Research Bulletin 40

Integrated Technologies to Enhance Productivity of Seasonal Deep Waterlogged Areas

Gouranga Kar, N.Sahoo, Ashwani Kumar, M.Das, S.Roychoudhury and Dinesh Chandra

WATER TECHNOLOGY CENTRE FOR EASTERN REGION
(Indian Council of Agricultural Research)
Chandrasekharpur, Bhubaneswar - 751023, Orissa, India
2007

WTCER

Research Bulletin

Integrated Technologies to Enhance Productivity of Seasonal Deep Waterlogged Areas

Publication No. 40

Gouranga Kar, N.Sahoo, Ashwani Kumar, M.Das, S.Roychoudhury and Dinesh Chandra

WATER TECHNOLOGY CENTRE FOR EASTERN REGION
(Indian Council of Agricultural Research)
Chandrasekharpur, Bhubaneswar - 751023, India

2007

Kar, G., Sahoo, N., Kumar, A., Das , M, Roychodhury , S. and Dinesh Chandra (2007). *Integrated Technologies to Enhance Productivity of Deep Seasonal Waterlogged Areas.* Research Bulletin No. 40, Water Technology Centre for Eastern Region (Indian Council of Agricultural Research), Bhubaneswar-751023, Orissa, India.

Published by

Dr. Ashwani Kumar
Director,
Water Technology Centre For Eastern Region
P.O.: S.E. Railway project complex, Chandrasekharpur
Bhubaneswar-751023, Orissa, India.

Principal investigator

Dr. Gouranga Kar
Senior Scientist

Printed By

Capital Business Service and Consultancy
B-51, Sahid Nagar, Bhubaneswar

PREFACE

Coastal Orissa with high concentration of population and economic activity are particularly vulnerable to multiple weather hazards like flood, drought, cyclone. The saucer shaped land forms, high rainfall (average 1500 mm) due to southwest monsoon (June–September), poor drainage condition makes the coastal region susceptible to waterlogging and flood prone and area remains submerged for about 2-3 months (July – September) under water depths varying from 0.5-2.0 m. In the seasonal deep waterlogged areas in the *kharif* season no cropping is possible due to excess water and in other season agricultural drought of varying intensities limit the crop production potential. Attempts were made in this study to develop mitigation strategies through rainwater harvesting and contingency crop planning to enhance the productivity of deep water coastal areas of Orissa. Deep water rice varieties were introduced in *kharif* season and *rabi* crops were tried with the harvested water of rainy season as a contingency planning to enhance the productivity of the seasonal deep water areas of eastern India. We hope this research will give some solution to achieve food security to farmers of waterlogged areas.

We take this opportunity to extend our deep sense of gratitude and indebtedness to the Director General, Deputy Director General (Natural Resource Management) and Assistant Director General (IWM), ICAR for their encouragement and guidance to carry out the study. Authors' sincere thanks are due to villagers of Alisha village, Satyabadi block, Puri for their active participation during the study. Thanks are due to Director, WTCER, all programme leaders, project associates, scientists, senior research fellows and staff members of WTCER for their moral support and help rendered during the study.

(Authors)

CONTENTS

1.0	**Introduction**	01
2.0	**Present Productivity Constraints of Seasonal Deep Waterlogged Areas**	03
3.0	**Physiography and Drainage of Coastal Orissa**	06
4.0	**General Agroclimatic Conditions of Coastal Orissa**	07
4.1	Seasonal distribution of rainfall	07
4.2	Coefficient of variation of monthly rainfall	08
4.3	Weekly rainfall probability analysis	10
4.4	Monthly rainfall probability analysis	10
4.5	Computation of crop water requirements	13
4.6	Flood probability analysis	14
4.7	Major cyclones in coastal Orissa	14
5.0	**Soils of The Coastal Waterlogged Areas**	16
6.0	**The Study Area**	20
6.1	Socio-economic and demographic pattern	21
6.2	Present cropping system	24
6.3	Flood-drought pattern	24
6.4	Characteristics of floodwater	25
6.5	Soil test report of experimental field	25
6.6	Aquifer characteristics of the study areas	28
7.0	**Development of Natural Resource Management Strategies to Enhance Productivity of Seasonal Deep Waterlogged Area**	29
7.1	Cultivation of deepwater rice and its interrelationship with time and depth of flooding Characteristics of deepwater rice	29
7.2	Design of rainwater harvesting pond for development of pond based farming system	34
7.3	Growing of rice after receding flood water and contingent plan	37
7.4	On farm trials of vegetable crops during *rabi*	38
7.5	Enhanced water productivity through pond based farming system	39
7.6	Introduction of aquatic plant species in seasonal waterlogged ecosystem	41
7.7	Cultivation of Waterchestnut	43
8.0	**Technolology Dissemination Programme Organized**	43
9.0	**Media Coverage and Impact**	48

1.0 INTRODUCTION

The eastern India is the rice dominated area of the country, accounts for about 63.3% of the India's rice area (26.8 mha out of total rice area). Out of that area, 14.7% (3.7 mha) is under deepwater or very deepwater. In Orissa particularly coastal regions are vulnerable to waterlogging and 0.5 mha deepwater or very deep areas are confined to this coastal region. Seasonal deepwater (0.5-1m) area spreads over 0.4 mha and very deepwater (1-2.5m) is confined to 0.1 mha area in Orissa.

Coastal Orissa with high concentration of population and economic activity are particularly vulnerable to multiple weather hazards like flood, drought, cyclone. The saucer shaped land forms, high rainfall (average 1500 mm) due to southwest monsoon (June–September), poor drainage condition make the coastal region susceptible to waterlogging and flood prone and area remains submerged for about 2-3 months (July – September) under water depths varying from 0.5-2.5 m. As a result deepwater and very deepwater area are confined to coastal deltaic region in Orissa.

The coastal deltaic region in Orissa extends from Rushikulya in the south-east to Subarnarekha in the north-east comprising of the districts of Ganjam, Gajapati, Puri, Khurda, Cuttack, Jagatsingpur, Kendrapara, Jajpur, Balasore and Bhadrak. This area is known as the 'rice bowl' of the state but now is troubled by many ecological problems such as salinization, land erosion, sand casting, waterlogging due to impeded drainage etc. and thereby posing a serious threat to the food security of the state.

The waterlogging situation is seasonal and confined mostly during July-October. Due to drainage of water from the upper land to the coastal plains and slow disposal of accumulated water in the plains to the ocean, the waterlogging problem becomes severe. Water logging and drainage problem have reached an alarming dimension in the deltaic region of Mahanadi River. The century delta stage-I (Cuttack district) and Delta-2 (Puri district) are badly affected due to drainage congestion. 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, and time of ocurance of accumulated rainwater. To much of waterlogging also makes the field unsuitable to grow any crop other than rice in rainy season. *Rabi* rice is practiced where canal water is available.

On the other hand, the winter and summer rainfall (November-May) is meager and erratic. As a result after December, the land becomes dry and evapo-

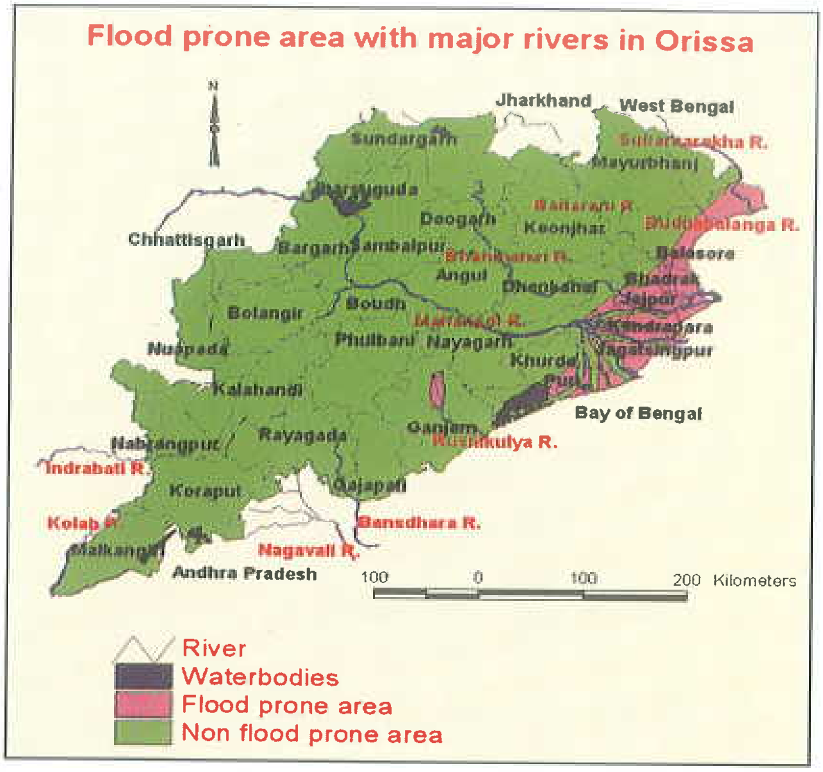


Fig.1(a) : Flood prone area with major rivers in Orissa

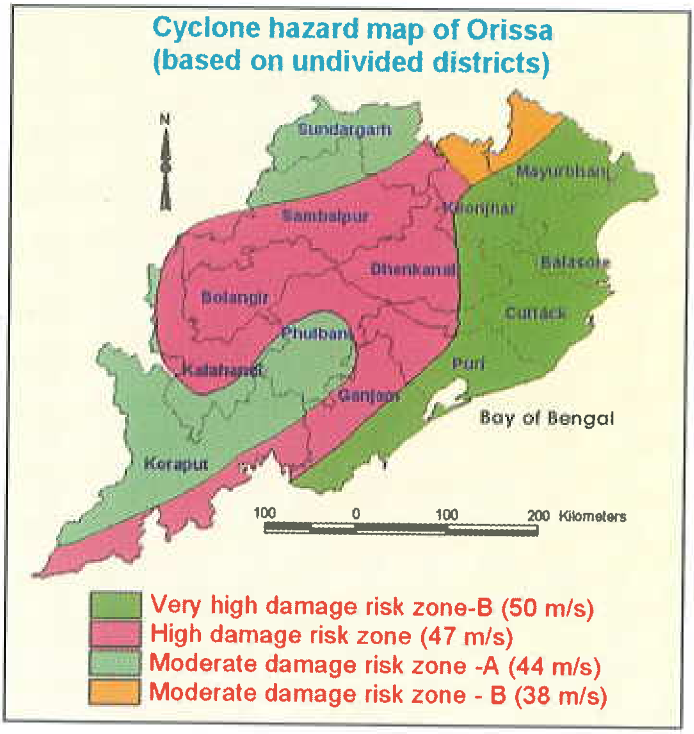


Fig 1 (b) : Cyclone hazard map of Orissa (based on undivided districts)

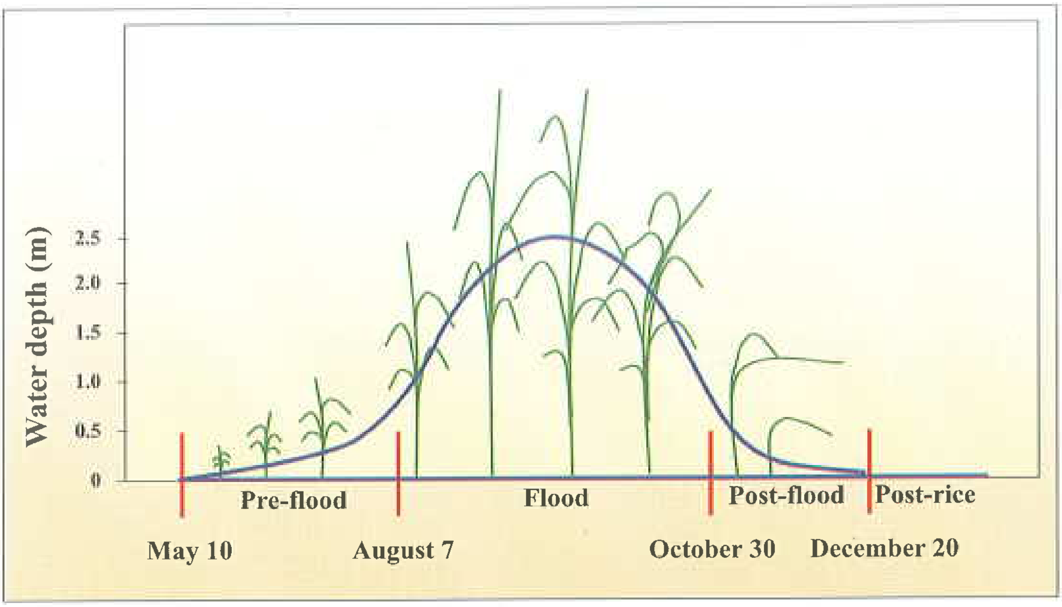


Fig. 2 : Present scenario of seasonal deep waterlogged areas of coastal Orissa

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.

Hence, integrated management techniques must be developed to utilize the seasonal waterlogged areas and enhance the productivity during rainy season. Proper water harvesting system should be designed to harvest excess water of rainy season, so, that it can be used in multiple ways during *rabi* season through integrated farming system to enhance income of this environmentally disadvantaged fragile region.

2.0 PRESENT PRODUCTIVITY CONSTRAINTS OF SEASONAL DEEP WATERLOGGED AREAS

- Seasonal deepwater ecology is the neglected one but a challenging ecology where present productivity is only 0.8-1.1 t ha^{-1}. The area is mainly monocropped and dominated by rice in *Kharif* only, under rainfed condition. The saucer shaped land forms and poor drainage conditions make the coastal regions susceptible to waterlogging and flood prone and area remains submerged for about 3-4 months (July-October) under water depth varying from 0.5-2.5 m. But success of obtaining good crop depends upon the distribution and intensity of southwest monsoon rainfall.

- Very little fertilizer is used for growing rice crop and weeding is generally not practiced.
- In deep water ecosystem submergence is a critical constraint to rice production.
- The water depth in the fields, vary from 1.0 m to 2.5 m in the main cropping season (kharif) with intermittent flooding, resulting in heavy crop loss almost every year.
- Erratic/ early heavy rainfall, results in sudden waterlogging in the rice fields and submerges the crop at early seedling stage.
- In some years, early drought affects germination, results highly thin plant population and reduced initial growth of the crop.
- Prolonged waterlogging for most part of the crop growth reduces tillering and normal growth of the rice crop; sometimes flash flood inundates the standing crop for 8-10 days at a stretch, resulting in heavy mortality.
- Problems of saline water in coastal deepwater rice areas.
- Non-availability of suitable high yielding deep water rice varieties and improved cultural practices, resulting in poor crop yield. Mostly low-yielding traditional rice varieties, not having adequate tolerance to high water depths, are being used. In deep waterlogged areas traditional rice varieties can neither elongate fast nor survive inundation.
- On the other hand, most of the area remains fallow in the *rabi* (winter) season for non-availability of irrigation water and suitable package of practices. The proper water harvesting system was also not designed to harvest excess water of rainy season.

Prospects of undertaking research in seasonal deep waterlogged areas

Although sporadically some research works were undertaken in deepwater rice ecosystem in India and abroad but still scope exists for improving productivity of that ecosystem and for augmenting income and year round employment generation by adopting integrated or holistic approach.

Sesonal deepwater ecology is subjected to receive both extreme events. In one season the area is underproductive due to excess water, in other season agriculture is not possible because of lack of water. But there is a tremendous scope to introduce aquatic crops, deepwater rice, aquaculture, waterlogging tolerant medicinal plants through pond based farming in that eco-system to utilize the seasonal waterlogged land during rainy season. By harvesting some portion of excess water of rainy season, provision of supplemental irrigation can be made for growing *Rabi* crops during winter and summer period. Development of rice-fish integrated diversified farming system to enhance water productivity of deepwater rice area is another option. These options will also suit to socio-economic and bio-physical conditions of the region.

Scope to enhance productivity of seasonal deep waterlogged areas through different technological options.

