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Deep Water Rice and Pond Based Farming System for Enhancing Water Productivity of Seasonal Flood Prone Areas

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1.0 INTRODUCTION

The vast region on the east coast of India forms the rice-bowl of the country and supports livelihoods of several million rural poor. But now coastal areas are witnessing increased anthropogenic activities and these areas are at a great risk to the adverse effects of human activities and extreme weather events. The deep water ecology (> 0.50 m waterlogging) in these coastal regions have increased over the past years and the increase was due primarily to the construction of roads, highways, rail, roads, canals, embankments on both sides of the rivers and siltation in the river beds and canals. Further, the saucer shaped landforms, non-uniform distribution and heavy rainfall during southwest monsoon season (June to September) and congestion of drainage channels aggravate the problems of waterlogging. This waterlogging situation is rainfall dependant, seasonal and affected areas remain submerged for about 3 months (July-September) under water depths varying from 0.5 m to 2.0 m. At the end of the rainy season when drainage channels become empty, the accumulated surface water starts to receede and the lands become dry from December onwards. In the waterlogged areas farmers grow only rice during rainy season under rainfed condition but success of obtaining profitable crop depends on distribution of monsoon rain, time and depth of flooding/waterlogging. Too much of waterlogging also makes the field unsuitable to grow any crop other than rice in rainy season. Prolonged waterlogging during rainy season for most part of the crop growth reduces tillering and growth of the normal rice crop. Erratic/ early heavy rainfall, results in sudden waterlogging in the rice fields and submerges the crop at early seedling stage.

The crop is damaged completely if this situation occurs in early vegetative period. In some years, early drought affects germination, results highly thin plant population and reduced initial growth of the crop. On the other hand, there is no alternative other than to grow rice in coastal lowlands where surface water accumulation of 0.5-2.0 m occurs during rainy season. So proper establishment of crop before onset of flooding and adoption of waterlogging tolerant rice varieties are of paramount importance to realize net returns from the crop. Early sowing (first week of June) allows the rice crop to grow about 1.2 to 1.3m height within the middle of the August and the crop can cope up with the situation if flood comes after this period. Waterlogging tolerant rice varieties (deep water rice floating rice) can be grown to make the waterlogged land productive during rainy season. Therefore, performance evaluation of improved varieties with better yield potential in deep water areas is one of the critical needs for sustainable rice production in the deep waterlogged ecology.

Thus, in one hand coastal waterlogged areas remain unproductive during rainy season due to excess water. On the other hand, the winter and summer rainfall (November-May) are meager and erratic. As a result after December, the land becomes dry and evapo-transpiration loss of any crops are not meet with the available moisture in the land under rainfed situation. So growing of profitable *rabi* crops without supplemental irrigation is not possible during winter/summer season in the region. Poor aquifer characteristics and saline ground water also limit the crop production. It is therefore, urgently needed to develop appropriate sustainable water and crop management strategies to enhance the productivity of the resource rich coastal waterlogged ecosystem. Average land holding of the farmers in this region is only 0.75 ha and their economic conditions were not good. Hence to raise the income of the farming community, it looks imperative to diversify the rice-fallow cropping sequence with other farming options viz. horticulture, fisheries along with high value field crops. Water harvesting and pond based farming system provides opportunity to increase the economic yield per unit area by virtue of double cropping, diversification of crops and integration of fisheries. In this study farm pond was also designed and implemented to harvest excess water of rainy season and pond based farming system was developed to enhance the land and water productivity. After harvesting rice, second crops were grown on the same land utilizing supplemental irrigations from the harvested rainwater of the pond. Water productivity was enhanced through multiple use (fisheries + on-dyke horticulture + growing of crops during dry season with supplemental irrigations) of harvested water.

2.0 AGRO-CLIMATIC CHARACTERISTICS OF STUDY AREA

Among the eastern Indian coastal states, Orissa is the most vulnerable to elevated climate induced natural disaster and extreme weather events because of its geographical position. The state is placed at the head of the Bay of Bengal and even a slight change in the seas behaviour can have an immediate impact on the coast. The Bay becomes the center of low pressures causing heavy rains and cyclones in the coastal Orissa. Hence, as a case study, an attempt was made to enhance the productivity of seasonal waterlogged coastal areas of Orissa state through development of sustainable integrated water and crop management technologies. The study was undertaken in representative places ie. Alisha and Churali villages of Satyabadi block and Talajanga village of Puri sadar block, District Puri (Lat. 19°45/, Long. 85°49/, 6m above sea level) from 2006-07 to 2009-10. The spatial location of the study area is given in Fig. 1. On an average, the region receives 1500 mm annual rainfall and 75-80% of which occurs during rainy (June-Sept) season. The mean date of onset of effective monsoon (OEM) was found to be on 16th June and southwest monsoon generally ended on 29th September. The pan evaporation varies from 8.1 mm in May-June to 3.5-5 mm in December-January. In the region, mean maximum monthly temperature ranges from 33 to 37°C during pre-flood period (May - June). During the main flooding period (July-September), the monsoon cloud cover lowers the maximum temperature and temperature within narrow range of 31-32 °C occurs. In November and December, maximum temperature drops to 24-27 °C and night temperature may go below 15 °C.

The bio-physical and socio-economic survey of study villages were carried out and summary results are presented in Table-1. The dominance of seasonal waterlogged areas was the main constraints for successful crop cultivation during *kharif*/rainy season. The villages were dominated by small and marginal farmers with average holding is < 1 ha.

Table-1: Bio-physical and socio economic survey of study villages

Category		Villages		
		Alisha	Churali	Talajanga
Land	Cultivated land	240 ha	112 ha	854 ha
	Water logged area	205 ha	96 ha	257 ha
	Forest land	29.1 ha	25.6 ha	33.2 ha
	Waste land	16.0 ha	12.8 ha	263.4 ha
Demographic pattern	Total population	1291	728	8628
	SC populationv	130	32	873
	Literacy(%)	48	42	53
Socio-Economic Pattern	Landless	15	08	80
	Marginal (< 1 ha)	28	33	440
	Small (1 to 2 ha)	154	98	925
	Medium Big (> 2 ha)	20	06	130
	Average annual income (from Agriculture)	Rs.4000 to 5000/-	Rs.3000/- to 4000/-	Rs. 5000/- to 7000/-

Formulation of agricultural production strategies in deep water areas by organizing brain storming session and meeting with Government officials of Orissa State.

Fig. 1 : Spatial location of the study area

Overview of Waterlogged study area during rainy season at Alisha village, Puri

2.1 Rainfall-Flooding depth relationship in different study years

The saucer shaped topography, non-uniform distribution of rainfall, heavy rainfall during south west monsoon months and congestion of drainage channels create waterlogging in some parts of coastal Orissa. The rainfall distribution of 3 study years with deviation from normal is presented in Table-2. The rainfall-flooding depth relationship for 3 study years and for 3 different waterlogged ecologies are also presented in Fig. 2(a), 2(b) and 2(c), for 2007, 2008 and 2009, crop seasons, respectively. Study revealed that in 2007 and 2008 excess rainfall occurs in early part of the *kharif* season with 21% and 59% more rainfall in June in 2007 and 2008, respectively. In 2009, 29% and 21% excess rainfall occurred in the month of July and September, respectively.

The flooding depth was measured in 3 types of waterlogged ecosystems, situated in 3 different study villages. It was found that there was a relationship between rainfall pattern and flooding depth in the region. The rainfall in *kharif*/ rainy season in the region starts with the onset of south west monsoon on 10th June. Initial rainfall caused the dry soils saturated and flooding or surface waterlogging started after one or two heavy rainfall. In Alisha village (Location-1), flooding depth of more than 1 m occurred in the 3rd week of July in 2008. In 2007 and 2009 flooding depth exceeded 1 m in the second week of August. Maximum flooding depth of about 1.95 m occurred in the first and second week

Table-2: Rainfall (mm) of three crop seasons at Puri district of Orissa

MONTHS	PURI DISTRICT						
	Normal	2007	Dev. (%)	2008	Dev. (%)	2009	Dev. (%)
January	10.9	0.0	-100	24.1	121.1	19.5	95.0
February	25.4	58.5	130.3	16.9	-33.5	3	-88.1
March	15.5	0.8	-94.8	3.5	-77.4	5	-67.7
April	18.5	0.0	-100	66.0	256.7	66	256.8
May	62.1	49.5	-20.3	22.4	-63.9	158	154.4
June	188	228.0	21.2	299	59.0	120	-36.2
July	292	99.2	-66.0	334	14.4	378	29.4
August	298	418.4	40.4	312	4.7	298	0
September	243	390.8	60.8	267	9.8	295	21.4
October	182	86.5	-52.4	49	-73.1	102	-43.9
November	67	8.3	-87.6	26	-61.1	0	-100
December	6.4	0.0	-100	0.0	-100	0	-100
Total	**1408.8**	1340.2	-4.86	1409	0.014	1444.5	2.4

Source: Orissa Agricultural Statistics, Government of Orissa.

