

Category	Type of soil	Av. top Soil depth	Present use

Dahi(Up Land)	Sandy & stony soil	2.5 to 15 cm.	Either covered by *babui* grass or fallow
Danga (Paddy Land)	Sandy loam &morum soil	15 -30 cm	Short duration Kharif paddy
Sole(Valley/Low Land)	Clay & sandy loam	>30cm.	Long duration Kharif paddy, Summer paddy,

Source: PRADAN,Nayagram

Soil Status in Nayagram

The land surface is characterized by hard rock, upland, lateritic covered area. Extremely rugged topography is seen in the west part of the district It represents the more backward areas compared to the less backward areas of the eastern part where good soil and water resources together have brought significant changes through multiple cropping, horticulture and allied activities. The western part of the district having red and laterite soils are often affected by drought.

Table 6: Soil Status of Nayagram

	Net Cultivated Area	Predominant type	% to total area	Other Type	% of to total Area
Nayagram	22826	Letaritic	90%	Alluvium	10%
PaschimMedinipur	786553	Letaritic	52%	Alluvium	48.0%

Source: PRADAN, Nayagram

Agricultural Development in Nayagram

The cropping pattern of the district is heavily loaded in favor of paddy. The change of cropping pattern is slow. The drought-prone areas in Nayagram prevent the cultivation of more than one crop in these areas. During rainy season paddy is cultivated as a major rain-fed crop, while during *rabi* and summer season, vegetables, oilseeds and *boro* paddy are grown under irrigated condition. Cropping intensity of the district is 172 % but it is low i.e. 162 % in 11 LWE Blocks (Table7).

Table 7: Net Cultivated Area, Gross Cropped Area and Cropping Intensity in Nayagram Block and PaschimMedinipur

	Net Cultivated Area (ha)	Gross Cropped Area (ha) in 2008-09	Cropping Intensity (%)
Nayagram	22826	36990	162
PaschimMedinipur	573575	988748	172

Source: DPO, PaschimMedinipur

There is immense scope for bringing more area under plantation crops, replanting of old, uneconomic plantations and irrigation, land development for rejuvenation and revitalization of existing plantations with a view to increasing production and productivity.

Irrigation Development in Nayagram

The district of PaschimMedinipur is rich in both groundwater and surface water resources. 56.48 % of the net cultivable area is irrigated in the district but exploitation of groundwater potential is only 28% of the utilizable recharge. The groundwater development and judicious management of the surface water are the crucial factors in promoting modern agriculture through high yielding and remunerative crops in the district. The irrigation status of the Nayaram block is very poor compared to the district average (Table 8).

Table 8: Irrigated Status in Nayagram

	Net Cultivated Area (ha.)	Irrigated Area (ha.)	% of Irrigation
Nayagram	22826	7485	32.79
PaschimMedinipur	573575	323963	56.48

Source: DPO, PaschimMedinipur

The livelihood of the People

Most of the tribals living in Nayagramare basically forest-dependent people and they were relying on forest for centuries as their principal source of food, fodder and fuel. In fact, they remained as the custodian of the forest till the British Government intervened in their rights and claims with the enforcement of the Forest Act, 1896. They are also the worshippers of forest trees and still today they maintain many sacred grooves in this District. The people also depend on sabai cultivation and sabai rope making also.

Human Development in Nayagram

The Human Development Index (HDI)has been prepared by giving equal weightage to education index, the health index and economic livelihood index. In the district of PaschimMedinipur, Daspur II ranks first in terms of human development index (0.772). Table 9 gives a perception about human development Nayagram Block in PaschimMedinipur.

Table 9: Human Development Indices of the Nayagram Block

Block	Education index	Health index	Economic Livelihood index	HDI	Rank
Nayagram	0.622	0.387	0.26	0.423	29