- Selection and introduction of high yielding deep water rice varieties with adequate waterlogging tolerant through farmer's participatory on-farm research/ demonstration programmes for mass cultivation in the *Kharif* season.
- Popularization of line-seeding/dibbing in place of broadcasting for proper plant population.
- Adoption of bunch planting.
- Popularization of delayed planting and *kharuan* cultivation i.e. double nursery system.
- Intercultural operations of post-flood standing crop (application of fertilizer etc.) to recoup growth.
- Developing seed-village or seed bank of suitable deepwater rice varieties for easy access of seeds to the farmers.
- Creating micro-water sources for raising second crops (cash crop) in the winter/ summer season.
- Introduction of rice-fish integrated or pond based diversified farming system in the deepwater rice area.
- Making proper water management/ drainage facilities for favourable low lands.
- Enhancement of water productivity of seasonal deepwater ecologies through development of suitable package of practices for aquatic crop cultivation, like water chestnut, swamp taro, bach (*Acorus*) etc.

Keeping the importance of above aspects in view, to increase the productivity, profitability, cropping intensity and sustainability of the seasonal deepwater areas, emphasis was given in this study on the following technological interventions.

- Enhancing productivity of deepwater area (0.5 – 2m) through improved deepwater rice varieties and cultural practices.
- Development of pond based farming system and micro-water resources in seasonal deepwater areas for growing *rabi* crops during winter/ dry season.
- Enhancement of water productivity of deepwater rice ecologies through introduction of aquatic crops (water chestnut, swamp taro and medicinal plants) and aquaculture in stored water as well as in swampy areas.

In this Research Bulletin, integrated technologies to enhance the productivity of seasonal deep waterlogged areas developed through the project have been discussed.

3.0 PHYSIOGRAPHY AND DRAINAGE OF COASTAL ORISSA

Coastal region in Orissa have been formed by the alluvial deposits of the rivers like Subarnarekha, Budhabalanga, Baitarani, Brahmani, Mahanadi and her branches and sub branches, Rusikulya, Bomshadhara and Nagavali. The coastal region from the sea extends inland wards for about 100-120 km. It has its rising uplands merging with Northern plateau, Central table land and Eastern Ghat ranges in the south. The coastal zone can be broadly divided into three long and narrow strips from north east to south west. The first strip being the saline coast line with swampy mangrove vegetation, the second being the alluvial plain and the third is hilly strip. In the first strip there is no hill but in second and third there are small hills. There are three prominent lakes – Anshupa (near Athagarh), Sura (Puri district) and Chilika (Khurda district), in the coastal areas.

The Sura lake is a back water lagoon of river Bhargavi. It is about 7 km long and 3.5 km wide. It has no outlet to the sea and is separated from the sea by wide and high sand ridges. The Chilika is the biggest lake in India. In summer it covers an area of about 900 sq km and in rainy season swells to cover about 1200 sq km. Its mouth to the Bay of Bengal is narrow and on sides of this narrow mouth there exists Sand ridges.

Near Dhanmandal and Jenapur small hilly eruptions stand. From Chandikhol to the west there are Dubri and Daitari hills. From Balugan, Soleri, Valari, Malua Bhanja near Chilika and Khalikot side small hills continued through Berhampur. These hills in the coastal zone throwout spurs and promontories into the Bay of Bengal forming island and valleys.

Rivers of the coastal tract of Orissa

Balasore and Bhadrak: Subarnarekha, Budhabalanga, Salandi, Genguti, Mantel and Baitarani are important rivers of Balasore and Bhadrak. Salandi, Genguti, Mantel are tributaries of Baitarani. These rivers cause extensive flood in these two districts causing heavy damage to life and properties. They empty large volume of water and silt.

Cuttack, Jagatsingpur, Jajpur and Kendrapara: Mahanadi, the most important river of Orissa has its final course in these districts before it falls into Bay of Bengal. It has many branches at some places reuniting and at some diverging. The important ones are Katjuri, Birupa, Chitrotpala, Sukapanika, Kharasuan, Devi, Biuakhari and many others.

Puri: Important rivers of Puri district are the branches from Mahanadi. The Delta-II of Mahanadi project consist of *doabs* of Kethjodi- Kushabhadra, Kushabhadra-Bhargave and west of Daya. There are many creeks in the district on the coast line. They get saline water from the sea. The flood prone areas with major river system in Orissa are given in fig.1, which is susceptible to deep waterlogging situation during rainy season.

4.0 GENERAL AGROCLIMATIC CONDITIONS OF COASTAL ORISSA

4.1 Seasonal distribution of rainfall

From the normal monthly rainfall (Table-1), distribution in different seasons *viz.* southwest monsoon (June-September), post monsoon (October-November), winter (December-February) and pre-monsoon (March-May) were computed (Table-2). Study revealed that about 62-173 mm rainfall occurs during pre-monsoon period which would be useful for summer ploughing to make the land ready for final land preparation for sowing rice crop.

The average rainfall during southwest monsoon months (June-September) were 863-1413 mm (62-88 %) but major part of this rain is generally lost through runoff which can be utilized for providing supplementary irrigation to second crops.

Table - 1 : Normal rainfall (mm) of different undivided districts of Orissa

Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Puri[a]	14.2	26.2	19.7	26.8	67.2	207.0	310.8	300.3	244.7	167.0	57.9	7.3	1449.1
Cuttack[b]	13.7	27.5	20.8	34.2	86.5	222.3	351.8	315.8	229.2	147.4	46.7	5.4	1501.3
Balasore[c]	17.1	30.6	34.3	53.1	105.1	218.2	332.6	313.8	243.1	171.0	42.3	7.2	1568.4
Ganjam[d]	10.8	22.2	21.3	42.3	76.8	169.2	221.6	242.4	229.6	179.8	68.6	11.0	1395.6

a Undivided Puri district represents Puri, Khurda districts
b Undivided Cuttack district represents Cuttack, Kendrapara, Jajpur, Jagatsingpur districts
c Undivided Balasore district represents Balasore & Bhadrak districts
d Undivided Ganjam district represents Ganjam and Gajapati districts

Table - 2 : Season wise distribution of rainfall in different undivided districts of Orissa

Districts	Monsoon		Post monsoon		Winter		Pre monsoon	
Puri[a]	1062.8	(73.3)	224.9	(15.5)	47.7	(3.3)	113.7	(7.8)
Balasore[b]	1107.7	(70.6)	213.3	(13.6)	54.9	(3.5)	192.5	(12.3)
Ganjam[c]	862.8	(61.8)	248.4	(17.8)	44.0	(3.2)	140.4	(10.1)

The figure in parenthesis indicates percentage of total annual rainfall.
a Undivided Puri district represents Puri, Khurda districts
b Undivided Balasore district represents Balasore & Bhadrak districts
c Undivided Ganjam district represents Ganjam and Gajapati districts

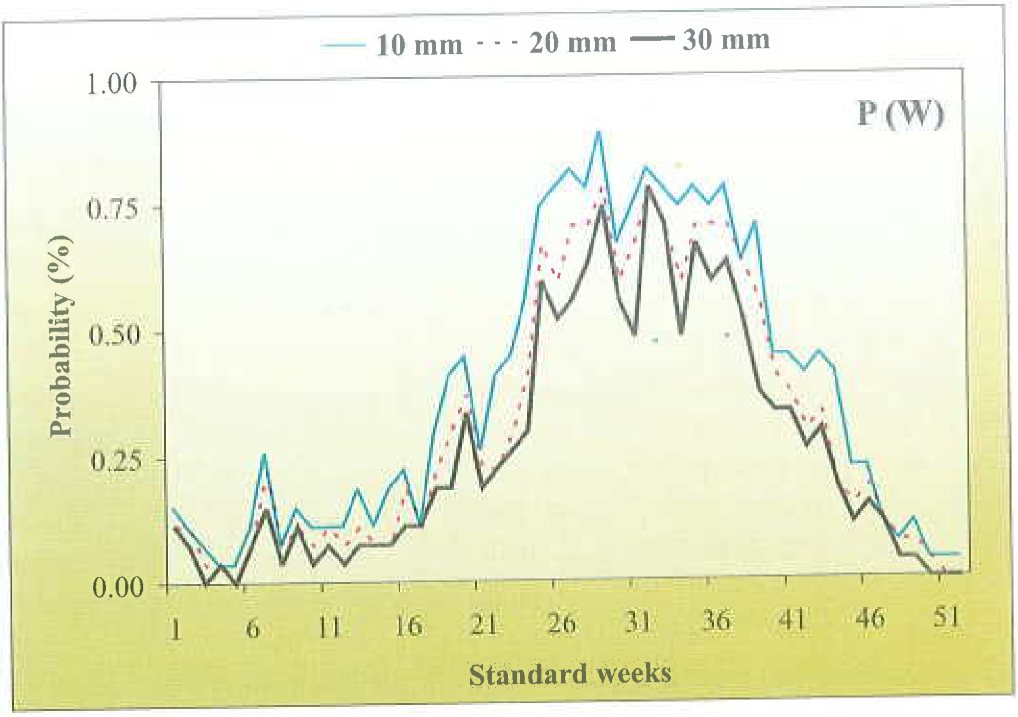
4.2 Coefficient of variation of monthly rainfall

The coefficient of variation of monthly rainfall was computed and results are presented in Table-3. Study reveals that among different months rainfall variability is less during monsoon months for all the districts. Among different months, rainfall was less variable in July and August. The summer and winter rainfall are meager and highly variable. So growing of second crop during winter season after rice without supplementary irrigation would be risky. In lowland rainfed rice ecologies, second

Table - 3 : Coefficient of variation (%) of monthly rainfall in different undivided districts of Orissa.

Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Puri[a]	193.36	144.09	125.60	102.60	167.30	52.00	39.60	35.78	38.24	99.32	144.38	261.72
Cuttack[b]	193.79	126.40	135.18	92.66	99.85	41.69	38.98	29.74	36.88	85.26	164.47	258.77
Balasore[c]	144.69	120.54	114.61	81.11	78.84	44.73	31.35	33.85	41.29	78.62	163.85	282.92
Ganjam[d]	152.70	129.13	102.17	65.21	117.09	49.36	36.64	37.25	40.93	70.03	137.91	331.50

a Undivided Puri district represents Puri, Khurda districts
b Undivided Cuttack district represents Cuttack, Kendrapara, Jajpur, Jagatsingpur districts
c Undivided Balasore district represents Balasore & Bhadrak districts
d Undivided Ganjam district represents Ganjam and Gajapati districts



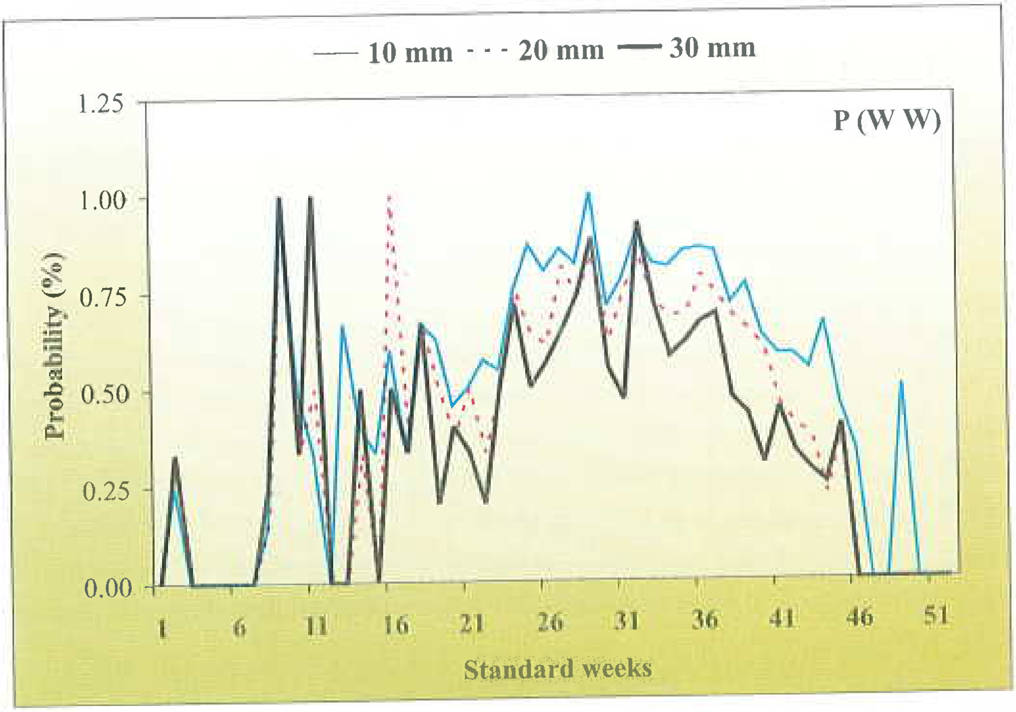


Fig. 3 : Initial P (W) and conditional probabilities, P(W/W) of rainfall in different standard weeks.

crops like pulses (greengram, blackgram, pea), oilseeds (linseed, safflower, niger) can be grown utilizing residual soil moisture.

4.3 Weekly rainfall probability analysis

The week in which initial probability of receiving 20 mm or more rainfall exceeded most dependable limit (70% probability) is considered as wet week. The first wet week after the onset of southwest monsoon in the region can be considered as sowing week of direct seeded upland crops. Result reveals (Fig. 3) that initial probability, P (W) of receiving 20 mm or more rainfall exceeded most dependable limit (70% probability) in the 24^{th} to 33^{rd} and 36th to 43rd standard meteorological weeks' after onset of monsoon so the 24^{th} standard week (11 to 17^{th} June) can be considered for final land preparation and sowing of rice crop in the region. The conditional probability [wet week followed by wet week, P (W/W)] of occurring 20 mm or more rainfall followed almost same trend, exceeded 70% probability level after onset of full fledge southwest monsoon and occurred from 23^{rd} to 28^{th} and 36th to 42^{nd} standard weeks. At 16^{th} to 19^{th} weeks (during pre-monsoon period) initial probability, P (W) of receiving 10 mm or more rainfall exceeded 70% probability level (dependable limit), so in those weeks light showers can be expected which can be utilized for off-season tillage in the areas.

In general, from weekly rainfall probability analysis it can be said that (i) pre-monsoon shower may occur between 16^{th} to 19^{th} weeks making off-season tillage and preparation of seed beds for rice crop feasible then. (ii) rainfed rice can be successfully grown during rainy season (24^{th} to 38^{th} weeks) and earliest sowing can be completed in 24th standard meteorological week (11^{th} to 17^{th} June) at 70% (dependable) probability level.

4.4 Monthly rainfall probability analysis

Prediction of rainfall in different seasons is of paramount importance for raising crops successfully with high and stable yield. In this study monthly rainfall were predicted at 30%, 50% and 70% probability levels using different probability distibution. Because of high rainfall during southwest monsoon months and saucer shaped topography of the coastal region water accumulates on the surface. Winter or summer season rainfall is very less and uncertain and stagnant water starts to recede after November. Land becomes dry from January onwards and winter/summer rainfall is erratic and uncertain. Sowing of high value crops without supplemental irrigation is not possible during winter/summer season.

The monthly probable rainfall with different probability distribution functions are given in Table - 4.

Table - 4 : Predicted and observed monthly rainfall (mm) at Costaldistricts.