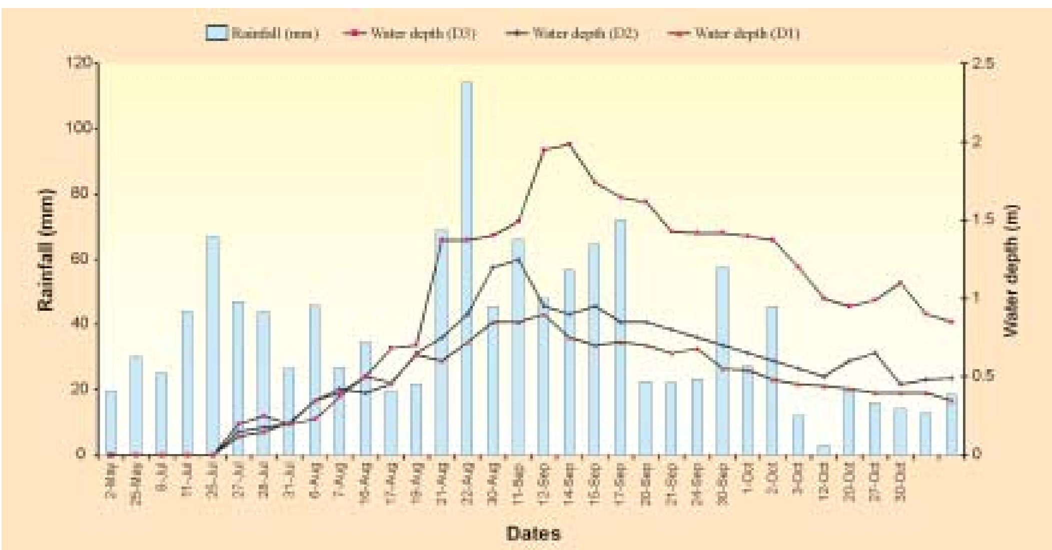

Fig. 2(a): Rainfall-Flooding depth relationship in 2007

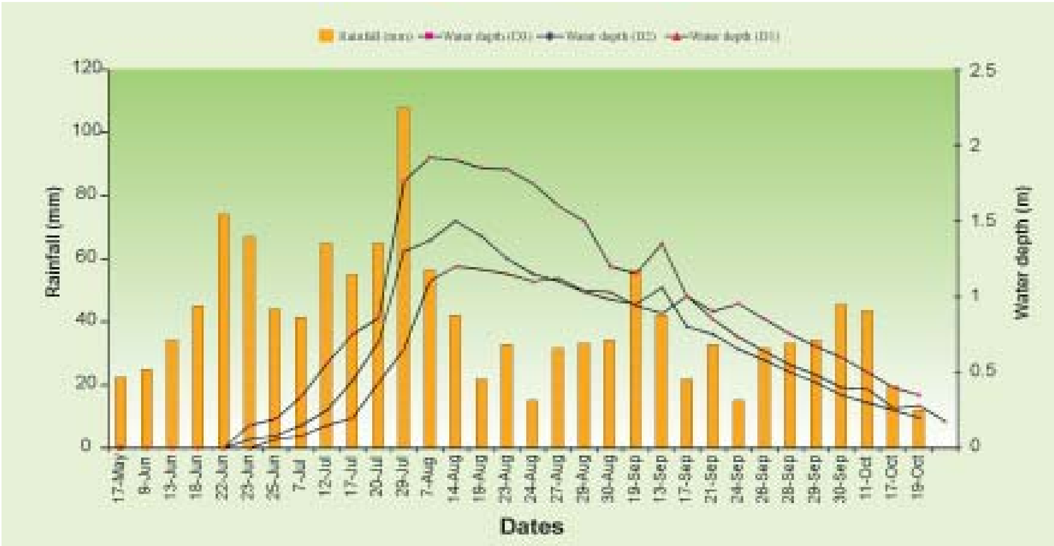

Fig. 2(b): Rainfall-Flooding depth relationship in 2008

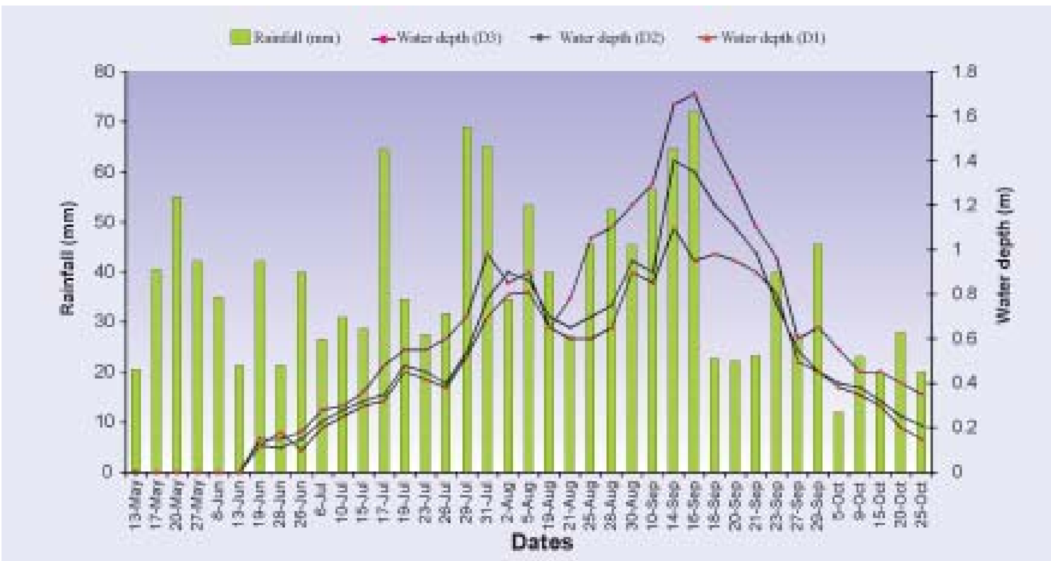

Fig. 2(c): Rainfall-Flooding depth relationship in 2009

of September in 2008 and 2007, respectively. In 2009 though heavy rainfall occurred in last week of July but peak flooding depth was (1.7 m) observed during second week of September after accumulating sufficient amount of rainfall. In other two villages (Location 2 & 3) also, flooding pattern follows rainfall distribution pattern but flooding depth in these two locations was lower than that of the location -1 (Alisha village). In 2007 peak flooding depths of 1.1 m and 0.72 m were observed in location – 2 (Churali) and Location -3 (Talajanga), respectively.

3.0 BASIC SOIL PHYSICAL/CHEMICAL PROPERTIES OF THE SITE

Texture and other physical properties of soils of two representative sites in two waterlogged ecosystems viz., deep waterlogged (1-2 m) and shallow waterlogged (0.5-1m) were analyzed and results are presented in Tables 3(a) and 3(b), respectively. Taxonomically, the soil belongs to very fine, mixed, iso-hyperthermic, vertic endoaquepts soil series. The soil texture varied from clay to heavy clay with higher bulk density (1.59 to 1.65 Mg m^{-3}). The soils were clay textured, poorly drained, with very low saturated hydraulic conductivity (0.11 – 0.24 cm hr^{-1}).