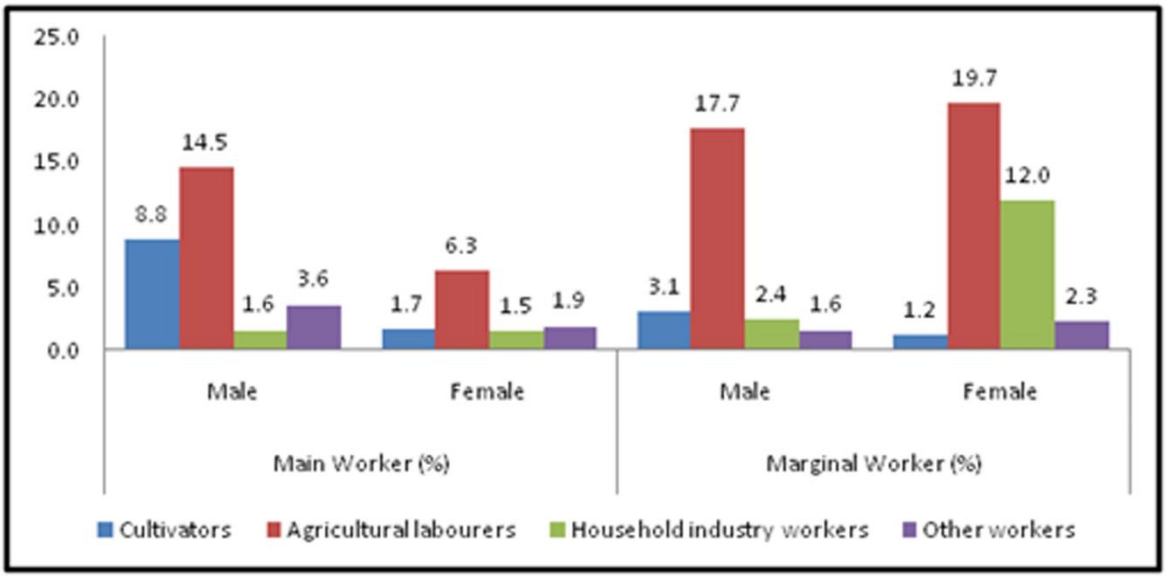
Source: District Human Development Report PaschimMedinipur, 2011

INNOVATIVE EXPERIMENT: HAPPA

Happa is small, deep ponds, dug on farmland to store rainwater(Figure 3). They are usually located in medium and high lands as these have less water for cultivation and greater runoff to fill ponds. Low lands benefit through seepage and runoff.

The Government of India (GoI), under its flagship programme for employment generation, the MGNREGS, is funding the construction of happas—mud-excavated small water harvesting structures—of an average size of 50 × 45 × 12 ft in a command area of about 0.6–0.75 acres. Introduced as an experiment in some dry zones, the happais being excavated on the private land of farmers so that they can irrigate their agricultural land. The construction of the happa is paid for by the government but it is subsequently managed by the farmers and all operational expenditure for maintaining it is incurred by them. This model has seen some success in the dry zones like PaschimMedinipur, Bankura and Purualia districts of West Bengal. The authors have selected Naygram Block for our study. There is a geographical concentration of poverty and backwardness in this area that has led to the continuous degradation of natural resources.

Figure 3 : Happa in Nayagram



Happa Characteristics

Characteristics of the Happa surveyed are presented in the following Table 10

Table 10: Happa characteristics

	Average of 20 Happa
Average Length (Ft.)	40
Average Width (Ft.)	35
Happa Area (Sqer Ft.)	1338
Average Depth(Ft.)	10
Average Commend Area (Bigha=52 Decimal)	0.9
Average Construction Year	2009
Average Construction Cost (Rs.)	47100

Source: Primary Survey

A number of households getting different benefits from Happais presented in Table 11.

Table 11: Benefits of Happa Received by Households

Benefit of Happa	No. of Households (N=20)
Aman Paddy	20
Boro Paddy	2
Vegetable	20
Fish Cultivation	15

Live Stock	15
Embankment Cultivation	16

Source: Primary Survey

Construction Cost of the Happa; In doing cost-benefit analysis authors have taken only construction cost as costs for the Project. Out of the 20 Happassurveyed,happaas surveyed during 2008 -2014. The construction cost of happa ranges from Rs. 25,000 to Rs. 57,000.

Benefits from Happa: Different types of benefits of the 20 Happas surveyed are given in the following Table 12. The benefits arise from different production activities like the production of Amanpaddy,Boro Paddy, Vegetable, fishing and tree plantation. The monetary values of different production from happa is reported in Table 12.

Table 12: Estimation of Value of Benefits from Happa (Rs.)