Puri[a]															
	Normal			Lognormal			Log Pearson			Extreme Values			Weibulls		
	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%
Jan	25.8	12.9	-	-	-	-	-	-	-	21.7	8.8	-	9.8	2.6	0.0
Feb	29.0	16.6	3.9	-	-	-	-	-	-	25.1	12.7	2.4	20.1	8.0	0.7
Mar	34.6	20.9	7.0	-	-	-	-	-	-	30.2	16.6	5.4	30.3	8.1	0.8
Apr	36.7	23.9	10.9	-	-	-	-	-	-	32.6	19.9	9.3	31.7	16.6	7.5
May	105.9	56.7	6.6	-	-	-	-	-	-	90.2	41.2	0.5	60.7	32.0	22.4
Jun	204.7	161.1	116.7	185.2	142.0	108.4	184.8	141.6	108.1	190.7	147.3	111.3	186.5	150.8	105.2
Jul	342.3	283.9	224.5	321.4	265.3	218.2	317.7	261.3	216.0	323.6	265.5	217.3	334.9	261.2	216.0
Aug	375.2	318.7	261.0	362.8	299.6	246.4	370.8	309.9	253.3	357.1	300.8	254.0	366.8	328.8	274.5
Sep	261.4	217.7	173.2	255.3	198.9	154.3	269.5	226.1	176.0	247.4	203.9	167.8	255.7	222.3	174.0
Oct	201.7	133.0	63.0	146.3	84.2	48.0	156.3	93.6	52.3	179.7	111.3	54.4	134.6	106.3	62.0
Nov	73.4	41.9	9.8	-	-	-	-	-	-	63.3	32.0	5.9	43.5	15.8	2.0
Dec	10.0	4.3	-	-	-	-	-	-	-	8.2	2.5	-	0.8	0.0	0.0

Balasore[b]															
	Normal			Lognormal			Log Pearson			Extreme Values			Weibulls		
	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%
Jan	17.2	9.8	2.3	-	-	-	-	-	-	14.8	7.5	1.4	10.4	2.6	0.0
Feb	31.6	19.4	7.0	-	-	-	-	-	-	27.7	15.6	5.5	29.3	6.9	0.1
Mar	49.8	31.0	12.0	-	-	-	-	-	-	43.8	25.5	9.7	38.8	22.2	3.5
Apr	72.2	50.7	28.9	-	-	-	-	-	-	65.3	44.0	26.2	60.2	41.2	19.8
May	138.6	98.3	57.2	113.8	71.3	44.3	122.0	80.2	49.0	125.9	85.6	52.2	104.7	81.5	54.1
Jun	294.0	238.6	182.0	276.5	214.9	166.2	286.1	227.2	174.2	276.3	221.0	175.1	284.0	230.3	164.1
Jul	317.6	273.2	227.9	308.5	259.6	217.7	313.7	266.4	222.3	303.4	259.2	222.4	222.9	270.1	302.9
Aug	378.9	322.6	265.1	378.0	298.7	234.9	395.9	345.5	277.0	360.9	304.8	258.1	380.8	325.2	266.2
Sep	302.1	248.4	193.6	289.5	224.3	173.0	302.4	242.3	185.2	284.9	231.4	186.9	295.4	244.7	183.9
Oct	217.1	154.0	89.7	176.2	115.0	74.5	184.3	123.2	78.7	196.9	134.1	81.9	154.4	123.1	72.9
Nov	60.0	32.4	4.3	-	-	-	-	-	-	51.2	23.7	0.8	25.8	8.7	1.0
Dec	9.3	3.8	-	-	-	-	-	-	-	7.5	2.0	-	0.0	0.0	0.0

	Cuttack[c]														
	Normal			Lognormal			Log Pearson			Extreme Values			Weibulls		
	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%
Jan	16.3	8.1	-	-	-	-	-	-	-	13.7	5.6	-	7.6	0.5	0.0
Feb	28.3	17.1	5.6	-	-	-	-	-	-	24.7	13.5	4.2	20.3	5.2	0.5
Mar	42.3	24.8	6.9	-	-	-	-	-	-	36.7	19.3	4.7	26.9	14.1	4.2
Apr	42.0	28.4	14.4	30.9	16.0	8.5	33.5	18.5	9.4	37.7	24.1	12.7	35.4	19.5	8.2
May	131.2	86.3	40.6	95.5	56.8	33.5	101.4	62.4	36.1	116.8	72.2	35.0	97.2	62.9	33.9
Jun	233.2	191.6	149.1	219.5	175.6	139.9	221.2	177.6	141.1	219.9	178.4	144.0	224.6	178.0	139.1
Jul	374.5	310.5	245.3	351.8	289.9	238.0	349.9	287.8	236.7	354.0	290.3	237.4	358.6	285.6	225.6
Aug	401.1	347.4	292.7	288.1	333.1	285.1	388.0	333.0	285.0	384.0	330.5	286.0	392.7	322.2	271.5
Sep	269.1	225.8	181.7	268.8	203.9	153.8	284.8	240.7	183.7	255.3	212.1	176.3	266.6	230.8	206.4
Oct	200.6	139.0	76.2	157.4	96.0	58.0	166.7	105.2	62.5	180.9	119.5	68.5	144.1	109.1	72.9
Nov	64.9	35.0	4.5	-	-	-	-	-	-	55.3	25.5	0.8	29.5	8.7	1.4
Dec	6.6	2.8	-	-	-	-	-	-	-	5.4	1.6	-	0.0	0.0	0.0

	Ganjam[d]														
	Normal			Lognormal			Log Pearson			Extreme Values			Weibulls		
	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%
Jan	19.7	11.0	2.1	-	-	-	-	-	-	16.9	8.2	1.0	9.7	1.3	0.0
Feb	34.2	20.5	6.5	-	-	-	-	-	-	29.8	16.1	4.7	22.8	8.2	0.0
Mar	42.5	27.7	12.7	-	-	-	-	-	-	37.8	23.1	10.9	31.4	18.9	7.5
Apr	50.4	37.6	24.5	-	-	-	-	-	-	46.3	46.3	22.9	50.5	32.1	21.0
May	124.8	76.9	28.0	85.1	49.1	28.1	94.4	59.6	33.5	109.5	109.5	22.0	77.8	52.2	35.2
Jun	214.5	145.0	123.3	197.7	147.7	109.7	206.5	158.8	116.7	200.0	200.0	117.7	196.4	132.5	120.3
Jul	259.2	217.6	175.2	247.5	203.5	166.8	249.9	206.5	168.6	245.9	204.5	170.0	152.5	201.8	171.6
Aug	291.1	244.4	296.2	282.2	226.0	180.2	293.6	242.7	192.1	276.6	229.5	190.3	279.1	242.4	193.2
Sep	259.1	213.3	166.4	240.5	198.9	163.9	234.0	192.3	160.5	244.9	198.7	160.7	229.5	185.7	155.3
Oct	236.6	173.4	109.1	199.8	133.1	88.0	206.3	139.7	91.4	216.4	153.5	101.2	207.3	144.9	73.4
Nov	93.7	53.9	13.3	-	-	-	-	-	-	81.0	41.3	8.4	64.7	20.0	2.8
Dec	16.4	5.9	-	-	-	-	-	-	-	13.0	2.5	-	1.3	0.0	0.0

a Undivided Puri district represents Puri, Khurda districts
b Undivided Balasore district represents Balasore & Bhadrak districts
c Undivided Cuttack district represents Cuttack, Kendrapara, Jajpur, Jagatsingpur districts
d Undivided Ganjam district represents Ganjam and Gajapati districts

Table - 5 : Number of drought months (DM) in a year at different probability levels.

Number of DM in a year	Probability (%) of years			
	Cuttack	Puri	Balasore	Ganjam
8.0	2.22	6.25	2.22	-
7.0	6.66	12.50	6.66	-
6.0	17.77	22.50	14.44	7.77
5.0	31.11	37.50	29.99	28.88
4.0	46.66	58.75	54.44	52.22
3.0	69.99	80.00	73.33	75.55
2.0	88.88	92.50	87.77	93.33

4.5 Computation of crop water requirements

The crop water requirement (ET_c) of major crops in the region was computed by multiplying the crop coefficients (K_c) with reference crop evopoiranspiration (ETo) at different growth stages (Doorenbos and Pruitt, 1977 ; Doorenbos and Kassam, 1979). The ET_o was computed by CROPWAT 4.0 model. The computed ETo and crop water requirements of 4 coastal districts (Puri, Cuttack, Balasore, Ganjam) are presented in Table 6 and 7, respectively.

Table - 6 : Computed reference crop evapotranspiration (mm) with CROPWAT 4.0 model

Districts	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cuttack	93	104	176	198	220	159	115	118	111	124	96	84
Balasore	96	109	180	201	217	156	118	121	111	118	96	87
Ganjam	124	123	170	162	177	150	121	130	123	136	126	118
Puri	124	129	167	159	174	150	127	136	132	146	126	121

Climatic data source: Climatological Table, IMD, New Delhi

Table - 7 : Computed water requirements (mm) of major crops using CROPWAT 4.0 model in four coastal districts

Crop	Puri	Cuttack	Balasore	Ganjam
Blackgram (K)	359	347	345	347
Blackgram (R)	347	283	291	342
Cowpea	351	340	337	339
Greengram (K)	359	347	345	347
Greengram (R)	347	283	291	342
Groundnut (K)	448	417	414	431
Groundnut (R)	451	390	401	448

Crop	Puri	Cuttack	Balasore	Ganjam
Maize(K)	334	319	317	322
Maize (R)	325	267	276	322
Pigeonpea	529	471	468	507
Sesamum	293	214	215	280
Sugarcane	1753	1726	1740	1733
SummerRice	714	744	759	721
WinterRice	725	619	616	695
SpringWheat	453	400	412	451

K=Kharif, R= Rabi

4.6 Flood probability analysis

The Mahanadi and the Baitarani and their distributaries form the major drainage system in the region. Flood probability was analysed based on ocurrance of flood point discharge level using Weibull's and log Pearson Type - III probability distibution model. In the year when discharge exceeds 9,00,000 cusec in the Mahanadi is considered as flood year. Study revealed that probability of occurrence discharge exceeding 900000 cusec from the Mahandi river is 32.7%, so probability of occurrence of flood is 33% in the Mahanadi river basin area. (Table - 8).

Table - 8 : Discharge (cusecs) at different probability levels from the Mahanadi

Weibulls			Log Pearson Type-III		
Value	Ret. Period	Probability	Value	Ret. Period	Probability
178349	1	99	165464	1.01	99
587680	1.16	80	525717	1.25	80
654126	1.6	70	626759	1.42	70
749738	1.7	60	711837	1.66	60
809088	1.98	50	809066	2	50
825888	2.3	43	871720	2.32	43
926973	3.18	30	988129	2.33	30
984192	5.11	20	1092690	5	20
1166549	6.82	15	1148333	6.66	15
122799	10.24	10	1223661	10	10
1349844	13.65	7	1282093	14.28	7
1408798	20.48	5	1317708	20	5

4.7 Major cyclones in coastal Orissa

The ecosystem services and livelihoods of the region are also affected by cyclone. A cyclone is a small low pressure system with winds spiralling anti clockwise in the northern hemisphere and clockwise in the southern hermisphere around a central area of low pressure. Occurrence of major cyclones (1970-2007) in coastal Orissa is given in Table - 9.

Table - 9 : Occurrence of major cyclones in coastal Orissa between 1970-2007

Sl. No.	Date	Area affected	Damage/losses
1.	September 7-14,1971	South Orissa coast and adjoining North Andhra coast.	This system caused considerable damage to crops, houses, telecommunications and other property in the coastal districts of Orissa. viz, Ganjam, Puri and Cuttack. 90 people died and 8000 catle heads perished.
2.	September 20- 25.1971	South Orissa coast near Gopalpur.	Considerable damage to crops and houses due to flood and heavy rain at Vamsadhura village in Srikakulum and Koraput districts.
3.	October 26-30,1971	Crossed Orissa coast near Paradip early in the morning of October 30. Maximum wind speed recorded was 150 - 170 KMPH (81-92 Kt.). Lowest pressure recorded 966 hPa near the storm.	10,000 People died and more than one million people rendered homeless. 50,000 Cattle heads perished, 8,00,000 houses damaged.
4.	September 7-14. 1972	Crossed the extreme North Andhra Coast on the afternoon of Sept. 10th. Maximum wind speed recorded at Puri was 175KMPH (94kt).	100 people died and 8000 cattle heads lost. Near about 2 lakhs people were affected due to this system. Heavy damage to crops and other property was reported from Ganjam, Puri and Cuttack districts, the worst affected being Ganjam district.
5.	September 20-25, 1972	Crossed extreme South Orissa coast near Gopalpur on the afternoon of 22nd September and weakened into a depression by the morning of the 23rd. September. Maximum wind recorded in gust was 136 KMPH (73 Kt.) at Gopalpur about 0740 UTC 0n 22nd.	Caused damage to crops and houses. No loss of life was reported.
6.	November 3-9,1973	Crossed Orissa coast close to and north of Paradip on the early morning of 9th November. It weakened rapidly and maximum wind speed was recorded 100 KMPH (54 Knot) at Paradip and Chandbali experienced surface wind of 100 KMPH (54 Knot).	Caused some damage to standing crops in the coastal districts of Orissa between Paradip and Chandbali.

Sl. No.	Date	Area affected	Damage/losses
7.	September,14-28, 1981	Crossed Orissa coast near Puri on the early morning of September 26 and weakened into a depression on that evening over interior Orissa and adjoining East Madhya Pradesh.	5 launches were lost in the Bay and many housed were damaged in Midnapur districts of West Bengal and Cuttack districts of Orissa.
8.	May 31 to June 5th, 1982	Crossed on 3rd June near Paradip, Orissa	As a result of high tides damage caused all along the this coastal stretch. This cyclone caused heavy damage in the coastal district of Puri, Cuttack and Balasore.
9.	October 9-14,1984	Crossed North Orissa coast near Chandbali in the forenoon of 14th October.	The system caused damage in Cuttack and Balasore district of Orissa and Midnapore districts of West Bengal.
10.	17-21 September 1985	Crossed on 20 Sept. closed to Puri Orissa.	Krishnaprasad, Chilika, Tangi submerged for 3 days due to inundation of sea water. 1.5 mt sea wave of Puri coast was recorded.
11.	13-17 October 1985	Crossed Balasore on 16th October.	High tidal wave of about 16 to 18 feet was observed
12.	29-30th Oct., 1999	Crossed Orissa coast near Paradip. (SUPER CYCLONE)	The super cyclone lasted three days and ravaged 14 coastal districts around 15 million people were affected and 17,000 square kilometer of agricultural land was devastated.

1 Knot (Kt) = 1.853 km hr $^{-1}$

5.0 SOILS OF THE COASTAL WATERLOGGED AREAS

Soils of the coastal areas consist of two types of soils

a) ***Soils of Utkal plain and***

b) ***Soils of Mahanadi delta.***

a) ***Soils of Utkal plain:*** A region consists of eastern coast comprises districts of Balasore, parts of Puri and Ganjam. The area covers recent and tertiary alluvium. In few places, Pleistocene alluvium also occurs. The soils occurring on nearly level to low lying coastal plains are dominantly very deep, imperfectly to poorly drained and fine textured soils. They are subjected to flooding and slightly to moderately salt affected.

Generalized soil scape characteristics of deep water areas of Utkal Plain

Dominant soil characteristics	Constraints
Inland plains	
Nearly level to gently sloping, deep to very deep, poorly drained, neutral, fine loamy	Poor drainage and moderate flooding
Coastal plains	
Very gently sloping, deep to very deep, poorly to imperfectly drained, neutral, fine textured soils	Moderately flooding and strong salinity

b) Soils of Mahanadi delta : The area representing Mahanadi delta includes undivided Cuttack, Puri and parts of Balasore. The region is covered with deltaic sediments of the Mahanadi and formed in recent times. Pleistocene alluvium occurs at several places along the coastal tracts.