Table - 3(a): Major soil physical properties of seasonal deep waterlogged (1-2 m) ecosystems

Depth (cm)	Sand (2.0 - 0.05 mm) (%)	Silt (0.05- 0.002 mm) (%)	Clay (<0.002 mm) (%)	Texture	Bulk density (Mg m^{-3})	Saturated hydraulic conductivity (cm hr^{-1})
0-15	24.5	19.6	55.9	c	1.59	0.17
15-30	20.4	17.6	62.6	c	1.60	0.20
30-60	12.5	21.7	65.8	c	1.63	0.24
60-90	22.3	15.4	62.3	c	1.65	0.23
90-150	25.6	15.9	58.5	c	1.65	0.11

c = clay

Table - 3(b): Major soil physical properties of shallow waterlogged (0.5-1 m) eco-systems

Depth (cm)	Sand (2.0 - 0.05 mm) (%)	Silt (0.05- 0.002 mm) (%)	Clay (<0.002 mm) (%)	Texture	Bulk density (Mg m^{-3})	Saturated hydraulic conductivity (cm hr^{-1})
0-15	25.6	36.9	37.5	cl	1.53	0.17
15-30	41.0	37.6	21.4	cl	1.55	0.20
30-60	15.0	42.6	42.4	sic	1.60	0.24
60-90	41.1	36.3	22.6	1	1.62	0.23
90-150	24.6	39.9	35.6	cl	1.62	0.11

Cl = clayloam, sicl = silty clay, 1 = loamy

Before initiating the experiments, 52 soil samples (0-15 cm and 15-30 cm) were collected from different farmers' field and soil chemical properties in respect of pH, EC, organic carbon, Ca & Mg, Available N, P, K were analysed in the laboratory. The results are presented in Table-4.

The soil reaction was moderately acidic with the pH ranged between 5.18 and 6.15. The available N in these fields varied form 109 to 259.5 kg/ha which belonged to low to medium category. The available phosphorous ranged between 10.21 to 20-56 kg/ha. The available potassium was also in the medium range category which varied from 95-195 kg/ha. No salt problem was detected in the soil profile and the highest electrical conductivity of 1 d S m[1] was observed at 0.15–0.30 m soil depth. The organic carbon status of the soils was moderately high which ranged between 0.45-1.75 %.

Table-4: Analysis of soil chemical properties of deep water project sites at Puri District

Sl. No.	pH		EC (dsm⁻¹)		Organic carbon (%)		Ca & Mg (meq/100g)		Avail. N (Kg/ha)		Avail. P (Kg/ha)		Avail. K (Kg/ha)	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
F1	5.73	5.90	0.44	0.66	0.87	1.10	0.45	0.75	145.6	148.6	12.48	19.65	113.4	145.6
F2	5.65	5.80	0.76	0.86	0.95	0.70	0.25	0.48	205.2	178.6	12.69	10.21	120.5	115.5
F3	5.55	4.71	0.47	0.56	0.80	0.65	0.18	0.95	143.6	205.5	14.50	15.07	95.5	110.10
F4	5.98	5.18	0.57	0.69	0.75	0.90	0.25	0.46	145.0	194.2	16.25	14.09	115.5	154.40
F5	5.60	6.05	1.06	1.05	1.15	1.05	0.20	0.65	109.4	174.4	13.92	16.03	124.9	119.55
F6	5.65	6.15	0.89	0.75	1.05	0.96	0.16	0.82	146.6	136.8	12.98	10.65	123.34	154.67
F7	6.12	5.60	0.45	0.80	0.86	0.95	0.17	0.45	240.2	201.6	12.80	19.2	97.23	98.22
F8	5.60	5.50	0.60	0.90	0.80	0.85	0.15	0.25	215.6	210.8	14.56	15.7	149.14	120.07
F9	5.70	5.70	0.90	0.85	0.65	1.05	0.18	0.65	220.6	194.7	15.29	17.9	185.15	191.38
F10	5.95	5.50	0.60	0.85	0.60	0.75	0.20	0.25	148.0	144.5	16.42	18.6	110.29	119.55
F11	5.80	6.10	0.48	0.84	0.75	0.75	0.22	0.45	225.6	238.5	10.28	20.50	123.34	154.67
F12	5.85	5.40	1.05	0.75	0.60	0.70	0.42	0.40	245.2	220.6	12.69	12.21	97.23	105.8
F13	6.15	5.20	0.40	0.85	0.75	0.96	0.48	0.55	210.6	218.2	14.56	22.12	149.14	125.5
F14	6.40	6.10	0.65	0.74	0.80	0.85	0.65	0.45	230.0	215.2	16.29	18.12	185.15	190.3
F15	5.85	5.10	0.66	0.5	0.86	0.50	0.38	0.40	186.4	205.1	12.42	16.15	110.29	120.55
F16	5.75	5.25	0.65	0.55	0.90	0.60	0.40	0.75	245.6	240.5	10.28	14.65	123.34	124.67
F17	5.90	5.40	0.80	0.80	0.95	0.75	0.28	0.90	200.5	220.9	12.69	20.20	107.23	105.22
F18	5.80	6.10	0.95	0.85	1.10	0.80	0.34	0.45	259.5	275.5	20.56	14.07	140.25	125.07
F19	5.60	6.80	0.60	0.64	1.10	0.95	0.25	0.45	212.0	204.2	16.29	17.09	105.24	115.5
F20	5.55	6.15	0.65	0.75	0.96	0.50	0.4	0.6	256.5	204.4	10.42	9.05	132.29	129.8
F21	4.85	6.10	0.45	0.45	0.85	0.76	0.3	0.4	275.8	246.8	14.28	8.65	105.34	150.8
F22	5.65	5.95	0.58	0.25	1.10	0.55	0.36	0.6	200.5	225.6	12.89	11.06	98.75	102.5
F23	5.60	6.10	0.48	0.65	0.55	0.45	0.15	0.45	175.6	209.2	11.16	13.07	140.2	145.5
F24	5.75	5.55	0.69	0.55	0.65	0.70	0.15	0.16	272.0	159.2	15.29	14.15	185.2	195.38
F25	6.05	5.40	0.55	0.50	1.05	0.84	0.15	0.6	245.8	172.4	17.89	16.15	110.3	120.55
F26	5.55	6.05	0.60	0.51	1.10	0.65	0.16	0.6	208.4	214.8	18.42	15.5	119.4	120.55

4.0 WATER QUALITY

Water samples of different ponds were collected and important physico-chemical characteristics were analyzed in the DWM laboratory. Based on the results, suitable cropping/farming systems were suggested. The results of water quality analysis are given in Table 5(a). Study revealed that use of pond water as irrigation was safe because electrical conductivity values were lower (0.20 to 1.10 dS/m) than that of the critical

limit (4.0 dS/m). In one pond (pond6), the electrical conductivity and Na were excessively higher with the values being 3.8 dS/m and 531.25 Mg/l, respectively, which might be due to localized presence of Na in strip.

The water quality of 4 tube wells was also analyzed and it was found that the electrical conductivity of one tube well was high with the values being 3.2 dS/m. Conjunctive use of this tube well water with fresh water is suggested for irrigation purpose. The water from other tubewell was safe to use for irrigation.

Table – 5(a): Results of water quality analysis of different ponds constructed at Alisha village, Puri

Sources	EC	pH	Ca (Mg/l)	Mg (Mg/l)	Cl (Mg/l)	SO4 (Mg/l)	K (Mg/l)	Na (Mg/l)
Pond1	0.20	6.90	0.0	0.156	0.070	-	0.67	35.17
Pond2	0.70	6.90	0.12	0.260	0.126	7.41	4.28	61.28
Pond3	1.10	7.10	0.23	0.124	0.030	-	2.12	70.9
Pond4	0.90	6.90	0.10	0.140	0.125	9.43	4.50	45.9
Pond5	1.20	6.50	0.15	0.340	0.234	10.20	9.32	40.5
Pond6	3.80	6.40	0.55	1.04	0.973	33.40	10.5	531.25
Pond7	0.85	6.85	0.138	0.115	0.068	1.62	1.2	32.3
Pond8	1.23	6.75	0.154	0.212	0.102	2.35	1.53	20.5
Pond9	1.10	7.05	0.169	0.210	0.036	2.04	2.34	35.3
Pond10	0.95	6.85	0.145	0.146	0.138	1.88	3.86	48.5

Pond1 = Pandav Pradhan, Pond 2-= Jagabandhu Swain, F Pond 3 = Sarbeswar Pradhan Pond 4 = Indramani Jena, Pond 5= Indramani Swain , Pond 6 = Prabhakar Biswal, Pond7 = Pandav Biswal, Pond8-= Prafulya Sahoo, Pond9 = Sibanarayan Mohanty, Pond10 = Chandramani Sahoo

Table - 5(b): Results of water quality analysis of different available water sources in the study area

Sources	EC	pH	Ca (Mg/l)	Mg (Mg/l)	Cl (Mg/l)	SO4 (Mg/l)	K (Mg/l)	Na (Mg/l)
Open well	1.00	6.65	0.12	0.27	0.253	-	3.57	93.87
Tubewell 1	2.20	6.95	0.35	0.254	0.190	-	2.35	240.50
Tubewell 2	1.10	6.90	.090	0.298	0.145	2.41	3.45	161.28
Drainage channel	2.10	7.40	0.306	0.49	0.479	10.16	9.0	187.5
Tubewell 3	3.20	7.21	0.705	1.10	0.875	0.32	2.98	330.25
Tubewell 4	1.05	7.0	0.345	1.01	0.565	0.12	3.45	223.4