HH No.	Aman	Boro	Vegetable	Fish	Tree	Total Benefit
1	8880	1360	3500	2300	6000	22040
2	3750	0	2760	1250	5000	12760
3	2790	2408	3250	1450	8000	17898
4	2590	0	2520	1710	7000	13820
5	630	0	3500	800	0	4930
6	4240	0	2310	1100	0	7650
7	912	0	2420	1700	3000	8032
8	3452	0	3300	1250	4000	12002
9	4300	0	3250	500	0	8050
10	4672	0	4000	770	4000	13442
11	4054	0	1760	540	0	6354
12	2660	0	2310	500	8000	13470
13	5850	0	3040	1800	0	10690
14	6260	0	2310	1200	0	9770
15	5820	0	2070	500	6000	14390
16	4410	0	2100	770	0	7280
17	3636	0	2300	720	0	6656
18	5850	0	2375	900	7000	16125
19	3614	0	2310	1750	0	7674
20	5100	0	2640	500	5000	13240

Source: Own Estimation

Cost-Benefit Analysis

In project appraisal, authors aim to determine the action that would maximize some overall measure of net social value. To do this authors 'list all parties affected by the project and then value the effect of the project on their welfare as it would be valued in money terms by them' (Layard and Glaister, 1994). Future costs and benefits are weighted according to individual preferences and equivalent present values are estimated. The affected parties should include not only the producers and consumers directly associated with the project but also third parties who experience the environmental impacts of the project. Moreover, insofar as future generations are deprived of scarce environmental resources, their loss should be taken into account. Environmental impacts have not been considered into our analysis.

Methodology of CBA

Net Present Value (NPV)

Net present Value (NPV) also known as the present value, is based on the desire to determine the present value of net benefits from the water harvesting structures. The formula used for the calculation of NPV is

$$\mathrm{NPV} = \frac{\text{Present value of Benefits}}{\text{Present value of Costs}} = \sum_{i=1}^{n} \frac{B_t - C_t}{(1+r)^t}$$

Where,

B_t= benefits obtained by the farmers in the command area due to the watershed structures in year t

C_t= cost of the renovation of the tank (Happa) in the WTA in the year t

r = social discount rate

The lifetime of the project has been taken as 15 years and the discount rate as 12%. The cost has been taken as the initial cost of renovation.A positive NPV indicates that estimated total benefits exceed total costs.

Benefit-Cost Ratio (BCR)

The benefit-cost ratio (BCR) is expressed in the following form.

$$\text{BCR ratio} = \frac{\sum_{i=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{i=1}^{n} \frac{C_t}{(+r)^t}} = \frac{\text{Present Value of Benefits (PVB)}}{\text{Present Value of Costs (PVC)}}$$

Where,

B_t= benefits from the tank in the WTA in the year t

C_t= cost of the renovation of the tank in the WTA in the year t

Table 13 reports the values of NPV, BCR, for all the 20 schemes under our study. The average benefit-cost ratio of Happas is 1.7. Two Happas have BCR less than one.

Table 13: Result of Cost-Benefit Analysis of the Happa

Name of the Village	Household No.	NPV (Rs.)	BCR(Rs.)
Baksha	1	114420	2.86
Baksha	2	47835	1.97
Panchami	3	81529	2.48
Panchami	4	51421	1.95
Baksha	5	5607	1.18
Balimundi	6	21355	1.58
Balimundi	7	14269	1.30
Dudhiasole	8	39553	1.76
Dudhiasole	9	8407	1.16
Panchami	10	55538	2.18
Panchami	11	-3531	0.93
Panchami	12	55751	2.19
Balimundi	13	22545	1.38
Panchami	14	24527	1.49
Baksha	15	63269	2.36
Panchami	16	16533	1.42
Panchami	17	-1227	0.98
Baksha	18	74004	2.51
Balimundi	19	11539	1.25
Balimundi	20	61997	2.59

Source: Own Estimation

INNOVATIVE EXPERIMENT: SMSRI (SLIGHTLY MODIFIED SYSTEM RICE INTENSIFICATION)

The traditional paddy cultivation was the oldest method of rice cultivation. The Traditional paddy cultivation practices also had undergone changes due to changing times where the cumbersome practices were replaced. The interest of the farmers in cultivating rice by using traditional method has decreased as large numbers of farmers were using fertilizers and pesticides in the method of traditional paddy cultivation to increase the production of rice. It was noticed that, farmers adopting conventional methods could increase their production only by using expensive inputs such as chemical fertilizers, pesticides and hybrid seed. It is becoming increasingly difficult for the community to afford these things. It is also known that using chemicals is harmful to the environment. A new method of growing rice called system of rice intensification (SRI) is designed for increasing rice production which can use the organic compost, and also the local seed. The SRI consists of a set of management practices that were mainly developed through participatory on farm experiments in the central highland of Madagascar in the 1980s. The main elements of SRI include early transplanting of young seedlings, transplanting single seedlings with wide spacing, mechanical weeding with a rotary push weeder, no need for continuously standing water during the vegetative growth phase, and reliance on compost as far as possible, with supplemental or no chemical fertilizer (uphoff, 2006). There are some differences between the SRI paddy and Traditional paddy in nursery management. While the SRI paddy cultivation needs 2kgs of seed per acre for nursery management, the Traditional cultivation needed 30kgs of seed per acre for nursery management. There are major differences between the SRI and Traditional paddy cultivation in the method of transplanting. The wider spacing was followed between the plants and rows in SRI paddy (25x25cms) as compared to Traditional paddy (20x15cms).