Generalized soilscape characteristics of deep water areas of Mahanadi delta

Dominant soil characteristics	Constraints
Gently sloping Coastal plains	
Very gently sloping, very deep, imperfectly drained, slightly acidic, loamy	Medium available water capacity and slight salinity
Lower Delta	
Very gently sloping, moderately deep to very deep, poorly to imperfectly drained, neutral to slightly alkaline saline, fine, medium to high available water capacity	Moderately flooding, moderate erosion and salinity

The flooding, slope, available water capacity, parent meterial and soil reaction maps of Orissa (Coastal districts of Orissa is separated by red line) are presented in fig.4 (a-e). (Source : NBSS & LUP, Nagpur)

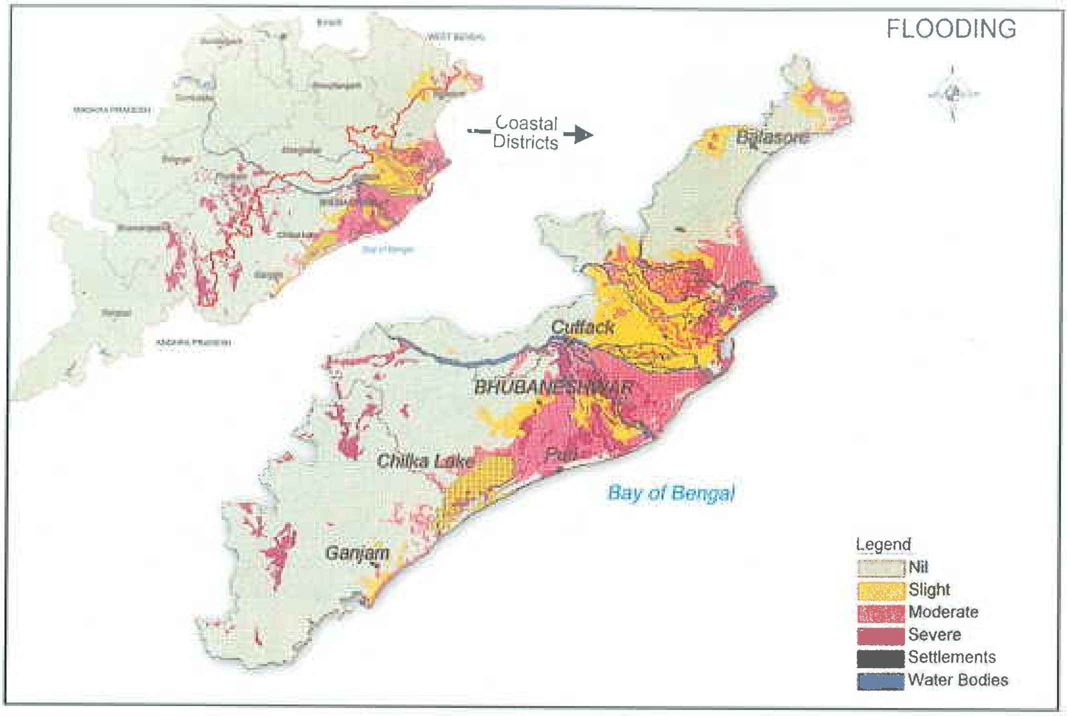


Fig 4 (a) : Flooding zone of Orissa

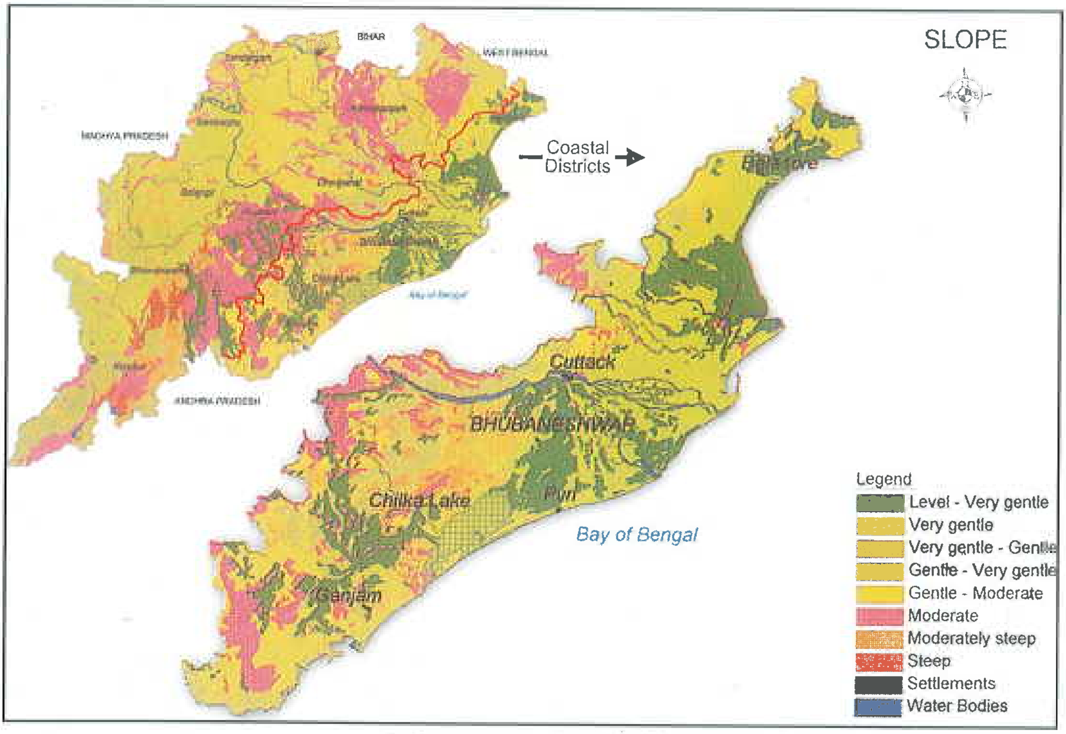


Fig 4 (b) : Slope map of Orissa

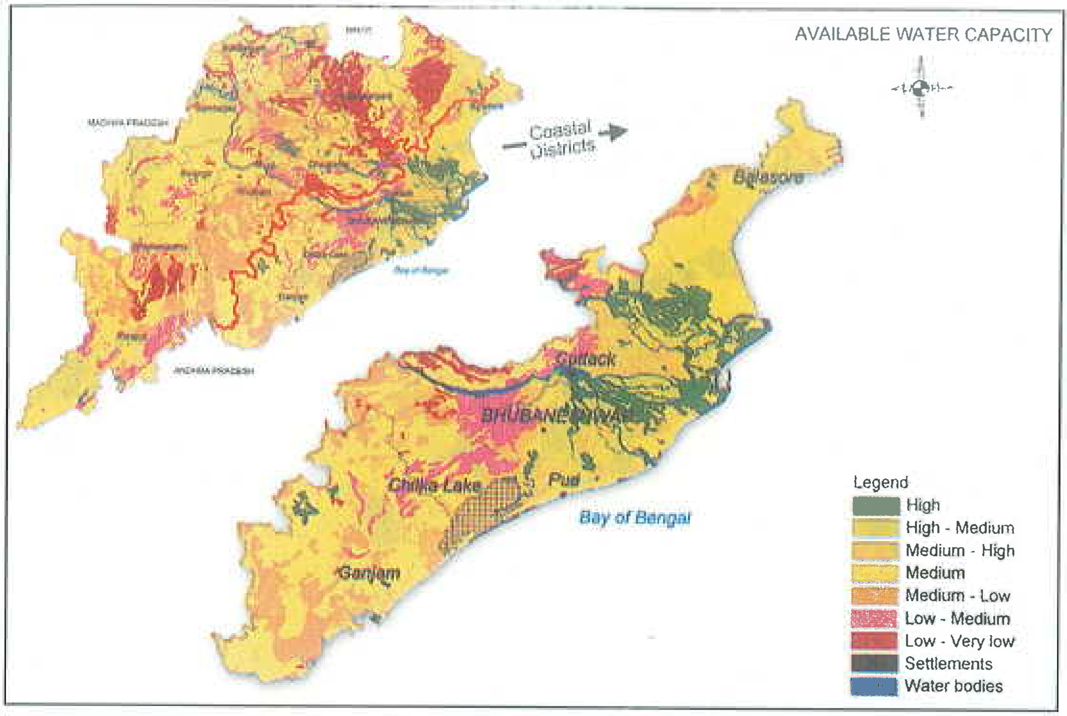


Fig 4 (c) : Available water capacity map of Orissa

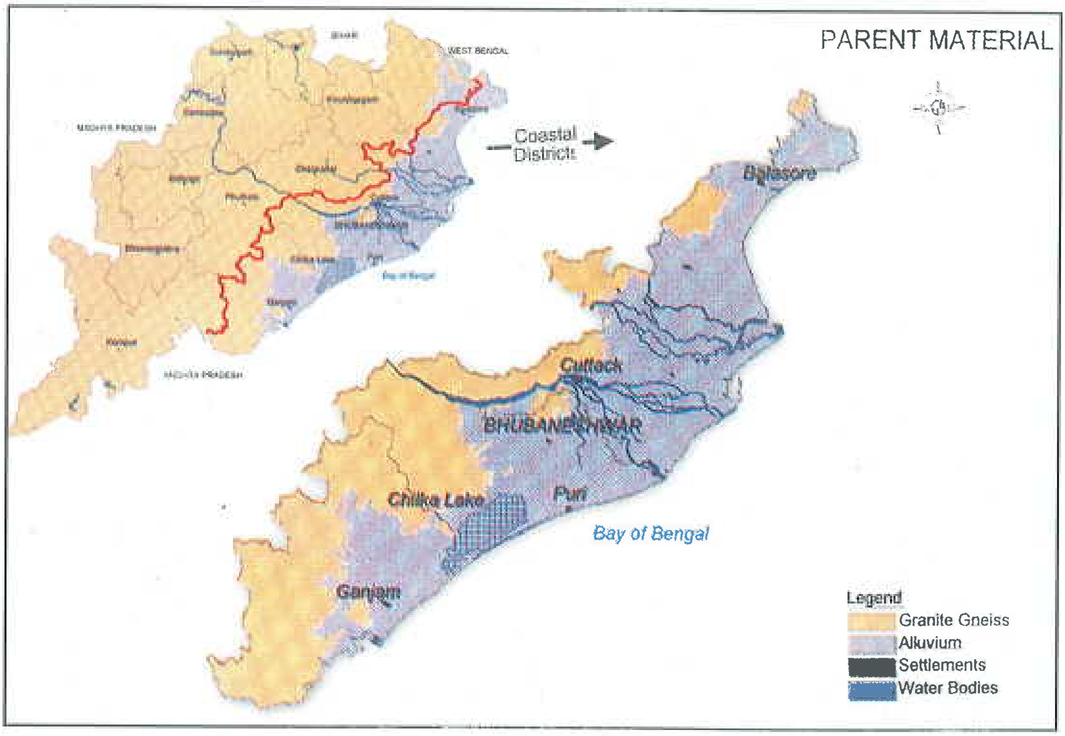


Fig 4 (d) : Parent material distribution in Orissa

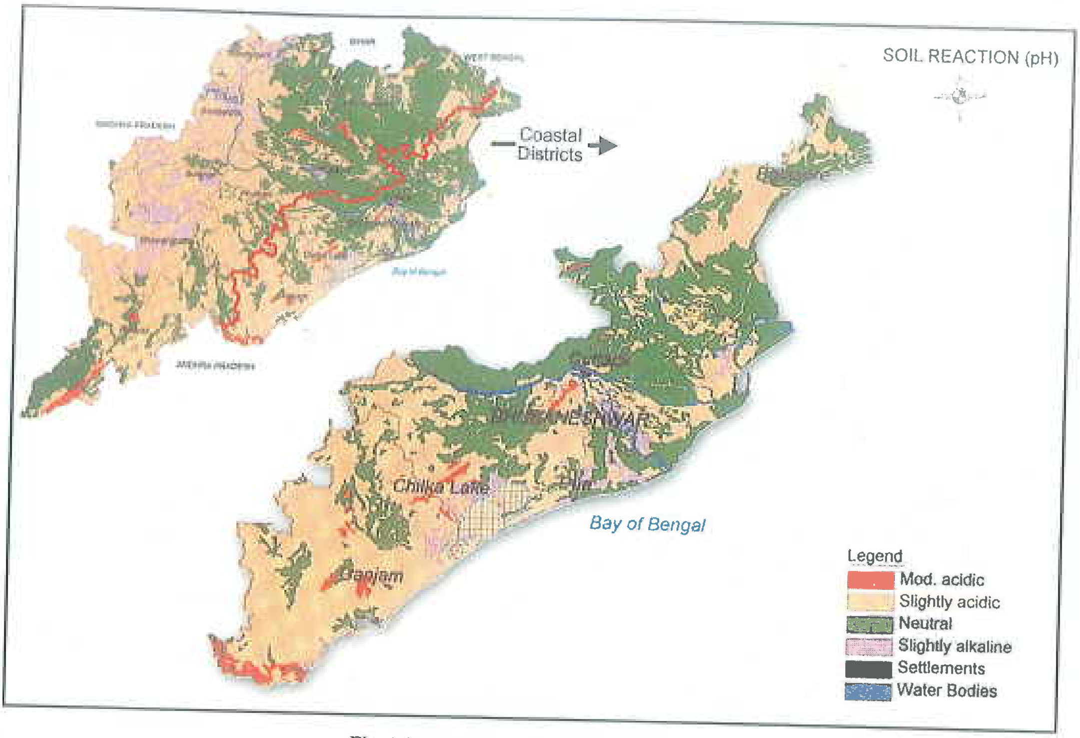


Fig 4 (e) : Soil reaction map of Orissa

6.0 THE STUDY AREA

With the aim to enhance productivity and profitability of seasonal deep waterlogged areas of cosatal Orissa, a study was undertaken in a representative place ie. Alisha

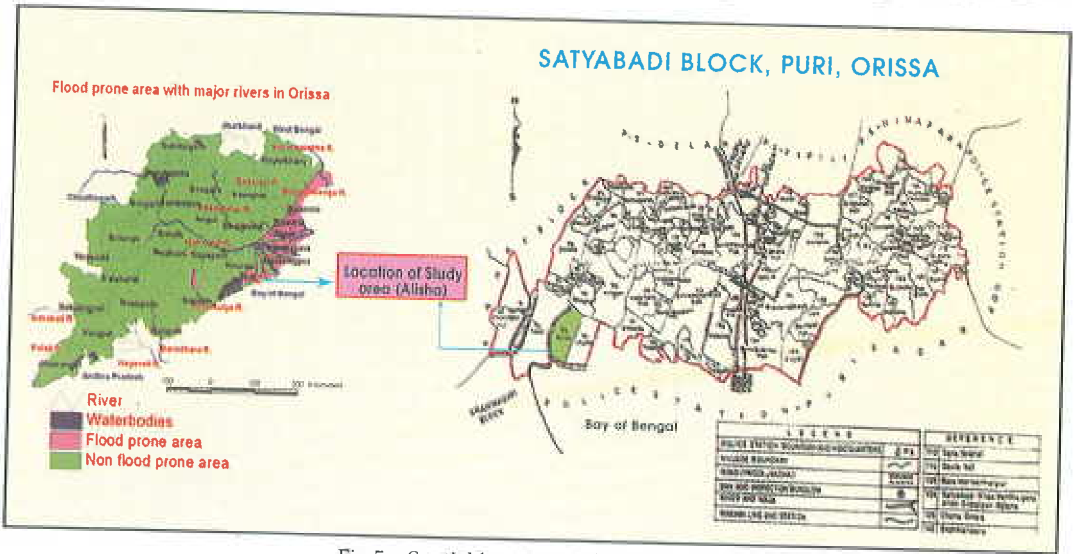


Fig 5 : Spatial location of the study area village of block Satyabadi, District Puri (Lat 19⁰45′, Long 85⁰49′, 6m above sea level) from 2004-05 to 2007-08. The spital location of the study area is given in fig. 5).

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 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 ^{0}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 ^{0}C occurs. In November and December, maximum temperature drops to 24-27 ^{0}C and night temperature may go below 15 ^{0}C. Variation of mean monthly temperature and rainfall is given in fig.6.

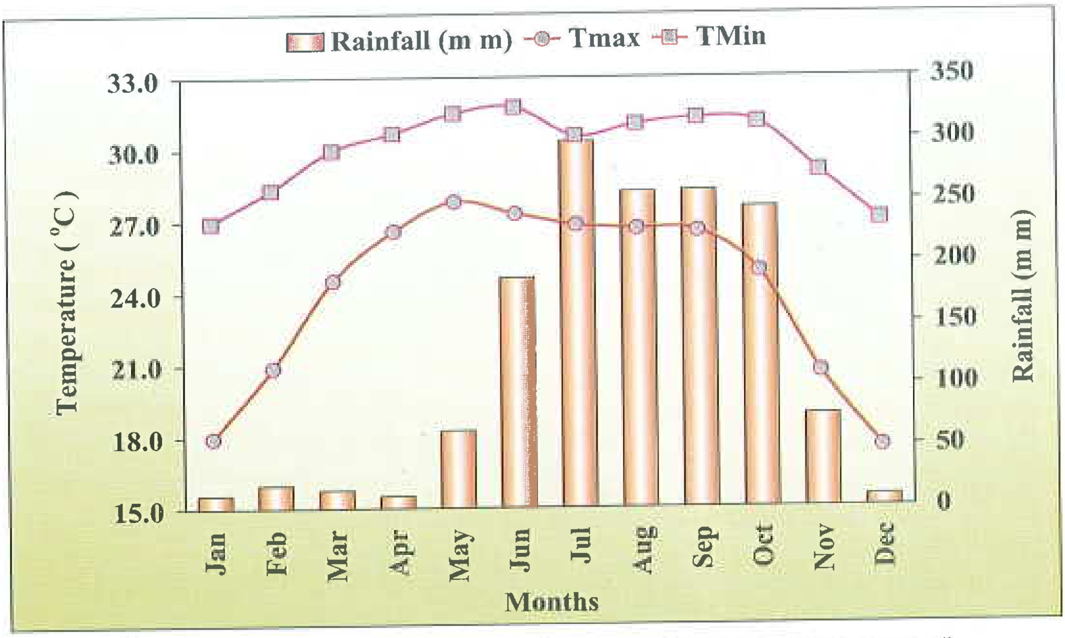


Fig - 6: Variation of mean monthly temperature and rainfall in study site (station: Puri)

6.1 Socio-economic and demographic pattern

As a case study, socio-economic survey was carried out in Alisa village of Satyabadi block to ascertain the ecological suitability of implementing the project. During the survey, due consideration was given on different aspects like current rice genotype practices, cultivation trend, animal husbandry etc. The secondary data from Deputy Director of Agriculture, District Agriculture Officer, Puri, Block office, Satyabadi and Puri Sadar was duly referred. Comprehensive interaction with the respondents from the village was also conducted. The constraints, adoption gaps and problem related to agricultural development were analyzed on the basis of key informants' and personal or group interviews. Brief information of survey is given below.