Tubewell 1= Dhruba Charan Pradhan (Alisa), Tubewell 2 =Brajabandhu Swain (Talajanga), Tubewell 3 = Laxman Mahapatra (Alisa), Tubewell 4 = Indramani Sahoo

4.0 CULTIVATION OF DEEP WATER RICE

In the deepwater ecosystem (0.5-2.5 m depth) normal lowland rice varieties fail to grow successfully. Prolonged waterlogging for most part of the crop growth reduces tillering and normal growth of the rice crop, somtimes flash flood inundates in standing crop for 8-10 days at a stretch, resulting in mortality. To overcome that problem, DWR varieties were introduced in the seasonal waterlogged areas. These DWR varieties have to adopt more complex ecosystem than those of rice of other ecosystem, which changes from rainfed upland conditions with drought in the early growth stages to a deeply flooded condition with variable flooding patterns during the rest of the growth cycle. Deepwater rice grows under rainfed dry land conditions for 1-1.5 months before the onset of flood, when plant produces basal tillers. With inundation, the plant becomes an emergent microphyte and grows in an aquatic environment for the remaining 3-4 months of its life. Nodal roots absorb nitrogen, phosphorous and probably other nutrients from floodwater. Stem elongation is stimulated by partial submergence; it results from cell division and elongation of cells in the control of two complementary genes.

5.1 Performance of DWR varieties in waterlogged situation.

Based on earlier study it was revealed that if flood comes before 2nd week of August, the farmers may not obtain any yield even from deep water rice (DWR). It was found that due to late season peak flood in 2007 and 2009, DWR produced more yield than that of local. The performance three DWR varieties viz., 'Hangseswari', 'Ambika', 'Saraswati' was compared with that of local variety ' Bankei' at Alsiha village (D3 location) where average flooding depth was >1.2 m from second week of August. The deepwater rice varieties were sown (spacing: 25 cm x 15 cm) in the first week of June with the pre-monsoon shower. The fertilizer dose of 30:20:20 was applied as basal. The comparison of crop growth attributes and yields of deepwater rice varieties with local one (Bankei) are given in Table-6.

Table-6: Comparison of crop growth attributes and yields of deepwater rice varieties with local cultivar

Plant attributes	Hangseswari (DWR)			Ambika (DWR)			Saraswati (DWR)			Bankei (Local)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Crop Height (cm)	190	182	190	180	175	182	175	170	176	160	155	165
Tillers/m^2	290	270	276	284	272	276	280	277	273	175	180	189
Plant/m^2	28	26	27	27	25	24	27	25	27	12	14	14
LAI	3.9	3.1	3.2	3.7	3.2	3.3	3.8	3.2	3.4	2.6	2.4-	2.5
Panicles/m^2	266	236	251	243	231	245	252	228	251	100	89	108
Grain yield (t/ha)	2.35	1.85	2.45	2.0	1.6	2.1	2.10	1.3	2.3	0.85	0.45	1.0
Straw yield (t/ha)	9.25	7.35	9.14	9.15	9.24	8.75	9.20	8.95	8.55	6.95	6.67	6.50

DWR= Deep Water Rice

5.2 Seasonal variation of crop growth and yield of DWR varieties in relation to flooding depth

The crop was grown in line (spacing: plant to plant distance 15 cm, row to row distance 25 cm) in three different waterlogged ecologies viz., shallow (D_1) (0.60 – 0.80 m), medium (D_2) (0.8-1.2 m) and deep flooded (D_3) (> 1.2 m). Study revealed that crop performs well when water accumulation depth was less than 1.5 m. After onset of peak monsoon, the flood occurred in the second week of August and crop remained submerged for 7 days in Alisha and Churali villages. In D_1 ecology the "Hangseswari" variety recorded 2.3 to 2.71 t/ha

Table-7(a): Comparison of yields (t/ha) of deepwater rice varieties with local cultivar at different waterlogged ecologies in 2007

Fields	D_3 location (village-Alisha)			D_2 location (village-Churali)			D_1 location (village - Talajanga)		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
F_1	1.42	1.32	0.58	1.82	1.72	0.88	2.87	2.45	1.23
F_2	1.05	1.10	0.54	1.71	1.55	0.95	2.91	2.55	1.34
F_3	1.11	1.05	-	1.60	1.65	0.79	2.91	2.75	1.56
F_4	1.10	1.08	0.78	1.55	1.60	1.12	2.85	2.45	1.35
F_5	1.11	1.04	0.67	1.40	1.35	1.16	2.75	2.50	1.50

V_1= *'Hangseswari'* ; V_2 = 'Saraswati' ; V_3 = *'local (Bankei)'*

Table-7(b): Comparison of yields (t/ha) of deepwater rice varieties with local cultivar at different waterlogged ecologies in 2008

Fields	D3 location (village-Alisha)			D2 location (village-Churali)			D1 location (village-Talajanga)		
	V1	V2	V3	V1	V2	V3	V1	V2	V3
F1	1.15	1.14	0.54	1.50	1.4	0.80	2.20	2.05	1.25
F2	1.05	1.20	0.60	1.54	1.35	0.82	2.24	2.24	1.35
F3	1.10	1.25	0.74	1.46	1.50	0.70	2.49	2.43	1.35
F4	1.20	1.12	0.57	1.50	1.45	0.95	2.35	2.36	1.40
F5	1.12	1.10	0.77	1.38	1.44	1.10	2.30	2.25	1.32

Table-7(c): Comparison of yields (t/ha) of deepwater rice varieties with local cultivar at different waterlogged ecologies in 2009

Farmers fields	D3 location (village-Alisha)			D2 location (village-Churali)			D1 location (village-Talajanga)		
	V1	V2	V3	V1	V2	V3	V1	V2	V3
F1	1.34	1.45	0.61	1.90	1.75	0.89	3.21	2.86	1.45
F2	1.15	1.25	0.57	1.82	1.70	0.98	2.72	2.67	1.46
F3	1.21	1.21	0.60	2.05	1.75	0.85	2.87	2.65	1.58
F4	1.20	1.32	0.71	1.85	1.81	0.90	2.78	2.81	1.48
F5	1.40	1.41	0.65	1.92	1.80	1.05	2.80	2.67	1.44

yield in different farmers field. On the other hand, in the land ecology with more than 1.2 m depth, the yield ranged from 0.11 to 1.62 t/ha.

Poor grain yields of rice in waterlogged areas with more than 1.2 m depth might be due to limited supply of assimilates to the developing grains (sources limitation) and / or because of limited capacity of the reproductive organs to accept assimilates (sink capacity).

6.0 POND BASED FARMING SYSTEM

6.1 Design of rainwater harvesting pond for development of pond based farming system in seasonal deep waterlogged areas

During rainy season (June-September), 0.5-2.0 m depth of surface water accumulates due to saucer shaped land form of the region, high rainfall and poor drainage conditions. On the other hand lands becomes dry from December onwards after receding flood water.

Generally, 25-30% of the total field of a farmer can be converted for water harvesting pond to store rainwater. Rest of the field may be utilized for intensive crop cultivation with harvested water. The ponds were dug in inverted trapezoidal shape and side slope was 1:1, because soil texture was clay to heavy clay. The bund width should be sufficient enough to resist the horizontal and vertical pressure of stagnant water during flood period. Generally, minimum bund bottom width of 8 m and top width of 3.5 m are recommended. The height of the bund was determined by the flooding depth. Study revealed that maximum flooding depth of 2.5 m occured in saucer shaped flood prone coastal areas. Therefore, keeping a free board of 0.5 m, maximum 3 m bund height was maintained for water harvesting pond in flood prone study areas. Since pond bund remains under continuous stagnant water for 3 months, that portion was strengthened by dub grass matting. The depth of pond ranged range between 2-3 m depending upon the water requirement. But shallow depth should be avoided as it favours high evaporation losses. One or two inlet systems can be designed and constructed on two sides for capturing outside floodwater into the pond. The design parameters of the rainwater harvesting system (pond) is given in Fig. 3.

After designing the water harvesting structures (pond based farming system), ten such systems were constructed at Alisha village, Puri in ten different farmers' field (Table -8).