This method is called “Slightly Modified System of Rice Intensification” (SMSRI). In this context, a study was undertaken in Nayagram Block in Paschim Medinipur district of West Bengal to note the impact of Traditional as well as SRI method of rice cultivation on the farmers.

SRI paddy cultivation was introduced in Nayagram block during the Kharif seasons in 2008-09. As SRI is applied in some modified form in the study area, it is called “Slightly Modified System of Rice Intensification” (SMSRI). It also promoted by PRADAN in there watershed villages since 2008-09. Besides, some progressive farmers came to know about it from the NGO and fellow farmers have started adopting the SRI since 2008-09 itself. The SRI is slowly spreading in this block. To understand the irrigation efficiency of the SRI a household's survey was conducted during 2008. This provides the opportunity to draw the experience of the farmers for all agricultural seasons since its advent. To know about the positive and negative aspects of the SRI, perceptions of farmers on the SRI paddy practices were also collected.

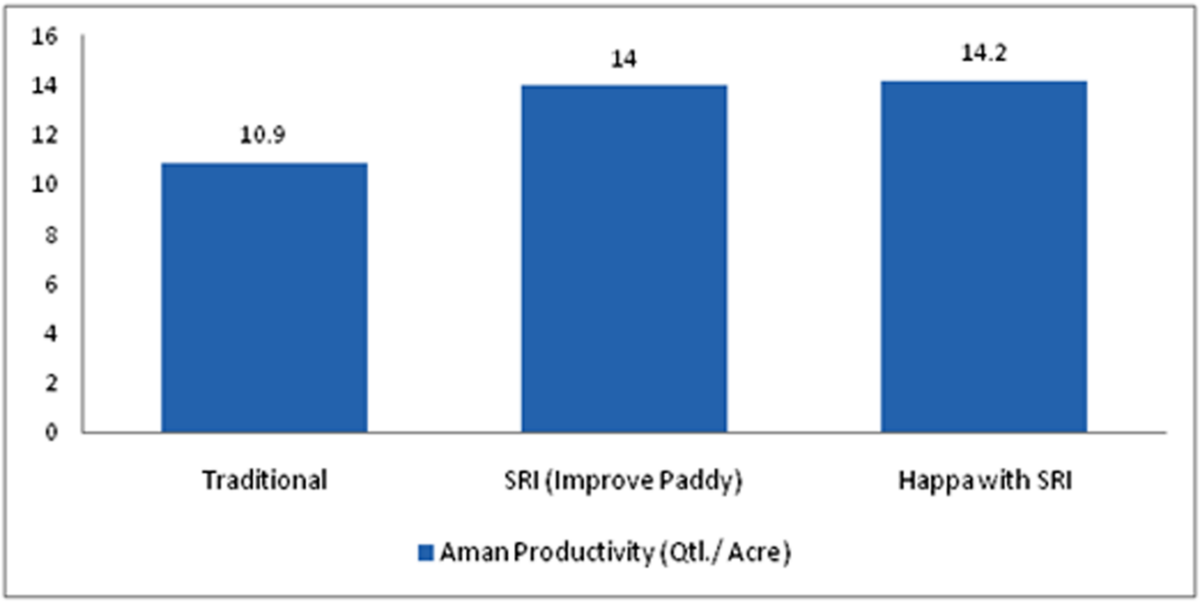
Table 14: Comparison of Traditional and SRI in productivity for sample households

		Mean				
	Variable	Traditional HHs (N=60)	SRI HHs(N=100)	Total HHs(N=160)	F Value	Level of Sig
Yield (Ton/Acre)	YTA	1.090	1.398	1.283	497.5	0.000
Total Value Main Production (Rs.)	TVMP	10870.3	14703.9	13266.3	227.1	0.000
Total Value By Product (Rs.)	TVBP	385.9	246.4	298.7	338.3	0.000
Total Production(Rs.)/Acre	TPA	11256.2	14941.8	13559.7	209.4	0.000

Source: Own Estimation

The productivity comparison of different types of farming is presented in Figure 4.