The proposed project areas have huge cultivated land but have more than 90% are under seasonal deep waterlogged areas. In the study village (Alisha) out of 240 ha of cultivated land 205ha land is waterlogged and the rest are under forest and wasteland.

Table - 10 : Land use pattern of study village

Land use pattern	Area (ha)
Cultivated Land	240.00
Forest Land	29.13
Waste land	16.00
Water logged	205.20

The cropping pattern of the village is peculiar in nature. In *kharif* season the productivity as low as that it can't cater two squares of meals for the family through out the year. That's why in rabi the farmers rather opt for paddy than other cash crops. In *kharif* season the average productivity is only 8-10 q ha^{-1}. Very few numbers of farmers cultivate black gram or green gram during rabi season. Hence, in the *rabi* season there is a tremendours scope to improve the productivity of the area

Table - 11 : Cropping pattern of the study village

Season/crop	Area (ha)	Productivity (q ha^{-1})
***Kharif* season**		
1. Paddy	152	8-10
***Rabi* season**		
1. Paddy	80	18-22
2. Biri (black gram)	44	2-4
3. Mung (green gram)	14	3

Though very few number of farmers are landless and they are earning their livelihood by daily wage labours in others field or cultivate shared cultivation. Whereas, maximum farmers belong to category of small farmers. Large farmers are few in number in the village. As less number of marginal and large farmers are available in the village, their average annual income ranges between Rs. 3000 to Rs. 4000 from agriculture.

Table - 12 : Different categories of farmers in the study village

Type of farmers	Alisha
Land less	15
Small	154
Marginal	28
Rich	20
Income from agriculture	Rs.4000-5000/annum
Avg. Income(others)	Rs.2000/annum

Table - 13 : Demographic pattern of the study village

Categories	Number
Total Population	1291
Male	673
Female	618
Literacy (%)	48
Govt. Servant	12
SC Population	130

Table - 14 : Livestock population in the study village

Livestock	Number
Bullock	140
Miltch Cow	28
Goat/Sheep	10

Table - 15 : Agricultural assets in the study village

Item	Number
Tractor	2
Sprayer/Duster	6
Pump/motor	23
Shallow/deep tube well	10
Harvester	Nil
Thresher/Winnower	Nil

6.2 Present cropping system

In the floodwater prone areas of coastal Orissa from July to November, there is stagnant water with the depth varies from 0.50 to 2.5 m. The prolonged water logging during the *kharif* season makes the field unsuitable for growing profitable field crops other than rice. Due to non-availability of suitable deepwater tolerant rice varieties, farmers depend only on local verities like 'Bankei', 'Dhala Kartik' etc. and get poor yield (1-1.5 tha^{-1}). But again the success or failure of the rice crop during *kharif* season depends upon receding water, summer rainfall, time of monsoon onset and cessation and rainfall distribution during the season. After interviewing with the local farmers based on last 10 years experience, it is revealed that best condition for obtaining good yield was good summer rain and well distributed monsoon rain and late flooding (September- October). During *rabi* after receding water farmers grow rice crop where canal irrigation facilities are available.

After receding water from January onwards (Pre-flood period) the land becomes dry and ready for growing any field crops. But due to non-availability of irrigation water, the farmers cannot grow any crop during pre-flood period (winter and summer) when edaphic condition is suitable. Poor aquifer characteristics and saline ground water also limit crop production during dry season. Hence, water-harvesting techniques must be designed to harvest excess water of rainy season for its multiple use. Provision of irrigation water may be made by constructing structures (pond/ tank/ ditches) to harvest rain or accumulated water of rainy season.

6.3 Flood-drought pattern

The onset of flooding can vary greatly between years. Generally in coastal Orissa flooding starts from last week of July onwards and lasts for 2-3 months. Maximum surface water depth of 2.5 m occurs in some locations but it varies again with the rainfall distribution pattern. The first rise of accumulated depth of water levels in the region depends entirely on rainfall in the catchment areas. At some locations, there is usually a positive relationship between river or stream depth and water depth in adjacent deepwater areas, and flooding depth is correlated with local rainfall. On the other hand, the flood recession phase is more consistent, which occurs October onwards. From December onwards, the land starts to dry and upto mid June, there is no standing water. Even soil moisture is not sufficient to meet the water requirements of any crops. Agricultural drought of varying intensities limit crop production potential in pre-flood periods. (January-June). The flood, post flood and post rice pre-flood pattern of the coastal Orissa is depicted in Fig. 2. Unlike, other places (Bihar, Assam, Bangladesh), the flood water in coastal Orissa moves very slowly over the land. The saucer shaped topography of the region and some embankments prevent natural drainage, as a result water rise is usually more steady, after commencement of full fledge southwest monsoon.

6.4 Characteristics of floodwater

The first floodwater spreading over the land at inundation is usually turbid with suspended alluvium brought down from the catchment plus material picked up as it spreads slowly over the land. After the initial spread of floodwater throughout the region the silt mostly deposit before flushing out to sea. Thus, the greater part of the flooding is mainly clear water, which probably originates largely from the accumulation of rainwater (0.5-2.5 m during flooding period) and can drain only very slowly because of the congested drainage channels. Temperature, oxygen level and pH of floodwater were recorded and study revealed that water temperature near the surface varies close from 29 to 35 ^{0}C during July-October. The pH is usually fairly close to neutral (5.9 – 6.3). The area is adjacent to the Bay of Bengal results continuous wind, which increases dissolved O_2 of floodwater. During most of the flooding period, the upper layer is usually aerobic in the daytime (6-7 mg/ liter). In the afternoon, O_2 level was the highest (9-10 mg/liter) and is usually decreased with water depth, at 40-60 cm it varies from 2-4 mg/ liter and below 10 cm only from 0-2 mg/liter. Temperature, pH and O_2 are generally at the lowest near dawn and rise to maximum in mid afternoon or early evening.

6.5 Soil test report of experimental field

Before initiating the experimental trials, soils of representative deepwater areas were tested in respect of different chemical properties like pH, EC, organic carbon, avaliable nitrogen, phosphorus, potassium, calcium and magnesium. The results are presented in Table 16-19.

Soil test report of experimental site of deep-water areas (Alisha village, Puri) revealed that soils were moderately acidic in reaction, non-saline, has high

Table - 16 : Results of soil test report of experimental site

Sample	pH	EC (dSm^{-1})	Organic carbon (%)	Av. N (%)	Av. P (ppm)	Av. K (ppm)	Ca (ppm)	Mg (ppm)
F1	5.6	0.3	1.8	0.20	Trace	5424	6.61	10.45
F2	4.9	1.0	1.1	0.08	2.32	5295	6.5	10.64
F3	5.4	0.0	1.7	0.13	2.95	4908	8.63	10.08
F4	4.9	0.9	1.6	0.15	6.32	3487	8.4	8.03
F5	5.3	0.4	2.0	0.18	1.47	4520	3.81	5.04
F6	5.1	0.9	1.5	0.17	3.93	3213	5.71	7.40

amount of organic carbon (1.1-2.0 %), K (0.34-.54%) but low in available N (0.08 to 0.2%) and P (trace-6.32 ppm) while presence of Mg superceded Ca. These soils need to be treated with soil amendments and soil test based fertilizer application is the need of the hour for improving soil reaction and thus crop production. The soil texture varies from clay to heavy clay with higher bulk density (1.59 to 1.65 Mg m^{-3}). The saturated hydraulic conductivity is also very low (0.19-0.35 cm hr^{-1}). Some of the major physical characteristics of soils of deep waterlogged areas (1-2.5 m) are given in Table-20(a). Taxonomically the soil belongs to very fine, mixed, iso-hyperthermic, vertic endoaquepts. Level to nearly level (0-1%) slope, very slight erosion with normal relief. The groundwater table is 1-2 m and soils are deep to very deep, find textured. They are poorly drained very slowpermeability, occures in lowlying areas and hence probelm of soil-air-water, relationship arises. Deep and wide cracks also appear during non-rainy periods. Application of organic matter alongwith inorganic fetilizer on such land is always recommended. Suitable crops which can be grown in these soils are rice, pulses, banana but with proper water management practices. The forest species like *Casuarina* and *Eucalyptus* can be grown in bund.

Table - 17 : Results of water quality analysis from different sources of the village

Sources	EC	pH	Ca (Mg/l)	Mg (Mg/l)	Cl (Mg/l)	SO_4 (Mg/l)	K (Mg/l)	Na (Mg/l)
Open well	1.00	6.60	0.12	0.27	0.253	-	3.57	93.87
Pond	0.20	6.90	0.0	0.156	0.07	-	0.67	35.17
Pond	0.70	6.90	.0998	0.260	0.126	7.41	4.28	61.28
Drainage channel	2.10	7.40	0.306	0.49	0.479	10.16	9.0	187.5
Pond	3.80	7.10	0.55	1.04	0.973	33.40	10.5	531.25

Table - 18 : Major soil chemical properties (Based on 30 samples)

Properties	Lower limit	Upper limit
pH	4.9	5.4
EC (ds m^{-3})	0.80	1.50
OC (%)	0.15	0.59
N (%)	0.01	0.034
P (ppm)	5.25	30.25
K (ppm)	66.6	251.6
Na (ppm)	104.1	752.8
Ca (ppm)	1.596	4.798
Mg (ppm)	0.833	7.66

Table - 19 : Water quality test report (Based on 30 samples)

	Lower limit	Upper limit
pH	6.6	7.4
EC (dS m^{-3})	0.0	3.8
Mg (ppm)	0.27	1.04
Cl (mg/l)	0.07	0.973
SO4(mg/l)	0.0	33.4
K (mg/l)	0.67	10.5
Na (mg/l)	35.17	331.25

Table - 20 (a) : Major soil physical properties of seasonal deep waterlogged (1-2 m) areas

Depth (cm)	Sand (2.0 -0.05 mm) (%)	Silt (0.05-0.002 mm)(%)	Clay (<0.002 mm) (%)	Soil 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
15-38	20.4	17.6	62.6	c	1.6	0.20
38-62	12.5	21.7	65.8	c	1.63	0.24
62-95	22.3	15.4	62.3	c	1.65	0.23
95-150	25.6	15.9	58.5	c	1.65	0.11

C = clay

Another profile sampling was done at moderately deep waterlogged areas (0.5-1 m). Soils are moderately fine textured, very deep (Table - 20 b) .Taxonomically the soil series has been identified as fine loamy, mixed iso-hyper thermic vertic

Table - 20 (b) : Major soil physical properties of seasonal moderately deep waterlogged (0.5-1 m) areas

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	l	1.62	0.23
90-150	24.6	39.9	35.6	cl	1.62	0.11

Cl = dayloam,   sicl = silty clay,   l = loamy

fluvaquents. This soils is also poorly drained with slow permeability and posses the problem of soil-air-water relationship. *Kharif* rice and *rabi* vegetables can be cultivated in moderately waterlogged areas.

6.6 Aquifer characteristics of the study areas

Photo - 1 : Soil profile of a dugout pond

The seasonal deep waterlogged areas of the delta and the coastal tracts (mostly east coast) have 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 2m and it extends up to a depth of 12 m to 13 m in areas where feasibility of very shallow tube well can be explored. 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 m^3/hr to 4.7 m^3/hr in sandy zone and 0.9 m^3/hr to 3.4 m^3/hr in clayey zone.

Photo - 2 : Clay to heavy clay soil texture

7.0 DEVELOPMENT OF NATURAL RESOURCE MANAGEMENT STRATEGIES TO ENHANCE PRODUCTIVITY OF SEASONAL DEEP WATERLOGGED AREA

In the seasonal deep waterlogged areas of coastal Orissa accumulated surface water of depth of 0.5-2.0m is found during southwest monsoon season. The prolonged waterlogging during the *kharif* season makes the field unsuitable for growing crops other than rice. Again success and failure of rice crop production depends on seasonal distribution of rainfall, timing of occurrence of flood and intensity of fainfall. On the other hand land becomes dry from December onwards and growing of crop during *rabi* season is also not possible without supplemental irrigation. Hence strategies must be developed to enhance productivity of the seasonal deep waterlogged (0.5-2.5 m) areas during rainy season and to grow high value crops during *rabi* season after receding surface accumulated water. Some of the interventions to make seasonal deep waterlogged areas productive and profitable are discussed below.

7.1 Cultivation of deepwater rice and its interrelationship with time and depth of flooding Characteristics of deepwater rice

Deepwater rice variety has 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.

Based on flooding depth, the deep-water ecosystem may by divided into two categories:

(i) Deepwater rice (DWR): DWR is cultivated where water depth varies from 50 to 100 cm. Mostly traditional cultivars with tall type are grown. Plant length usually more than 140 cm with weak to moderate or no elongation ability.

(ii) Floating rice: flooting rice is cultivated where water depth is more than 100 cm. Cultivars with strong elongation capacity are grown with elongation rate of 5-8 cm / day^{-1} at least for 7-10 days. Most of the cultivars are grown at water depths of 1-2 m.

DWR or floating rice should have three special adaptations: (i) ability to elongate with the rise of water levels; (ii) develop nodal tillers and roots from the upper nodes in the water; and (iii) ability to bend the upward parts of the plant (commonly called 'kneeing') and keep it above the surface of water as flood subsides.

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.

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 the seasonal deep waterlogged areas, waterlogging tolerant rice varieties were introduced through on-farm trials in representative area (Alisha village, Puri) during kharif 2005-2007. 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 does of 30:20:20 was applied as basal. Study, revealed that in *kharif* 2005 improved DWR cultivars like 'Hangseswari', 'Ambika', 'Saraswati' performed well and produced 1.96-2.38 t/ha mean grain yield. While, local variety 'Bankei' got partially damaged due to water accumulation of 5-6 feet depth and produced less than 1 t ha^{-1}. (Table-21). In the *kharif* 2006 the flood comes early (1st week of July), due to early heavy rainfall when the crop was at early growth stage. Due to sudden submergence of the crop at early stage, the crop failed to survive and was demaged. But in *kharif* 2007 again due to arrival of late monsoon and late flooding period, the DWR varieties performed well. In this year also varieties like Hanseswari, 'Sarasawti' performed well than that of local varieties. Prolonged waterlogging of 0.5-1.5m depth caused 40-50% demage to local varieties but 'Hanseswari' variety thrived very well (Table - 21). The rainfall distribution along

Table - 21 : Development of crop growth attributes and yield of deepwater rice varieties in different years of study

Plant attributes	Hangseswari			Ambika			Saraswati			Bankei		
	2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
Crop Ht.	205	-	190	175	-	180	180	-		165	-	160
Tillers/m^2	318	-	310	282	-	284	280	-	280	198	-	175
Plant/m^2	29	-	28	28	-	27	28	-	27	12	-	12
LAI	4.7	-	3.9	3.8	-	3.7	3.7	-	3.8	2.5	-	2.6
Biomass (tha^{-1})	1.50	-	1.45	1.35	-	1.41	1.42	-	1.40	1.10	-	1.13
Panicles/m^2	266	-	266	250	-	98	293	-	252	180	-	100
Grain yield (tha^{-1})	2.38	-	2.35	1.96	-	2.0	2.20	-	2.10	0.99	-	1.0
Straw yield (tha^{-1})	9.58	-	9.25	8.95	-	9.15	9.25	-	9.20	7.25	-	6.95

with time of accumulation of deep water during *kharif* 2005, 2006 and 2007 are presented in fig 7a,b,c, respectively. The crop performance and yield attributes followed the pattern of rainfall distribution and flooding pattern which can be reflected from results presented in Table - 21.