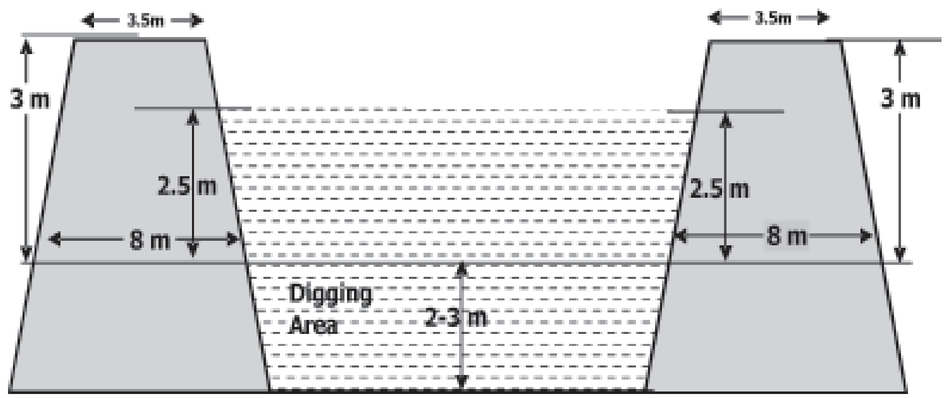

Fig. 3: Design of rainwater harvesting structures for flood prone coastal Orissa.

Table-8: Rainwater harvesting capacity of different ponds

Sl no.	Farmers' field	Volume of excavated area (m^3)	Positive height of harvested water (m)	Harvested Rain water (m^3)	Evaporation loss (Nov-March), (m^3)	Water used for agriculture (m^3)
1	F1	32 x 24 x 2.1	2.10	3456	346	1467
2	F2	32 x 24 x 2.3	1.50	3686	346	1459
3	F3	22 x 16 x 2.1	1.10	1478	158	781
4	F4	19 x 16 x 2.3	1.45	1307	137	520
5	F5	32 x 24 x 2.3	1.50	2918	248	2523
6	F6	32 x 25 x 2.3	1.55	3080	360	2256
7	F7	40 x 30 x 2.5	1.45	4740	365	2525
8	F8	40 x 30 x 2.5	1.50	4800	370	2670
9	F9	40 x 30 x 2.5	1.60	4920	1385	2800
10	F10	40 x 30 x 2.5	2.00	5400	402	2950

The rainwater harvesting capacity, volume of excavated earth, positive height of harvested water and water utilized for providing supplemental irrigation are given in Table-8.

6.2 Volume of harvested water in different ponds

The positive height of harvested water, pizeometric water depth and depth of digging of ponds are shown in Fig. -4. The positive height of harvested water and depth of digging of the pond determine the total harvested water depth. The groundwater table outside the ponds was also monitored using pizeometers. Study revealed that groundwater table depth was less than that of the digging depth (Fig.4), as a result chance of seepage loss from the pond is very less.

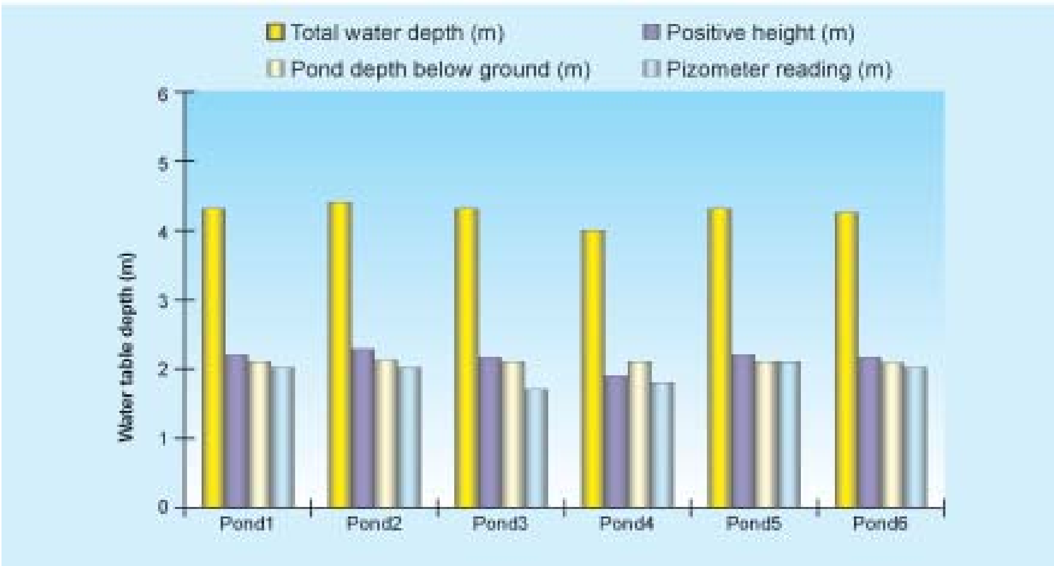

Fig. 4: Total depth of water harvested in different ponds

6.3 Growing of rice after receding flood water and contingent plan

Farmers of this environmentally disadvantaged areas struggle to obtain food security from *kharif* rice. In case of early flood, the entire crop is damaged and farmers even don't get back their seeds. The rice production during rainy season in the seasonal flood prone areas of coastal Orissa, India is highly unstable which depends on the time and occurrence of flood. On the other hand, agro-edaphic conditions are suitable to grow rice in winter (post-flood period), but water scarcity is the major problem for cultivating rice in the season. But to obtain food security, farmers of the region is highly dependant on the rice cultivation. Considering the importance of rice cultivation and non-availability of water in rice production, a study was undertaken to assess the effects of rice establishment methods and irrigation management on crop growth and productivity of rice. The second rice crop will give food security to farmers and can be cultivated where land preparation immediately after receding flood is not possible for growing other high value crops like vegetables.

In this study a medium duration, high yielding variety of 'Lalat' was grown in farmers' field with split plot design where 3 irrigations were assigned to the main plots and 3 methods of rice establishment were imposed in subplots. The three rice establishment methods were P_1 (transplanted puddle rice), P_2 (direct dry seeded broadcast), P_3 (direct wet seeded broadcast followed by beushening). The 21 days' old seedlings were transplanted at 20cm x 15cm spacing. The three irrigations were I_1 (continuously submerged), I_2 (Irrigation after 2 days drying), I_3 (Irrigation after 4 days of drying).

The dry weight of leaves, stems and panicles were determined separately after over drying for 3-5 days at 60^0c until a constant weight is reached. Grain yields from an area of 1m x 1m were recorded and converted on hectare basis. The statistical analysis of the data was carried out using standard statistical techniques (Gomez and Gomez, 1984).

Water balance

The crop evapotranspiration (ETc) and percolation of water under different rice establishment and irrigation practices were computed by Drum technique of Dastance et al., (1966) and are presented in Table-9.

Table-9: Water balance of *rabi* rice (cv. Lalat) under different management practices

Treatments	Irrigation (mm)		Rainfall (mm)		ET_C (mm)		Percolation (mm)		ET_C + percolation	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
P_1I_1	1020	1015	154	167	720	705	410	420	1130	1125
P_1I_2	835	945	154	167	720	705	380	395	1100	1100
P_1I_3	739	755	154	167	720	705	330	345	1050	1050
P_2I_1	705	610	154	167	720	705	255	268	975	973
P_2I_2	569	595	154	167	720	705	227	245	947	950
P_2I_3	525	575	154	167	720	705	205	235	925	940
P_3I_1	738	730	154	167	720	705	386	395	1106	1100
P_3I_2	615	620	154	167	720	705	365	380	1085	1085
P_3I_3	585	570	154	167	720	705	350	370	1070	1075

Crop growth and yield attributes under different rice establishment and irrigation practices.

Among growth attributes, the difference of the 1000 grain weight of rice grain are not statistically significant in different rice establishment methods and irrigation regimes. Averaged over irrigation methods, highest number of panicles per m^2 was observed in transplanted puddled rice(P1), followed by direct wet seeded broadest (P_3) and the lowest value was registered in direct dry seeded broadcast (P_2) (Table-10). Irrigation regime also had significant effect on panicle/m^2, H.I and grain yield. The minimum values were obtained in I_3. The highest value of H.I was observed in (P_1) followed by P_3 and P_2. The planting method had no significant influence on test weight. The P_1 treatment had the highest average grain yield (5100-5250 kg/ha) under I_1 regime.

Average over irrigation regimes, the yield reduction in P_2 was 7.56% as compared to P_1. In each planting technique irrigation water input affected the grain yield significantly. Average across planting methods, the yield reduction in I_2 and I_3 was 7.74 and 15.2%, respectively as compared to I_1.