Figure 4 : Productivity comparison of different types of farming in Nayagram



Economics of SRI/SMSRI Cultivation

As indicated earlier, the SRI is better yielding though at high costs and risk when compared to traditional methods of paddy. However,the difference in some of the variables statistical rigour.Paired 't' tests were carried on all the important indicators. As per the tests, differences in yields, seed, irrigation value, labor use, cost and profit are statistically significant (Table 15). This indicates that the yield gain of the SRI is translated into profits. This is solely, as observed in the earlier studies, due to lowlabor inputs in the SRI method. It is clear that farmers in Nayagram block are using more labor imputes well. From the farmers' perspective, the SRI is only as profitable as traditional paddy. And water savings are substantial in the case of the SRI. The SRI requires less number of irrigations. This implies less pressure on the precious groundwater resources as well as energy requirements for pumping groundwater resources are depleting rapidly in these regions imposing huge costs on the farmers. Judicious promotion and adoption of the SRI could result in sustainable and efficient use of scarce water resources.

Table 15: Difference between average of SRI and Traditional methods for important variables

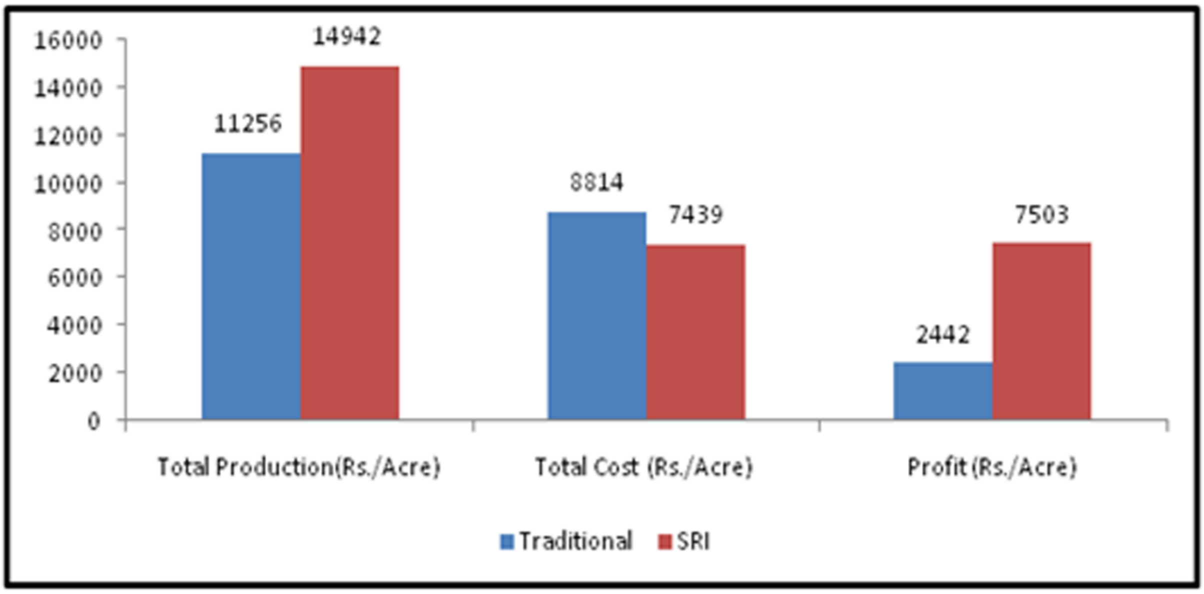
Variable	Average		't' statistic	Sig
	SRI HHs	Traditional HHs		

Seed(Kgs/Acre)	4.94	24.71	- 50.02	2.13E-37
Irrigation Value (Rs./Acre)	258.84	621.47	- 7.53	1.84E-12
Total Labour Use (Day/Acre)	34	44	-19.64	9.48E-12
Yield (Qt/Acre)	13.98	10.90	21.21	5.81E-41
Total Cost (Rs./Acre)	7439.1	8813.9	-14.87	6.94E-32
Profit (Rs./Acre)	7502.8	2442.3	19.45	2.64E-42

Source: Own Estimation

Figure 5 presents per acre value of production and cost and profit through bar chart for SRI and traditional crops.