Photo - 3 (a) : Deepwater rice at early growth stage

Photo - 3 (b) : Local variety (left) was damaged but DWR 'Hanseswari' (right) performed well

Photo - 3 (c) : Deepwater rice at tillering stage

Photo - 3 (d) : Bumper growth of DWR under 6 feet depth of water

Photo - 4 (a) : Deepwater rice 'Hangseswari' at ripening stage

Photo - 4 (b) : Local rice variety got damaged due to constant waterlogging

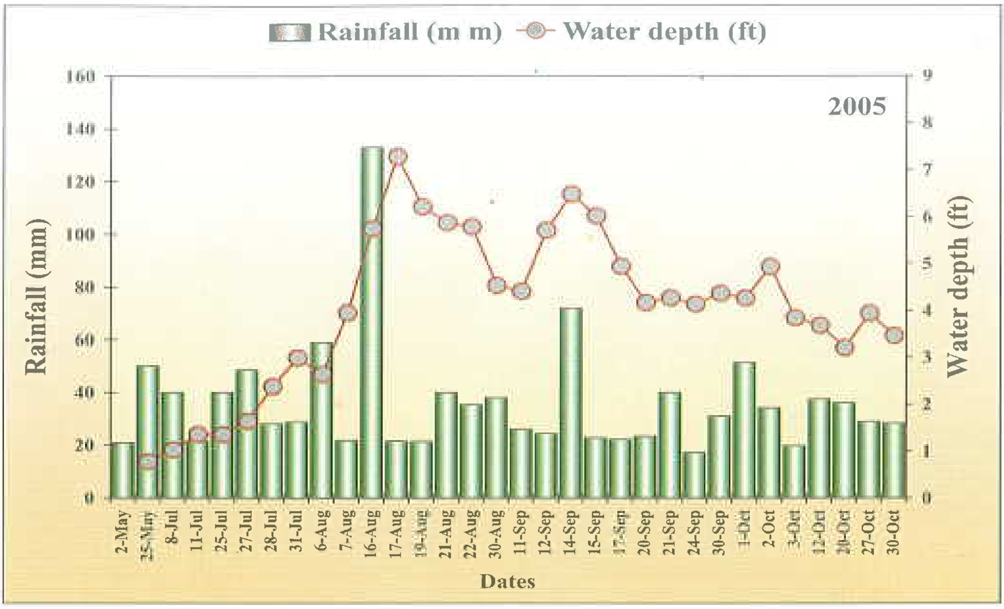


Fig. 7 (a) : Rainfall and accumulated water depth during kharif (rainy) season 2005

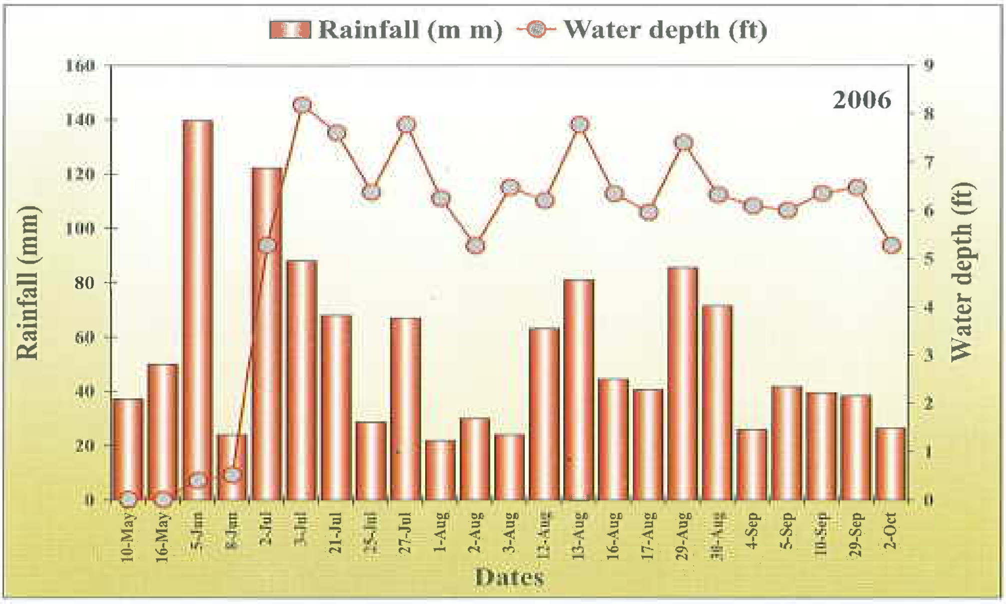


Fig. 7 (b) : Rainfall and accumulated water depth during kharif (rainy) season 2006

With the introduction of improved DWR varieties like 'Hanseswari', 'Saraswati', productivity during rainy season got enhanced and farmers received good yield (2.5 – 2.8 t ha^{-1}) and net return (Rs. 4500 ha^{-1}). Local variety produced only 1-1.5 t ha^{-1} yield but again the success and failure of the crops depends upon time of

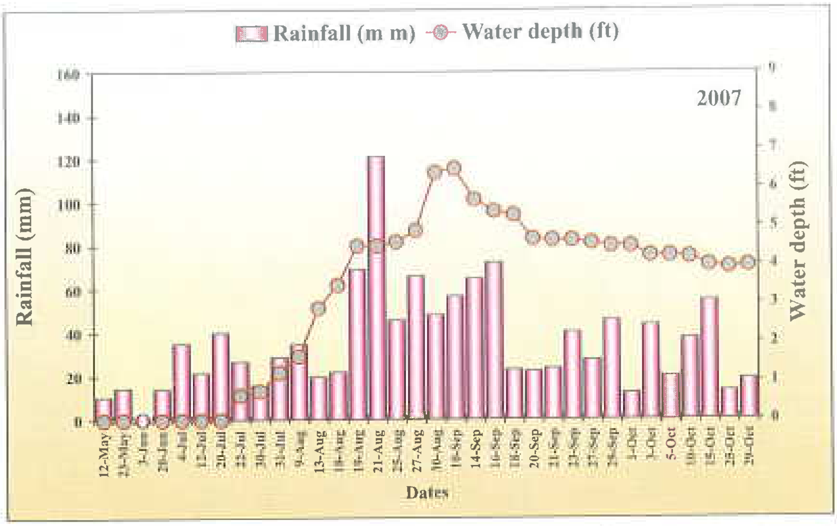


Fig. 7 (c) : Rainfall and accumulated water depth during kharif (rainy) season 2007

monsoon onset and cessation, rainfall distribution and receding water. After interviewing with local farmers based on the last 15 years experience, they revealed that if waterlogging occurs before 15th August when crop is at early vegetative stage, the crop will be damaged, as a result farmers may not get any yield in that year. Accordingly, we have attempted to analyse the probability of receiving flood before 15th August. Study revealed that (fig. 8) out of 34 years, in 16 years flood occurs before 15th August. Therefore at 48 % probability there is a chance of crop getting damaged. In that year farmers will not realize any yield even cost of the seed.

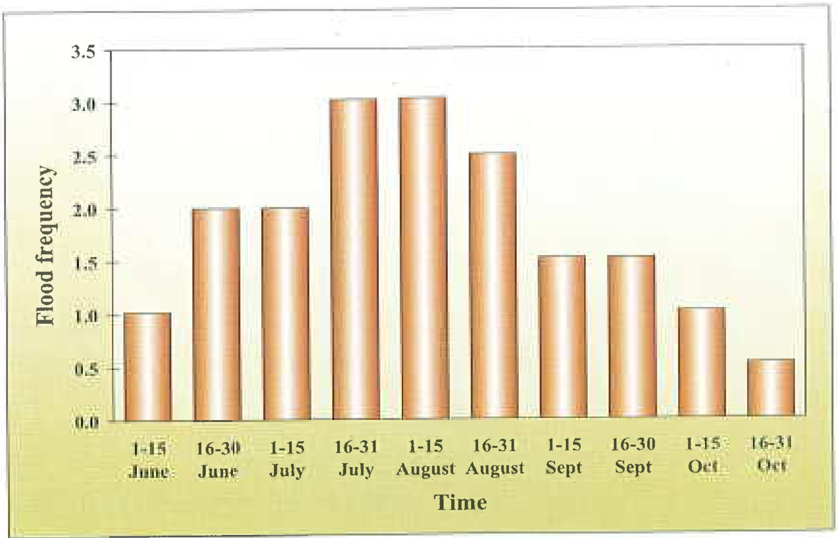


Fig. 8 : Frequency analysis of timing of flood (>1m water depth)

7.2 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 surface water was accumulated 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.

The rainwater harvesting pond can be constructed in the areas where specific water yield is very less and seepage water appears at very slow rate. The main principle behind rainwater harvesting in the region is that the capture of rainwater during flood period and when flood water will recede, the water will remain inside the pond. The size of the area of the pond will be based on the area availability. Generally, 25-30% of the total field of a farmer can be converted for water harvesting pond. Rest of the field may be utilized for intensive cultivation with harvested water. The pond should be dug in inverted trapezoidal shape and side slope should be minimum 1:1, because soil texture is 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 will be determined by the flooding depth. Study revealed that maximum flooding depth of 2.5 m appears in saucer shaped flood prone coastal areas. Therefore, keeping a free board of 0.5 m, maximum 3 m bund height should be maintained for constructing water harvesting pond in flood

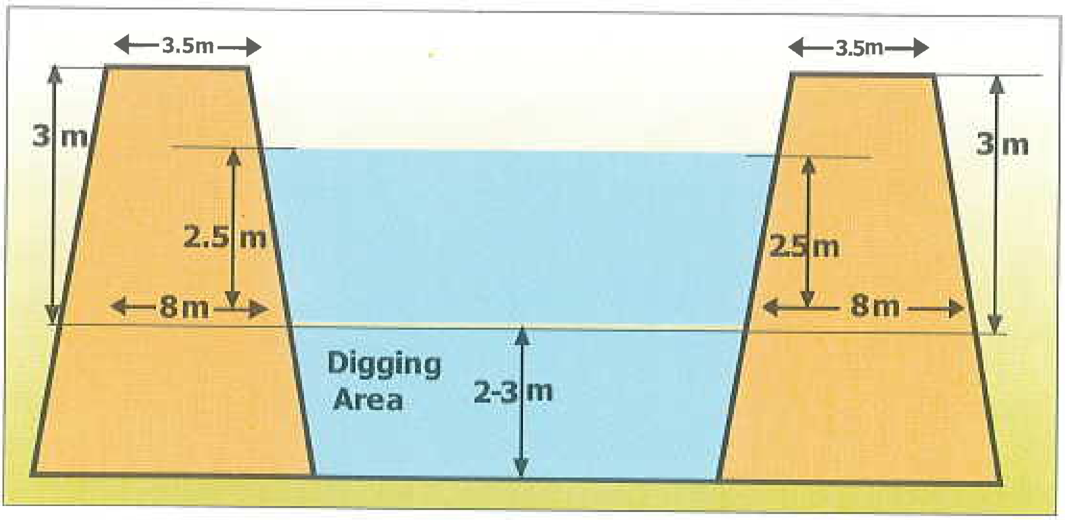


Fig. 9 : Design of rainwater harvesting structures in deep coastal areas (0.5 – 2.5 m)

prone coastal areas. Since pond bund remains under continuous stagnant water for 3 months, that portion may be strengthened by dub grass matting. The depth of pond should 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. Since water level inside the pond will always remain below the maximum height of the bund, no spillway is required for the system. The design parameters of the rainwater harvesting system (pond) is given in Fig. 9.

After designing the water harvesting structures (pond based farming system), six such systems were constructed at Alisha village, Puri in six dkfferent farmers' field (Table -22).

As per the design, six ponds were constructed in six different farmers field. The rainwater harvesting capacity, volume of excavated earth, positive height of harvested water and water utilized for providing supplemental irrigation are given in Table-23.

Photo - 5 (a) : Digging of pond in progress in land with shallow water table

Photo - 5 (b) : Digging of pond in progress in land with deepwater table

Table - 22 : Rainwater harvesting capacity of different ponds and water utilized for growing second crops during 2006-07.

Sl no.	Farmers field	Volume of excavated area (m^3)	Positive height of harvested water (m)	Rain water harvested (m^3)	Evaporation loss (Nov-March), (m^3)	Water used for agriculture (m^3)
1	F1	32 x 24 x 2.1	2.4	3456	346	1467
2	F2	32 x 24 x 2.3	2.5	3686	346	1459
3	F3	22 x 16 x 2.1	2.1	1478	158	781
4	F4	19 x 16 x 2.3	2.0	1307	137	520
5	F5	32 x 24 x 2.3	2.5	5229	518	2523
6	F6	32 x 25 x 2.3	2.5	3840	360	2256

Photo - 6 (a) : Condition of a pond during peak flood period

Photo - 6 (b) : Water harvesting in seasonal deep waterlogged areas

Photo - 6 (c) : Pond after half recede of surface accumulated water

Photo - 6 (d) : View of pond after full recede of accumulated water. The pond is full of water.

The positive height of harvested water, pizeometric water depth and depth of digging of ponds are shown in Fig. -10. 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.10), as a result chance of seepage loss from the pond is very less.

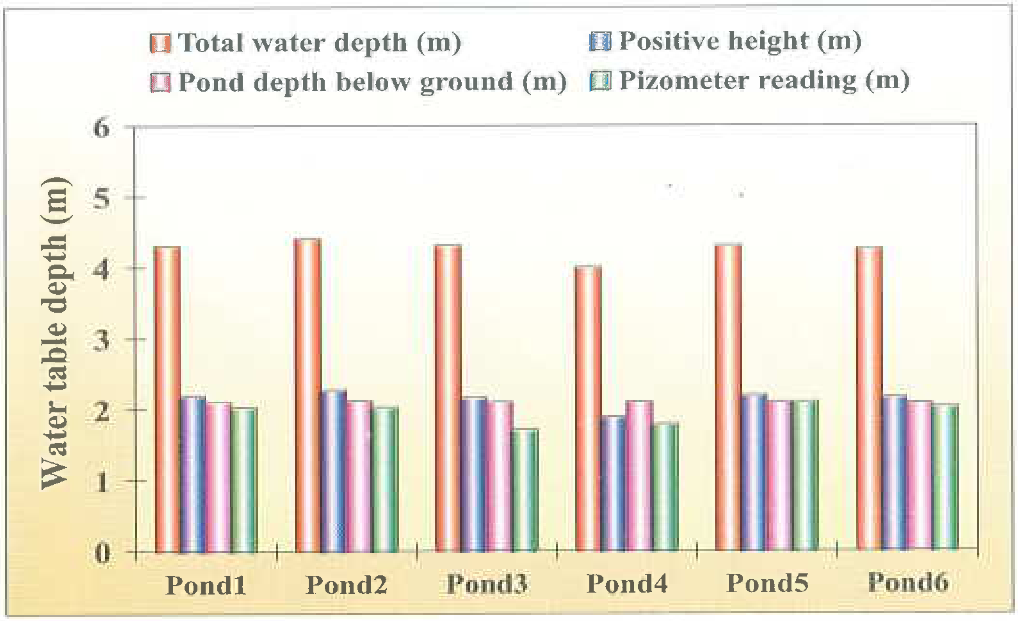


Fig. 10 : Total depth of water harvested in different ponds

7.3 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. Therefore, as a contingency measure, high yielding medium duration (120 days) rice varietes 'Lalat' was transplanted in the month of December after receding flood. Improved package of practices were followed for growing paddy during *rabi* with supplemental irrigation from harvested water of the pond and carry over water. The yield with scientific practices was compared with farmers' management (Table - 23). Study, revealed that under scientific practices and with supplemental irrigations rice produced mean yield of 4.85 tha^{-1}. 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. Under farmers' management only 1.96 tha^{-1} rice yield was achieved.