Table-10: Crop growth and yield attributes of *rabi* rice (cv. Lalat) under different rice establishment and irrigation practices

Treatments	Plant height (cm)		Panicles/m2		Harvest Index		1000-grain weight		Yield (kg/ha)	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
I_1P_I	119	120	329	342	0.4	0.41	24.5	23.8	5220	5100
I_2P_I	117	122	319	329	0.38	0.39	24.6	24.6	4850	4810
I_3P_I	118	121	285	296	0.35	0.36	25.4	25.1	4450	4510
I_1P_2	110	117	220	229	0.30	0.37	24.9	24.3	4020	3950
I_2P_2	111	112	202	205	0.26	0.26	24.5	25.2	3620	3600
I_3P_2	112	110	190	185	0.23	0.22	24.1	23.9	3330	3250
I_1P_3	114	114	296	290	0.28	0.29	25.1	24.6	4750	4550
I_2P_3	115	115	270	272	0.24	0.25	25.1	25.2	4405	4250
I_3P_3	114	115	248	245	0.20	0.27	25.2	25.1	4280	4110

L.S.D (0.01): Irrigation : 33.28 Planting method: 24.55, Irrigation x planting method: 42.33 for grain yield

Water productivity

Water productivity (net) was calculated as the cost of produce per unit amount of water used for evaporation or per unit area (NWP_1) or cost obtained per unit amount of water required for evaporation and percolation losses. (NWP_2).

Table-11: Water productivity *rabi* rice (cv. Lalat) in different rice establishment and irrigation practices

Treat-ments	Gross return (Rs/ha)		Cost of cultivation (Rs/ha)		Net returns (Rs/ha)		ET (mm)		ET + percolation (mm)		NWP_1 (Rs/m^3)		NWP_2 (Rs/m^3)	
I_1P_1	36540	35700	19440	18600	19440	18600	720	705	1130	1125	2.7	2.6	1.7	1.6
I_2P_1	33950	33670	17500	17220	1750	17220	720	705	1100	1100	2.43	2.4	1.5	1.5
I_3P_1	31150	3150	13150	13570	13250	13570	720	705	1050	1050	1.84	1.9	1.2	1.2
I_1P_2	28140	27650	13140	12650	13140	12650	720	705	975	973	1.82	1.7	1.2	1.2
I_2P_2	25340	25200	10840	10700	10840	10700	720	705	947	950	1.50	1.5	1.0	1.0
I_3P_2	23310	22750	9310	8750	9310	8750	720	705	925	940	1.29	1.2	1.0	0.9
I_1P_3	33250	31850	17150	15750	17150	15750	720	705	1106	1100	2.38	2.2	1.5	1.4
I_2P_3	30830	29750	15385	12900	15385	12900	720	705	1085	1085	2.13	1.8	1.4	1.1
I_3P_3	29960	28770	12960	11720	12960	11720	720	705	1070	1075	1.8	1.6	1.2	1.1

6.4 Growing of extra early variety for contingency planning

Due to flood in September, 2007 main *kharif* rice crop in higher depth of waterlogging (>1.5m) was damaged and land became fallow during post-flood period. To compensate that loss, as a case study extra rice variety, 'Heera' was grown with fertilizer dose of 100:50:50 (N:P:K) in the Alisha village, Puri as acontingent crop with the help of carry-over flood water only. This 'Heera' rice variety was transplanted in 3rd week of November 2008 and harvested in 1st week of February, 2009 and recorded average grain yield of 2.57 t/ha (Table 12). '*Heera*' rice was found to be very promising as contingent crop which could be grown during pre-*rabi* period when main *kharif* rice crop fails to grow due to flood.

Table–12: Duration and productivity of extra early rice variety "Heera" in farmers' field

Sl.No	Name of Farmers	Date of transplanting	Date of flowering	Date of harvest	Grain yield (t/ha)
1.	Bhimasen Pradhan	08.11.08	13.01.09	08.02.09	2.51
2.	Arjun Pradhan	14.11.08	18.01.09	15.02.09	2.63

6.5 On farm trials of vegetable crops during *rabi*

In areas where land becomes dry immediately after receding surface accumulated water, good tilth condition may appear for growing high value crops like vegetables.

Five salt resistant vegetable crops like watermelon, okra, spinach, brinjal, ridge gourd were cultivated during *rabi* season with harvested water to increase the cropping intensity and productivity of seasonal flood prone areas. Study revealed that the highest net return per hectare, was obtained from brinjal (Rs. 30950/-), followed by watermelon (Rs. 30400) and okra (Rs. 23550/-). Seasonal water use was computed as 670, 680, 540, 742 and 695 mm for watermelon, okra, spinach, brinjal and ridge gourd, respectively (Table-13). Highest net water productivity was obtained from water melon with the value being Rs. 4.53/m^3.

6.6 Enhancing water productivity through pond based farming system

Attempts were also made in this study to develop mitigation strategies through contingency crop planning and pond based farming to enhance the productivity of coastal waterlogged areas. Study revealed that introduction of deep water rice varieties during rainy season and cultivation of fishes, *rabi* crops with the harvested water of rainy season enhanced and

Table-13: Rice equivalent yield (RYE), net return and water use of different salt tolerant vegetables (Pooled data of 2007-08 and 2008-09)

Crops	Rice equivalent yield (t ha^{-1})	Water use (mm)	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	NWP (Rs./m^3)
Water melon	7.20	670	54600	30400	4.53
Okra	6.8	680	50500	23550	3.46
Spinach	5.04	540	35980	13280	2.45
Brinjal	7.55	742	56700	30950	4.17
Ridge gourd	5.9	695	44100	22340	3.21

stabilized the productivity of deep waterlogged area. The water productivity was enhanced from rice to integrated farming system (Fig. 5). From sole rice the net water productivity of Rs. 1.55-1.6/m^3 was obtained, whereas net productivity of Rs. 6.98 - 7.26/m^3 was obtained from Rice + Fish + On-dyke horticulture + *rabi* crops.

From constructed ponds (for 4 ponds data was available), net returns of Rs. 19807-23158/ha were obtained (Table-14,a) during 2008-09. In 2009-10, Rs. 28,317-31392/ha net returns were obtained from the same field (Table14, b).

Table 14 (a): Net return from pond based farming system during 2008-09

Pond	Pond based framing area (ha)	Income (Rs) from				Total income (Rs)	Total exp. (Rs) of cultiva-tion	Net returns (Rs) from the land	Net returns (Rs/ha)
		Kharif	Rabi (vegetables +rice)	Fish	on Dyke crops				
F1	**0.63**	-	19250	9050	2850	31150	16560	14590	23158
F2	**0.70**	-	19535	11235	3350	34120	16920	17200	24571
F3	**0.70**	-	20145	9045	2835	32025	18160	13865	19807
F4	**0.82**		20750	11745	2910	35405	18930	16475	20091

F_1= Sarbeswar Pradhan,F_2= Pandav Pradhan,F_3 = Jagabandhu Swain,F_4=Indramani Jena

Table-14 (b): Net return from pond based farming system during 2009-10

Pond	Pond based framing area (ha)	Income (Rs.) from				Total income (Rs)	Total exp. (Rs.) of cultiv-ation	Net returns (Rs) from the land	Net returns (Rs/ha)
		Kharif	*Rabi* (vegetables +rice)	Fish	on Dyke crops				
F1	0.63	-	22345	12400	3250	40995	18760	22235	30531
F2	0.70	-	18675	17650	3540	39865	17890	21975	31392
F3	0.70	-	23450	14565	3450	41465	20545	20920	29885
F4	0.82		24560	16540	3670	44770	21550	23220	28317