Figure 5 : per acre value of production and cost and profit for traditional and SRI Paddy in Nayagram



OTHER INNOVATIVE EXPERIMENTS

Rain Shelter for Vegetable Cultivation (Tomato)

Small and marginal farmers can adopt rain shelter for the successful cultivation of vegetables in the rainy season(Figure 6). It is much cheaper and easy to maintain and it is suited to homestead cultivation and many crops can be grown practicing crop rotation. The structure can be erected using locally available arecanut / casurinapols, ultra-violet stabilized plastic sheet is laid on the roof so that the crop is protected from excess rain for 3-5 years.

Figure 6 : Rain Shelter

The authors here describe here the experience of Ms. KajalMurmu who lives in Panchami Village, in Nayagram Block. She has limited labor. Sometimes her husband also helps her when he visits her. She is a model farmer and becomes a member of the LAMPS group. She produces tomatoes using Rain shelter vegetable cultivation. During her three months of training, she learnt about the technical steps by NGO named PRADAN. During the training, she did a Rain shelter vegetable cultivation (Tomato) experiment at her farm using rain shelter technology on 10 decimal trail plots. The system of planting consisted of planting 5 plants in three rows i.e. 5*3= 15 plants. Cultivation time is generally July last/ August first. The average input cost of the trial plot was about 2000/-. After the experiment, the net profit on the trial plot was approximate 5,000/-. After the experiment, she decided to expand her vegetable growing area to 20 decimal. She earns Rs. 400/- per week for about six months. Now, looking at her success, 30 villagers have become interested in rain shelter cultivation and have adopted the technique.

Orchard in Nayagram

Orchard has been found remunerative in the arid zone like Nayagram(Figure 7).

Figure 7: Orchard in Nayagram

Mr. Debendra Singh, a farmer, lives in Baksha Village in Nayagram Block in PaschimMedinipur District. He has two sons and one daughter. He has a 20 decimal of land for growing rice as well as 10 decimals for the orchard. Before he became a model farmer, he used to grow rice in the rainy season and did not grow vegetables or other crops during the dry season. The vegetables were often destroyed by insects. He spent a lot of money on buying other vegetables for family consumption. At the time of the rainy season in 2012, he started Mango orchard for the betterment of our life. He can earn Rs. 20000/- per year from the orchard. Other farmers have been motivated by Mr. Singh.

DIRECTIONS FOR FUTURE RESEARCH

The present paper has focused on innovative practices and technology in the field of agriculture that could improve the agricultural productivity in arid zone. This study has shown that there significant improvement in agricultural productivity is possible through adoption of appropriate technology. There is enough scope of future research in the area including the following:

- Identification of different innovative suitable technologies .
- Dissemination of information among the farmers

- Climate smart agriculture
- Development of institutional framework for providing agricultural services
- Integration of local market with global market

CONCLUSION

Our analysis provides some indicators regarding its potential for innovative technologies in the zones in India. The innovative technologies that have been discussed to improve agricultural productivity in the study area of Nayagram are Happa, SRI , Rain shelter, and mango orchard. The analysis indicates the yield advantages of the SRI. The number of households adopting SRI in Nayagram is about 1200. Many households have shown interest in SRI or DSR. The paper highlights the economics of SRI cultivation for tribal households in Nayagram Block in *Jungle Mahal* in West Bengal. SRI has been proved to be economic for the farmer households in the zones of West Bengal. The analysis supports the yield advantages and cost savings of the SRI technique of paddy cultivation. There is an urgent need for proper extension services, particularly on the part of the government regarding the economic and ecological advantages of SRI. The extension support system should work towards awareness building in terms of water use efficiency and improving the allocative efficiency of other inputs. There is also a high impact of production technology like *happa*in the study area. The public investment ofhappa is proved to be economically justifiable. The results of the survey strongly support for the case of adopting innovative agricultural technologies in the arid zones like Nayagram.

KEY TERMS

Happa: Small water harvesting structure
System of Rice Intensification (SRI): A farming method to increase the yield of rice
Jungle Mahal:A region of West Bengal dominated by tribal population
Babui: A type of perennial grass
Sole land: Low Lands where water is relatively more available
Net present Value (NPV): It is defined as the difference between the *present value* of cash inflows (benefits) and the *present value* of cash outflows (costs) over a period of time
Benefit-Cost Ratio (BCR): It is defined as the ratio of the *present value* of benefits and the *present value* of costs .

Rain Shelter Vegetable Cultivation: A technique of production whichmeant to protect vegetable crops from extreme weather conditions like heat and rain.

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