Table 23: Yield (t ha^{-1}) of *rabi* rice (cv. Lalat) in different farmer's field with scientific and farmer's management practices

Farmers field	Scientific management and supplemental irrigations				Traditional farmers practice			
	R1	R2	R3	Mean	R1	R2	R3	Mean
F1	4.90	5.10	4.70	4.90	1.90	2.10	2.20	2.07
F2	5.00	4.90	5.10	5.00	1.90	1.80	1.80	1.83
F3	4.40	4.70	4.90	4.67	1.70	1.80	2.00	1.83
F4	5.20	5.10	5.20	5.17	2.00	1.90	2.10	2.00
F5	4.90	4.8	4.40	4.70	2.10	2.20	1.90	2.07
F6	4.70	4.80	4.50	4.67	1.80	1.80	2.20	1.93
Average				4.85				1.96

R_1, R_2, R_3 are replications

Photo - 7 (a) : Bumper rice crop during winter from harvested rainwater

Photo - 7 (b) : Rice at ripening stage irrigated with harvested rainwater of pond

7.4 On farm trials of vegetable crops during *rabi*

In moderately deep waterlogged areas (0.5-1m) 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 deep waterlogged areas. Study revealed that the highest net return per hectare, was obtained from brinjal (Rs. 21660/-), followed by watermelon (Rs. 21152) and okra (Rs. 17390/-). Seasonal water use was computed as 545, 605, 495, 750 and 575 mm for watermelon, okra, spinach, brinjal and ridge gourd, respectively (Table-24).

Table 24: Rice equivalent yield (RYE), net return and water use of different salt tolerant vegetables (pooled data of 2004-05 and 2005-06)

Crops	Rice equivalent yield (t ha^{-1})	Water use (mm)	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})
Water melon	9.1	545	36060	21152
Okra	8.5	605	34072	17390
Spinach	6.5	495	26092	15005
Brinjal	9.8	750	39260	21660
Ridge gourd	7.8	575	31292	16092


Photo - 8 (a) : Bumper ladies finger crop after receding flood water in *rabi*


Photo - 8 (b) : Pumpkin crop druing winter season in farmers' field of seasonal waterlogged areas


Photo - 8 (c) : Exploring possibility of cucumber cultivation after receding flood water


Photo - 8 (d) : Watermelon is a profitable crop in coastal waterlogged areas during *rabi*

7.5 Enhancing water productivity through pond based farming system

Attempts were made in this study to develop mitigation strategies through rainwater harvesting and contingency crop planning to enhance the productivity of deep water coastal areas of Orissa. Study revealed that introduction of deep

Table - 25 : Net return from pond based farming system

Pond	Capacity (m³)	Income from *kharif* crops (Rs.)	*Rabi* income (Rs)	Fish income (Rs)	Income from on dyke veg-etables	Total expendi-ture (Rs) of cultiva-tion	Total income (Rs.)	Net return (Rs.)
F1	1613	-	17550	9050	2950	14410	29550	15140
F2	1766	-	19180	12135	3200	15800	34515	18715
F3	1766	-	17810	11020	2800	16160	31630	15470
F4	2012	-	21800	11830	2950	17820	36580	18760

water rice varieties during rainy season and cultivation of fishes, *rabi* crops with the harvested water of rainy season enhanced and stabilized the productivity of deep waterlogged area. The water productivity was enhanced from rice to integrated farming system (fig. 11). From constructed ponds net returns of Rs.15140 to Rs.18715 was obtained.

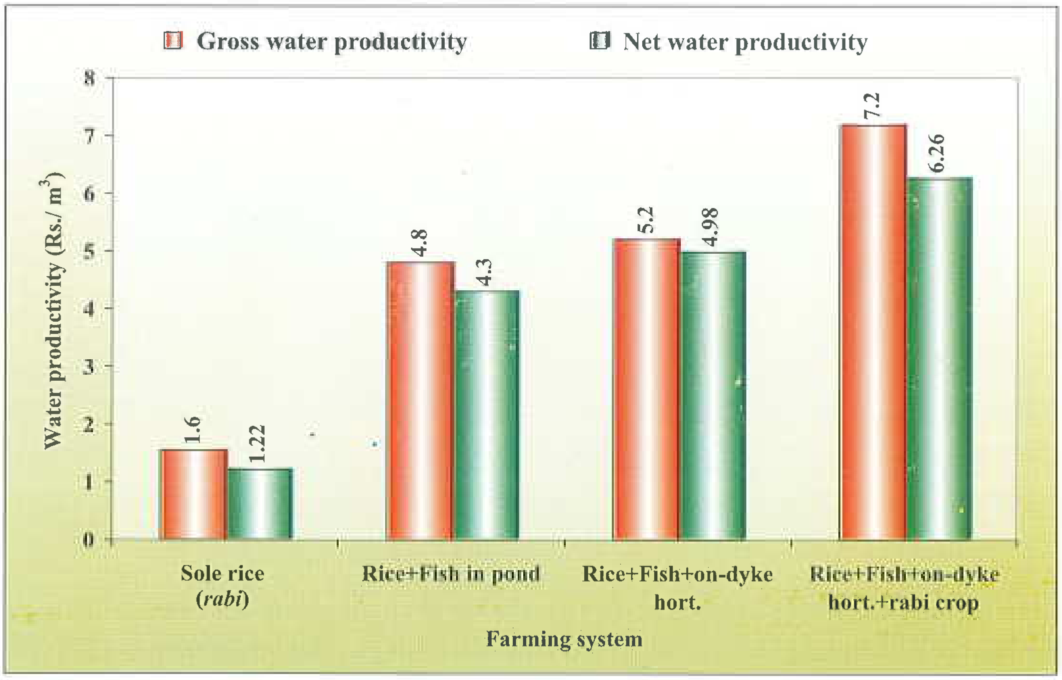


Fig. 11 : Comparison of water productivity from different components of farming system

Photo - 9 (a) : Harvested water in the pond in the month of February

Photo - 9 (b) : Banana plant is the best option to utilize pond bund

Photo - 9 (c) : Farmers are catching fish in harvested water

Photo - 9 (d) : Multiple use of harvested water in deep waterlogged areas

7.6 Introduction of aquatic plant species

Besides, deepwater rice other aquatic species like water chestnut and waterlogging tolerant medicinal plant, *Acorus calamas* (Bach) in deep water areas were introduced to obtain higher and stable yield. The *Acorus* rhizone was planted at the spacing of 40 cm x 30 cm during alst week of May with the help of pre-monsoon shower. The basal fertilize dose of 40:20:20 was applied to the crop. The planting material rate was 1,00000/ha. The yearwise cost of cultivation of the crop for planting one hectare

Photo - 10 (a) : *Acorus calamas* (Bach) grown underwater

Photo - 10 (b) : *Acorus* crop after receding flood

Photo - 10 (c) : Harvested rhizone of *Acorus*

Table - 26 : Cost of cultivation of Calamas (Bach plant)

SI. No.	Item of work	Cost for 1st Year in Rs. per Ha.	Cost of 2nd Year in (Rs.) per Ha.	Cost of 3rd Year in (Rs.) per Ha.
1	Site preparation	3,000.00	1,500.00	1,500.00
2	Cost of Rhizome @ Rs.0.60 (1,00000 Rhizome)	60,000.00	0.00	0.00
3	Transportation of seedlings	10,000.00	0.00	0.00
4	Planting including casualties replacement	7,000.00	1,000.00	1,000.00
5	Cost of Compost & organic fertilizer	10,000.00	5,000.00	3,000.00
6	Chemical Fertilizer & Pesticides	2,000.00	1,500.00	1,500.00
7	Weeding	2,500.00	2,500.00	2,500.00
9	Harvesting & processing	1,500.00	1,700.00	1,800.00
10	Watering	3,000.00	3,000.00	3,000.00
11	Packing	1,500.00	1,700.00	1,700.00
12	Misc. expenditure	2,000.00	2,200.00	2,200.00
	TOTAL	**93,500.00**	**20,100.00**	**13,200.00**

of land was computed and are presented in Table - 26. In the first year due to purchase of planting material farmers may not get net positive return. But from second and third year farmers will obtain Rs.0.90 lakh and Rs.1.24 lakh/ha, respectively.

The production details and cost-benefit analysis of the Bach plant (*Acorus*) are given in Table - 27.

Table - 27 : Production details and cost-benefit analysis in one hectare of land

Product output	1st year			2nd year			3rd year		
	Production	GR (Rs.)	NR (Rs.)	Production	GR (Rs.)	NR (Rs.)	Production	GR (Rs.)	NR (Rs.)
Dry rhizone	3750 kg	56,250	-	4700	70,500	-	4700 kg	70,500	-
Planting material	-	-	-	100000	40,000	-	180000	72,000	-
Total		56,250	-		1,10,500	90,000		1,42,500	1,24,000

GR = Gross return, NR = Net return

7.7 Cultivation of Waterchestnut

As per the standard package of practices, waterchestnut was introduced into the pond water. Study revealed that this crop has potential to provide net return of Rs.15000-19000/ha. This crop can also be cultivated as contingent crop to mitigate seasonal deep (0.5 - 2.0m) waterlogged areas provided proper plant protection measures are taken.

Photo - 11(a) : Introduction of waterchestnut in seasonal deep waterlogged areas at Alisha, Puri

Photo - 11(b) : Introduction of waterchestnut in seasonal deep waterlogged areas at Alisha, Puri

8.0 TECHNOLOLOGY DISSEMINATION PROGRAMME ORGANIZED

(1) Organized farmers' fair near the on-farm trial site

To disseminate the technology of improving productivity of deep water rice area, a farmers' fair was organized on 1.12.2005 at Alisha village, Puri.

Photo - 12 (a) : Large numbers of farmers gathered in field days

Photo - 12 (b) : District Magistrate, Puri, briefing media while attending farmers' fair regarding usefulness of the project

Mr. Ashwini Kumar Das, the District Magistrate and Collector of the Puri, Dr I.C.Mahapatra, former Vice Chancellor, OUAT, Dr J.K.Roy former Jt. Director, CRRI, Cuttack, Dr N.Panda, former

Head, Entomology, OUAT, Project Directorate, DRDO, Puri, District Agricultural Officer, Puri, Deputy Director of Agriculture, Puri were among the prominent speakers on that occasion. During the farmers' fair different technologies to enhance productivity of deep water area were demonstrated at the study site where on-farm trials were conducted. The farmers' fair was attended by about 1000 farmers, NGOs and state and central government agricultural officials. Dr. G. Kar, Sr. Scientist and Principal investigator organized the above event.

(2) On-farm brain storming session conducted

To formulate agricultural production technology of enhancing productivity of deep water areas, a brain storming session was organized at Alisha village, Puri on 2nd February, 2006 where different technological options were discussed and farmers-experts interactions were held. Dr I.C.Mahapatra, Former vice Chancellor, OUAT was the chairman of the programme. Dr Ashwani Kumar, Director, WTCER, Dr P.N.Bahl, Former DDG (crop Science), ICAR, Dr J.K.Roy former Jt. Director, CRRI, Cuttack, Dr N.Panda, former head, Entomology, OUAT, Project Directorate, DRDO, Puri, District Agricultural Officer, Puri, Deputy Director of Agriculture, Puri were among the prominent speakers on that occasion. Dr G. Kar, Senior scientist and Principal Investigator of the project coordinated the above event.

Photo - 13 (a) : Discussion at depth at the on-farm project site

Photo - 13 (b) : Dr. I.C. Mahapatra, Vice Chancellor, OUAT participated in the discussion

(3) Meeting with state government officials

A meeting with Agricultural production Commissioner, Principal, Secretary, Agriculture, Govt. of Orissa and Director of Agriculture, Government of Orissa was held on 3rd February, 2006 to explore the possibility of disseminating technologies of enhancing productivity of deep water areas by Government of Orissa. Different

Photo - 14 (a & b) : Detailed discussions are going on with DM, district planning and agricultural officials of Puri

state government agricultural officials like PD, DRDO, DDA, DAO of Puri district, Seed production officers of the State Government attended the meeting. The meeting was organized by Dr. G.Kar, Sr. Scientist and Principal invastigator of the project.

(4) Training cum awareness progarmme organized

A training cum awareness programme on "Enhancing productivity of deep water areas" was organized on 28.10.2007 at WTCER, Bhubaneswar. The programme was participated by 80 progressive farmers and NGOs and SHGs from different parts of the coastal district. In that training programme different aspects of improvement of productivity of deep water areas like improved 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 WTCER 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 organizing secretary of the training.

Photo - 15 (a) : Large numbers of farmers participated in the training programme.

Photo - 15 (b) : Farmers are actively interacting in the training programme

(5) Farmers-Scientists-experts meeting organized at the study village

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

Photo - 16 : Visit of Research Advisory Committee members of WTCER to project site

- Research Advisory Committee members of WTCER 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.

Photo - 17 : Visit of QRT members of WTCER to project site

- Third QRT team of WTCER 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 WTCER 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,

Photo - 18 (a) : Visit of former DDG (NRM) Dr. J.S. Samra to project site

Photo - 18 (b) : Farmers' experts interaction at the study site

Dr J. S. Samra visited the deep water areas of Puri district on 12.11.2006 and interacted with the farmers. He appreciated the efforts initiated by WTCER to enhance productivity of the waterlogged areas through micro-water resources development.

- A team comprises of (i) Dr. Panjab Singh, Vice Chancellor, BHU, Banaras, (ii) Dr. I.C.Mahapatra, former Vice Chancellor, OUAT, Bhubaneswar (iii) Dr. R.K Singh, 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.

Photo - 19 (a) : The team visualising contingent rice crop after damage of first rice crop due to early waterlogging

Photo - 19 (b) : Discussions are going on regarding viable technologies to mitigate seasonal deep waterlogged areas

9.0 MEDIA COVERAGE AND IMPACT

The Indian Express on 6.12.2004

New project to enhance productivity in deep water rice area of State

EXPRESS NEWS SERVICE

Bhubaneswar, Dec 5: The Water Technology Centre (WTC) of Indian Council for Agricultural Research (ICAR) has launched a new project that would look for technologies to enhance productivity in the deep water rice area of the State.

The research project has been initiated in Puri district. In eastern India, about 16 per cent of rice area is upland, while 48 per cent is lowland. Similarly, another 14.7 per cent paddy land comprises either deep or very water area which is below a depth of 50 cm water.

In Orissa, 50,000 hectare rice area is under deep water, whereas 10,000 is under very deep water. The objective of the WTC project is to devise a new technology that would help improve the rice productivity in these areas.

The project has been initiated in Puri dist

According to Dr Gouranga Kar, principal investigator of the project, sporadic research work on enhancement of rice productivity in deep water area has been carried in India and abroad. Holistic approach can go on to improve the production further. In fact, with availability of new rice varieties, it has become easy for the farmers as well as researchers.

The Water Technology Centre, Eastern Region office conducted an awareness programme for the farmers of Puri recently. Indian Rice Research Institute scientist Dr N. Panda and former joint director of Central Rice Research Institute Dr J. K. Roy were also present.

The Pioneer on 8.12.2004

MoUs signed to enhance rice productivity

...in Puri, Kendrapara, Balasore districts

Pioneer News Service | Bhubaneswar

Prolonged waterlogging for most areas of the State affected the rice growth. The crop growth is tillering and normal rice growth has been affected and large area has remained unproductive.

Too much of waterlogging makes the fields unsuitable to grow any other crop in that deepwater rice ecology; as a result, farmers of the deepwater rice area Orissa (Satyabadi, Kanas, Brahmagiri blocks of Puri district, Kendrapara and Balasore) are struggling to achieve food security.

To bring an technology for the farmers to achieve food security MoUs were signed on Thursday by Water Technology Centre for Eastern India (ICAR), Bhubaneswar, Ministry of Agriculture, Technology Information Forecasting Information and Assessment Council (TIFAC), Ministry of Science and Technology, Government of India, New Delhi and NGOs (AID, Bhubaneswar, SREE, Balasore) with a projected cost of Rs 70 lakh in presence of renowned International Agriculturist and former Vice Chancellor, OUAT, IC Mahapatra and Director, WTCER, Bhubaneswar, Ashwani Kumar.