F1= Sarbeswar Pradhan,F2= Pandav Pradhan,F3 = Jagabandhu Swain,F4=Indramani Jena

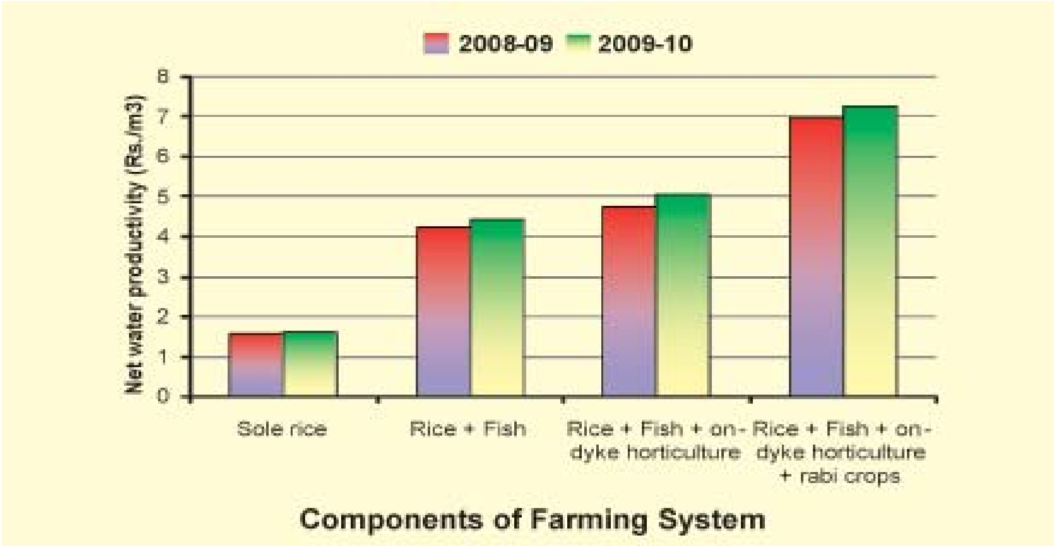

Fig. 5. Comparison of water productivity from different components of farming system

7.0 EXPLOITATION OF SHALLOW GROUNDWATER TABLE THROUGH SHALLOW TUBE WELL

Aquifer characteristics of the study areas

Aquifer characteristics of the study area revealed that it has a huge pile of unconsolidated sediments in which clays appear to predominate. The clays encountered in the deltaic tracts are sticky in nature. However there is a sandy zone below 5-6 m and it extends up to a depth of 9 m to 11 m where feasibility of very shallow tube well can be explored to exploit shallow fresh ground water. Below that level water yield is very less. However, lower aquifer below 195-300 m bears good quality ground water but it is expensive to use. Pumping test data revealed that recharge rate varies from 1.18 to 4.7 m^3/hr in sandy zone and 0.9 to 3.4 m^3/hr in clayey zone. This type of perched aquifer extends to several kilometer length with 4-5 km width. This zone extends upto 5 to 10 km from sea shore.

In this study 4 shallow tube wells were installed at a depth of 12 m. Details of soil layers of 4 sites are given in Table-15. By installing 2.5 H.P pump, shallow groundwater was drawn and used for irrigating crops in command areas of different tube wells.

Table-15: Types of soil layers at different depth of tube well

Soil layers	Depth (m)			
	F1	F2	F3	F4
Sandy Clay	0-3.6	0-3.35	0-3.9	0-3.9
Clay	3.6-6.09	3.35-5.48	3.9-6.7	3.9-6.4
Water bearing sand	6.09-9.75	5.48-9.4	6.7-10.6	6.4-11.58
Clay	9.75-13.0	9.4-13.0	10.6-13.0	11.58-13

F1: Dhruba Charana Pradhan; F2: Laxman Mohapatra; F3: Indramani Sahoo (Alisha Village), F4: Brajabandhu Swain

Different vegetable crops like potato, okra, cucumber, bitter gourd, cucumber, chilli, spinach were grown in the command areas of three tubewells. Study revealed that Rs.22869 to 28,420 per ha net returns were obtained in the command areas of different tube wells through vegetables cultivation. The command areas of each tube well, gross and net returns in the commands are presented in Table 16 and Table 17 for the year 2008-09 and 2009-10, respectively.

Table – 16: Net returns from the command areas of the tube wells during *rabi* 2008-09

Area (ha)	Crops grown	Numbers of farmers involved	Cost of cultivation from land (Rs.)	Gross return from the land (Rs.)	Net return from the land (Rs.)	Net returns (Rs/ha)
Command areas of Tubewell-1						
1.75	Potato, okra, cucumber, bitter gourd, cucumber, chilli, spinach	14.0	35380	77991	42611	24349
Command areas of Tubewell-2						
1.00	Pumpkin, cucumber, chilli, Bitetr gourd.	9.0	19350	47770	28420	28420
Command areas of Tubewell-3						
1.30	Cauliflower, brinjal, chilli	18.0	25050	54780	29730	22869
4.05 ha						

Table –17: Net returns from the command areas of the tube wells during *rabi* 2009-10

Area (ha)	Crops grown	Numbers of farmers involved	Cost of cultivation from land (Rs.)	Gross return from the land (Rs.)	Net return from the land (Rs.)	Net returns (Rs/ha)
Command of Tubewell-1						
1.80	Potato, okra, cucumber, bitter gourd, cucumber, chilli, spinach	15.0	37500	80991	43491	24161
Command of Tubewell-2						
0.95	Pumpkin, cucumber, chilli, Bitetr gourd.	11.0	21850	44770	27920	24126
Command of Tubewell-3						
1.25	Cauliflower, brinjal, chilli	18.0	27550	59780	32230	25784
4.00 ha						




8.0 EVALUATION OF PRODUCTIVITY OF DEEP WATER RICE IN *KHARF* AND HIGH YIELDING RICE IN *RABI* SEASON IN FARMERS' FIELD

8.1 Performance of deepwater rice under farmers' management during *kharif* season

During *Kharif* 2007, deep water rice variety 'Hangseswari' were grown in three villages of Puri district *viz*, Alisha, Churali and Talajanga in 10.1 ha of area by involving 34 farmers to evaluate the performance of this variety under farmers' management practices. The crops was sown in the month of June with pre-monsoon shower. The fertilizer dose of 20:20:20 was applied at basal. Prolonged waterlogging of 0.5-1.5m depth caused 40-50% damage to local varieties but 'Hangseswari' variety thrived very well. The maximum flood water depth in Alisha was 1.57 m, while in Churali and Talajanga, maximum water depths were 1.48 m and 1.41 m, respectively with average depth of standing water of about 1 meter, continued till mid-October. In Alisha village, yields of 'Hangseswari' ranged from 825 to 3196 kg/ha with the average yield for the village being 1527 kg/ha. In Churali, yield of 'Hangseswari' ranged from 2187 to 2600 kg/ha with village average of 2350 kg/ha. In Talajanga village, average grain yield was 2200 kg/ha. The overall average yield of 'Hangseswari' was 1700 kg/ha. The 33.8% to 149.3% higher yield was observed in 'Hangseswari' than that of local cultivar 'Bankei'. The productivity of the 'Hangseswari' rice in different study villages during *kharif* season of 2007, 2008 and 2009 are given in Table-18.

Table - 18: Performance of 'Hangseswari' rice variety in different farmers' field in different study years

Villages	Farmers involved	2007		2008		2009	
		Area (ha)	Average yield (kg/ha)	Area	Average yield (kg/ha)	Area (ha)	Average yield (kg/ha)
Alisha	26	7.3	1527	6.57	1040	7.37	1938
Churali	5	2.0	2356	2.22	920	1.45	1785
Talajanga	3	0.8	2219	1.79	2410	1.36	2780

In 2008, highest water depths of 192 cm was observed in Alisha village, 203 cm in Churali and 180 cm in Talajanga, caused 30-40% damage in 'Hangseswari' rice variety and 70 to 100 % damage occurred in local rice variety 'Bankei'. Even under extreme submerged situation in 2008, 'Hangseswari' variety recorded a yield level of 1040 kg/ha in Alisha, 920 kg/ha in Churalli and 2410 kg/ha in Talajanga village, Puri.

8.3 Performance of HYV rice during the *rabi* seasons under farmers' management

During *rabi* 2006-07, high yielding medium duration rice varieties ***Lalat (Samrat) Parijat*** and ***Khandagiri*** were transplanted in the month of December, 2006 after receding flood in Alisha village. Twenty eight farmers were involved in *rabi* rice programme. Improved packages of practices with supplemental irrigation from harvested water of the pond and carry-over accumulated water were utilized for growing paddy. The performance of Rabi rice during winter season in different study villages during 2006-07, 2007-08, 2008-09 are presented in Table-19.

Table - 19: Performance of *rabi* rice in different farmers' field

Villages	2006-07		2007-08		2008-09	
	Area (ha)	Productivity (kg/ha)	Area (ha)	Productivity (kg/ha)	Area (ha)	Productivity (kg/ha)
Alisha	20	3350	7.5	4550	7.2	4780
Churali	4	--	1.8	4015	1.8	3980
Talajanga	4	--	1.2	4450	1.5	4675

8.4 Productivity of high yielding varieties of rice during rabi 2008-09

9.0 TECHNOLOLOGY DISSEMINATION PROGRAMME ORGANIZED

Training cum awareness programme on "Enhancing productivity of deep water areas

A training cum awareness programme on "Enhancing productivity of deep water areas" was organized on 28.10.2007 at DWM, Bhubaneswar. The programme was attended by 80 progressive farmers and NGOs and SHGs Deep water rice varieties, pond based farming system, introduction of aquatic species, rice-fish integrated farming system, pest and disease management etc. were discussed. Possibility of linking state government to implement some of the successful technologies of DWM was also discussed in that training programme. Director of Agriculture, Govt. of Orissa Dr. A.K. Padhee was present as chief guest on the occasion. Dr. Gouranga Kar was the coordinator of the training.

Farmers-Scientists-experts meeting organized at the study village

Several farmers-Scientists-experts meetings were organized at the study village (Alisha) to find out the prospects of technological interventions to enhance the productivity of seasonal deep waterlogged areas.

Research Advisory Committee members of DWM comprises Dr Yaswant Singh, former professor of IIT, Khargpur, Dr P.C.Bhatia, Ex-ADG, ICAR, Dr. T.N.Choudhury, Ex-ADG,

ICAR visited deep water areas of Puri district on 5.9.06 and interacted with the farmers. The committee appreciated the pond based farming technology initiated by the centre to enhance productivity and profitability of this challenging deep water ecosystem.

Third QRT team of DWM comprising of Dr C.D.Tahtte, former Secretary, MoWR, Govt. of India, Shri A.D.Mahile, former chairman, CWC, New Delhi, Dr C.L.Achariya, former Director, IISS, Bhopal visited deep water rice project areas of DWM on 30.11 .06 at Alisha village, Puri, where interventions to combat seasonal drainage congestion problem were made by the centre. During their visit they interacted with the farmers and suggested some possible mechanisms to enhance productivity of seasonal deep waterlogging areas. The team appreciated the interventions and suggested macro-level approach along with micro-level interventions to mitigate the problems.

To appraise the situation and to interact with farmers of the deep water coastal waterlogging areas, Hon'ble former Deputy Director General (NRM), ICAR, Dr J.S. Samra visited the deep water areas of Puri district on 12.11.2006 and interacted with the farmers. He also appreciated the efforts initiated by DWM to enhance productivity of the waterlogged areas through micro-water resources development.

A team comprises of (i) Dr. Panjab Singh, Vice Chancellor, BHU, Banaras, and ex-DG, ICAR (ii) Dr. I.C.Mahapatra, former Vice Chancellor, OUAT, Bhubaneswar (iii) Dr. R.K Singh, former Secretary, NAAS, New Delhi (iv) Dr. H.S Chauhan, former Dean, GB Panth University of Agriculture and Technology (v) Dr. G. Goswami, Scientist SE, TIFAC, DST, New Delhi paid visit to deep water project site at Puri and interacted with the farmers. The team was appraised of the technologies of enhancing productivity of the deep water areas.

Farmers' training programme on "Scalling up of water productivity in Agriculture

One 7-days farmers training programme on "Scalling up of water productivity in Agriculture for livelihoods" was organized on 29th Nov.-5th Dec, 2009 at Alisha village, Puri. During this training programme, 28 resource persons from various institutes had given brief description about the updated technologies on water and crop management for enhancing crop productivity in deep water areas. Farmers' were trained to increase the

water productivity through different means such as deep water rice production technology, crop management planning and practices, crop diversification, rain water harvesting, integrated farming in waterlogged areas, livestock management, *in-situ* water conservation techniques, integrated pest management, irrigation scheduling and water requirement of various crops, pisciculture etc.

Training programme on “Quality seeds production, preservation & use

A training programme on “Quality seeds production, preservation and use for increasing productivity of deep water rice areas” was organized by AID, Bhubaneswar on 06/12/08 and 31.03.2009 in the village Alisha, Satyabadi block of Puri district. Farmers from adopted and neighboring villages participated in the training programme,

Interaction with TIFAC, PRMC members

Project Review and Monitoring Committee (PRMC) from Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi comprising Dr. Panjab Singh, former Director General, ICAR and Vice Chancellor, BHU, Dr. I.C. Mahapatra, former Vice Chancellor, OUAT and BAU, Dr. Anupam Verma, National Professor, IARI, Dr. P.N. Bahl, Former DDG, ICAR (Crop Science), Dr. G. Goswami, Scientist, E, TIFAC, New Delhi visited DWM, Bhubaneswar from 5th to 8th October, 2009. During their visit they reviewed the progress of two ongoing TIFAC sponsored projects at DWM viz., (i)

Enhancing productivity of deep water rice area and (ii) Agricultural diversification for enhancing productivity of acidic upland of eastern India and visited on-farm project sites at Puri, Balasore and Mayurbhanj districts of Orissa. The committee expressed satisfaction on overall progress of the projects and approved for extension of the project for another six months beyond the scheduled ending date. Dr. G. Kar, Pr. Scientist of the centre and Principal Investigator of both the projects organized the visit.

Field day was held on “Enhancing productivity of deep water areas

A field day on “Enhancing productivity of deep water areas” was organised at Sukala Block, Puri on 28th October 2009. Dr. J.S. Samra, CEO, National Rainfed Area Authority, GoI was the Chief Guest. More than 250 farmers participated in that field day. Different aspects of improvement of productivity of deep water rice varieties, pond based farming system, rice-fish integrated farming system, and pest and disease management, etc were discussed. Dr G. Kar, principal scientist of the event coordinated the event.

Interaction with TIFAC PRMC members

The TIFAC PRMC members Dr. Panjab Singh, former DG, ICAR and VC BHU, Dr. I.C. Mahapatra, former VC OUAT and, Dr. G. Goswami, Scientist, E TIFAC, New Delhi, visited the project site on 17.3.2010 at Alisa, Sukala Gram Panchayet, Puri. A field day was organized on "Enhancing productivity of deep water areas" on that day. Dr. Panjab Singh, former DG, ICAR and VC BHU was the Chief Guest on the occasion and more than 500 farmers participated in the field day. Different aspects of improvement of productivity of deep waterlogged were discussed in that day

Collaborative extension programmes

(i) Collaborative extension programmes with Department of Agriculture, Government of Orissa

The State Department of Agriculture, Government of Orissa started seed multiplication of identified improved deep water rice variety ' Hangseswari'. Earlier the seeds of improved deep water rice cultivar Hangseswari' was not in State Seed Chain now the State Government of Orissa released the variety to put under State Seed Chain and adopted for seed production in State Farm to supply to farmers on large scale.

(ii) Collaborative extension programmes with sister ICAR sister organizations

For **Agricultural diversification through multiple use of water**, collaborative extension programmes were made with ICAR sister organizations like CHES (regional centre), Bhubaneswar for disseminating fruit production technology, with CTCRI (regional centre), Bhubaneswar to propagate tuber crop production technology, CRRI, Cuttack and CARI (regional center), Bhubaneswar for disseminating Rice-Fish-Duck production through pond based technology by Organizing farmer's training programme, filed day etc.

(iii) Collaborative extension programmes with Krishi Vigyan Kendra, OUAT, Orissa

Collaborated with Krishi Vigyan Kendra, OUAT, Orissa for dissemination soil management technology, vermi-composting, fertlilizer management and livestock management and resource persons from OUAT imparted training to the farmers during training programme, field day etc., organized by the Institute.

(iv) Collaboration with Bank and other organizations

State Bank of India, Puri has identified the generated technology as Bankable Technology and many farmers have received loan to implement the technology to enhance productivity of waterlogged areas.

The detailed cost estimates, investment, man days generation in Pond based farming in Seasonal Deep Water have been computed and technology has been included under 'National Rural Employment Guarantee Act (NREGA) for implementing on large scales.

10.0 MEDIA COVERAGE AND IMPACT

The training awareness programme and success stories of deep water rice production technologies were also disseminated through TV talks, and print media.

The media coverage of farmers' training/meeting/awareness programme in print media

Sl.No.	Headline of the News	Date of publish	Name of the NewsPapers
1.	"Make use of excess water, farmers told"	29.09.2007	The Indian Express.
2.	"Chha Phut Jalare Dhanachasa"."	26.01.2006	The Indian Express.
3.	"New project to enhance deepwater rice area".	06.12.2005	The Indian Express.
4.	"Contingency crop planning is need of the hour"	30.07.2008	The Indian Express
5.	"Soil testing a must for proper crops"	12.11.2006	The Statesman