To enhance the productivity, profitability and cropping intensity of rainfed challenging areas of Orissa, Water Technology Centre for Eastern India (ICAR), Bhubaneswar proposed the Technology Information Forecasting Information and Assessment Council (TIFAC), Ministry of Science and Technology, Government of India, New Delhi for possible funding for two project proposals like enhancement productivity of deep water rice area, enhancing productivity of acidic upland of Eastern India, prepared by the Centre. The proposals were based on the field experiences and lessons learned from earlier works of WTCER, Bhubaneswar.

Gouranga Kar, Senior Scientist of WTCER is the Principal Investigator of the projects. The deep water projects 'enhances productivity of deep water rice area,' which will be executed in Puri Sadar, Brahmagiri and Satyabadi blocks of Puri district and upland acid soil project 'enhancing productivity of acidic upland of Eastern India' will be executed in Remuna block of Balasore and Badasahi, Mayurbhanj districts.

Kar said the results of these projects can be implemented in 70,000 hectares of upland acid soils area and 50,000 hectares of deep water areas of Orissa.

Farmers can earn Rs15,000-35, 000 per hectare with the adoption technologies and socio-economic conditions of the poor farmers of these challenging areas of the State will be raised. The secretaries of NGOs Asutosh Das from AID, Bhubaneswar and Manoj Kumar Das from SREE, Balasore were present as the signatories of MoUs.

On that occasion, Director, WTCER said that to enhance the productivity of challenging areas of the State, these projects were executed by the WTCER, Bhubaneswar.

The Indian Express on 29.9.2007

Make use of excess water, farmers told

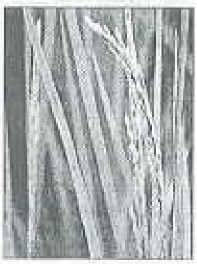
EXPRESS NEWS SERVICE

Bhubaneswar, Sept 28: Improved water harvesting techniques and proper selection of aquatic crops can transform livelihood of farmers fighting water-logging and drought in coastal areas, thanks to scientists at Water Technology Centre for Eastern Region (WTCER) here.

Keeping the coastal calamities and agro-economic parameters in mind, an awareness programme on 'Deep-water rice area' was conducted by WTCER here on Friday.

Meant for 70 farmers of Puri district, the programme emphasised on enhancing productivity through use of improved genotypes, micro-water resources development through water harvesting structure for rabi crops during dry season and enhancement of water productivity of deep-water rice ecologies through introduction of aquatic crops, said senior scientist and principal investigator of the project Gouranga Kar.

Deep-water rice



Single rice crop can be supplemented by cash crops for better returns

Coastal Orissa with high concentration of population and economic activity is vulnerable to multiple weather hazards like flood, drought and cyclone. Farmers grow only rice during rainy season but success of obtaining profitable crop depends on distribution of monsoon rain, he added.

On the other hand, the winter and summer rainfall is meagre and erratic. As a result after December the land becomes dry and the crops suffer. So growing of profitable rabi crops without supplemented irrigation is not possible. Poor aquifer characteristics and saline ground water also limit crop pattern. Hence, water-harvesting techniques must be designed to harvest rain and stagnant water of rainy season, so that it can be used in multiple ways through integrated farming system, the scientist informed.

WTCER Director Ashwani Kumar admitted that deep-water rice is a neglected area. The fields are utilised to harvest a single cop and dominated by rice in kharif season. Too much of water-logging also makes the fields unsuitable to grow other cash crops, he said.

Renowned agriculturist and former vice-chancellor of OUAT Prof I.C. Mohapatra emphasised strengthening of agriculture extension programme for adoption of proper farming technologies.

Agriculture Director Arabinda Padhee assured implementation of some of the projects to enhance productivity of deep-water rice area in the State. He urged the scientists to prepare a proper action plan to manage the crisis.

Former joint-director, Central Rice Research Institute, J.K.Roy and former HoD, Entomology of OUAT, Prof N.Panda were present.

୬ ଫୁଟ ଜଳରେ ଧାନଚାଷ

ଭୁବନେଶ୍ୱର(ସ.ବ୍ୟୁ): ଚାଷୀମାନଙ୍କ ପାଇଁ ଖୁସି ଖବର । ବର୍ତ୍ତମାନ ପାଖୁଏ ଜଳରେ ପାଣିରେ ବୁଡ଼ି ରହୁଥିବା ଜମିରେ ବି ଧାନଚାଷ ସମ୍ଭବ ହୋଇପାରୁଛି । ପୁରୀ ଜିଲ୍ଲା ସତ୍ୟବାଦୀ ବ୍ଲକ ଆଳିଗ ଗ୍ରାମର ଚାଷୀମାନେ ଏହାର ସୁଫଳ ପାଇପାରିବା ଅନ୍ୟ ଚାଷୀମାନଙ୍କୁ ବେଶ୍ ପ୍ରେରଣା ଦେଉଛି । ଖାଲି ସେତିକି ନୁହେଁ ଉକ୍ତ ଜଳରେ ଧାନ ଚାଷ କରିବା ସହ ଜଳ ଅମଳ କରି ସେଥିରେ ମାଛ, ପଦ୍ମ ଓ ପାଣି ସିଙ୍ଗଡ଼ା ଆଦି ଚାଷ କରିବାକୁ ଯୋଜନା ପ୍ରସ୍ତୁତ ହେଉଛି । ଏହାଦ୍ୱାରା ଚାଷୀମାନଙ୍କୁ ଡବଲ ବେନିଫିଟ୍ ମିଳିପାରିବ । ବିଶିଷ୍ଟ କୃଷି ବୈଜ୍ଞାନିକ ତଥା ଓୟୁଏଟିର ପୂର୍ବତନ ଡିନ୍ ଡ. ନିରଞ୍ଜନ ପଣ୍ଡା ଓ ଧାନ ଗବେଷଣା କେନ୍ଦ୍ରର ଅବସରପ୍ରାପ୍ତ ବରିଷ୍ଠ ବୈଜ୍ଞାନିକ ଡ. ଜେ.କେ.ରାୟଙ୍କ ଦୀର୍ଘ ଦିନର ଗବେଷଣାରୁ ଏହି ସୁଫଳ ମିଳିପାରିଛି । ସତ୍ୟବାଦୀ, ବ୍ରହ୍ମଗିରି, କଣାସ ଓ ପୁରୀ ସଦର ବ୍ଲକର ପ୍ରାୟ ୪୦ ହଜାର ହେକ୍ଟର ଚାଷଜମି ବର୍ଷ ତମାମ ଜଳମଗ୍ନ ରହିଥାଏ । ବର୍ଷାଦିନରେ ସେଠାରେ ୬ ଫୁଟ୍ ଉଚ୍ଚର ପାଣି ରହୁଥିଲା ବେଳେ ଖରା ଦିନରେ [illegible] କରିବାକୁ ଅନୁପଯୁକ୍ତ ବୋଲି ମୋଟାମୋଟି ଧରି ନିଆଯାଇଥିଲା । ତେବେ ସ୍ୱେଚ୍ଛାସେବୀ ସଂଗଠନ ଆସୋସିଏସନ ଫର ଇଣ୍ଟିଗ୍ରେଟେଡ୍ ଡେଭେଲପମେଣ୍ଟ(ଏଡ୍) ସେଠାରେ ପହଞ୍ଚି କୃଷି ବୈଜ୍ଞାନିକମାନଙ୍କ ସହଯୋଗରେ ଚାଷୀମାନଙ୍କୁ ସାହାଯ୍ୟ କରିବାକୁ କାର୍ଯ୍ୟକ୍ରମ ଆରମ୍ଭ କଲା । ଏଥିପାଇଁ ବୈଜ୍ଞାନିକ ଡ. ପଣ୍ଡା ଓ ଡ. ରାୟ ରାଜ୍ୟ ବାହାରୁ ବିଭିନ୍ନ କିସମର ବିହନ ଆଣି ଗବେଷଣା ଆରମ୍ଭ କରିଥିଲେ । ଶେଷରେ ୪ଟି କିସମର ବିହନ ଯଥା ଅମ୍ବିକା, ହଂସେଶ୍ୱରୀ, ସବିତା ଓ ସରସ୍ୱତୀ ଫଳପ୍ରଦ ହେଲା । ବଙ୍କେଇ ଓ ବାକୁଅ ଭଳି ପାରମ୍ପରିକ ଧାନ ଚାଷ କରି ହେକ୍ଟର ପିଛା ୩/୪ କ୍ୱିଣ୍ଟାଲ୍ ଅମଳ କରୁଥିବା ଚାଷୀମାନେ ଏବେ ଏହି ନୂତନ କିସମର ବିହନ ଦ୍ୱାରା ୧୫ରୁ ୧୬ କ୍ୱିଣ୍ଟାଲ ଧାନ ଅମଳ କରିପାରୁଛନ୍ତି । ଚାଷୀଙ୍କ ଅର୍ଥନୈତିକ ମାନଦଣ୍ଡ ବୃଦ୍ଧି କରିବା ପାଇଁ କେନ୍ଦ୍ର ସରକାରଙ୍କ ଜଳ ପ୍ରାଦ୍ୟୋଗିକ କେନ୍ଦ୍ର ଏବେ ଆଗେଇ ଆସିଥିଲା ବେଳେ ଜିଲ୍ଲା ପ୍ରଶାସନ ସମସ୍ତ ସାହାଯ୍ୟ ସହାୟତା ଯୋଗାଇଦେବ ବୋଲି ପୁରୀ ଜିଲ୍ଲାପାଳ ଅଶ୍ୱିନୀ କୁମାର ଦାସ ଦୃଢ଼ ପ୍ରତିଶ୍ରୁତି ଦେଇଛନ୍ତି ।

ଉପକୂଳ ଚାଷୀଙ୍କ ପାଇଁ ସୁଖବର: ଛଅ ଫୁଟ୍ ପାଣିରେ ବି ଧାନ ହେବ

[illegible]

The Indian Express on 20.10.2005

Pact inked to tide over waterlogging in coastal farmlands

EXPRESS NEWS SERVICE

Bhubaneswar, Oct 19: Two premier bodies have come to the rescue of farmers of coastal belt facing the problem of waterlogging in paddy fields,

The Water Technology Centre for Eastern Region (WTCER), a body under ICAR, has now joined hands with the Technology Information Forecasting and Assessment Council (TIFAC) for raising productivity in rainfed areas of the State using a new technology.

These two units, imparting technical knowhow for greater productivity, signed an MoU recently to implement a deep-water project and an upland acid soil project in the State. Director, WTCER Dr Ashwani Kumar and former V-C, OUAT, Dr I C Mohapatra were present when the agreement was inked.

The project at an estimated cost of Rs 70 lakh, can be replicated over 70,000 hectare upland acid soil area and 50,000 hectare deep-water area.

The deep-water project would be implemented in Puri sadar, Brahmagiri and Satyabadi blocks. In these areas, waterlogging is a perennial problem for the farmers.

"Prolonged waterlogging (above 1 metre) render the fields unsuitable for farming. That's the reason why farmers of Puri, Kendrapara and Balasore have been struggling to entist of WTCER Dr Gourang Kar said.

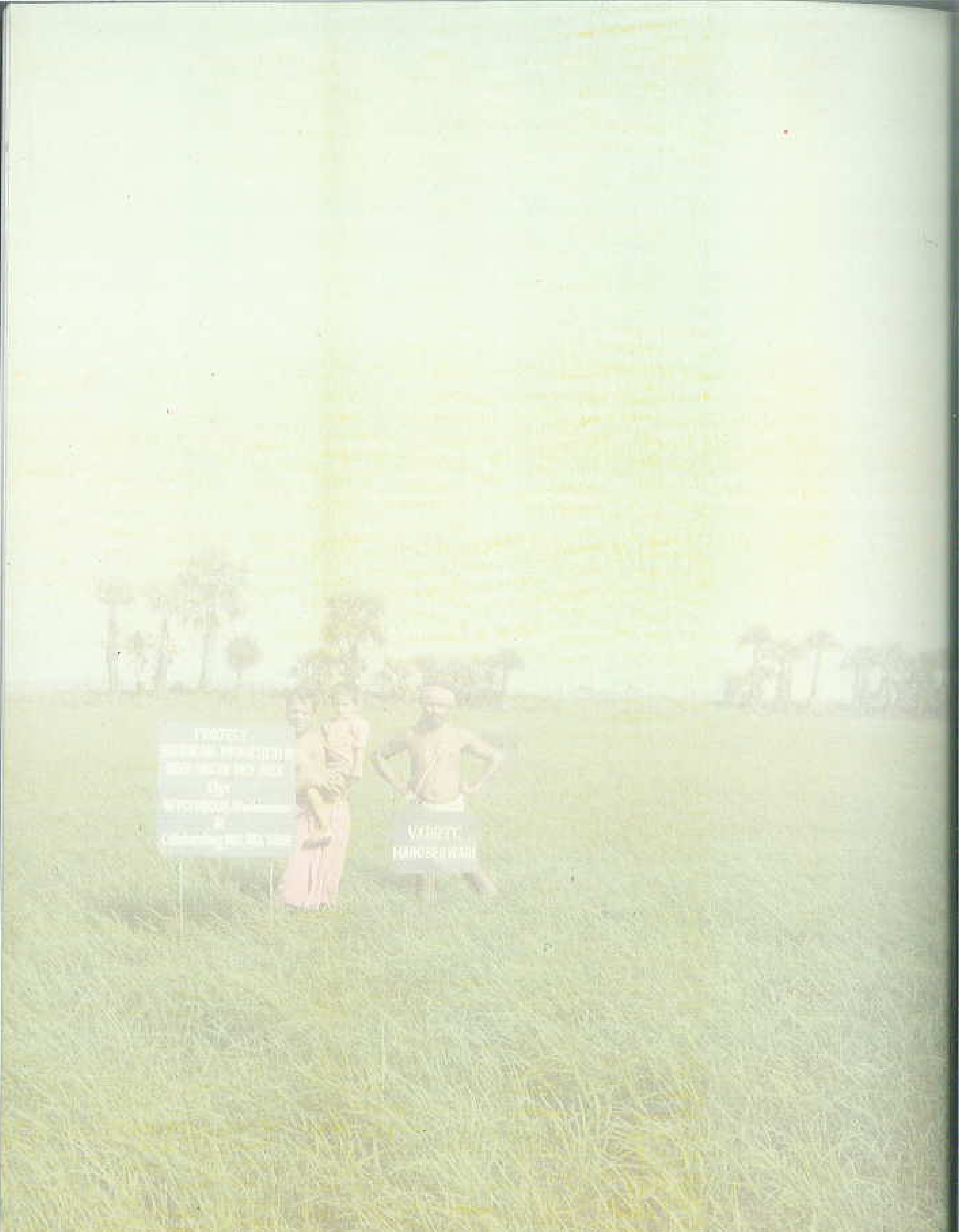
The upland acid soil project would be implemented in Balasore's Remuna and Mayurbhanj's Badasahi blocks.

If the projects are successfully replicated, farmers can earn anything between Rs 15,000 and Rs 35,000 per hectare using the technology.

IMPACT

After effective dissemination of the concept water harvesting and pond based farming system by organizing field day and through print and electronic media, large number of farmers and NGOS have come forward to adopt the technology developed by WTCER, Bhubaneswar. The cropping intensity of farmers was increased with the range between 150-250%. In the year 2006-07, 80 farmers adopted the cultivation of deepwater rice variety 'Hanseswari'. The State Government of Orissa has initiated trial at state seed farm for releasing the 'Hanseswari' variety in Orissa.

The cost-benefit aspects and sustainability of the pond based technology to mitigate seasonal waterlogged areas were also discussed in meeting on 12.3.2006 conveyed by Agricultural Production Commissioner, Government of Orissa, Dr R.N.Bohidhar. Principal Secretary of Agriculture, Government of Orissa, Dr H.S.Chahar, Director of WTCER, Bhubaneswar, Dr Ashwani Kumar and Director of Agriculture, Government of Orissa, Smt. Ranjana Chopra were also participated in that meeting. The Technology Information forecasting and Assessment Councli (TIFAC), Ministry of Science and Technology, Govt. of India has come forward to sponsor a project to disseminate the technologies of enhancing deep waterlogged ecosystem.


PROJECT
VARIETY