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Climatic Risks, Rice Production Losses and Risk Coping Strategies: A Case Study of a Rainfed Village in Coastal Orissa

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Abstract

Abiotic stresses observed in the village Kaudikol , district Cuttack, Orissa have been recorded for 8 years and analysed. Survey data collected for four years (1996-97 to 1999-2000) from the farmers of this village have been analysed to find out their livelihood system, importance of rice in this system and the coping mechanisms followed by them in case of loss to the *kharif* rice crop. The abiotic stresses have been found to cause flood / submergence to different degrees in 5 years, drought in 3 years and cyclone in one year out of the total 8 years, causing production losses to rice. The maximum losses to rice crop have been observed during 1999 *kharif* season due to cyclone. It has been found that rice is the major crop during the *kharif* season, covering up to 79 per cent of the total cultivated area with contribution of 21 per cent to total income. Service has been found to be the most important source of income, followed by rice and business. The average annual income of the farmers has been noticed to vary from Rs 23,329 for marginal farmers to Rs 84,072 for large farmers over the period 1997-98 to 1999-2000. Rice has been found to be the major source of income for medium than other categories of farmers. For large farmers, salaried job has been observed as the most important source of income. The marginal and small farmers have been found to compensate their rice income loss from sources like wage earnings, jute and *rabi*/ summer rice.

Through non-farm income and crop diversification, the farmers have been able to reduce the effect of rice income losses to some extent. Therefore, more non-farm employment opportunities should be created in this area to increase income and living standard of the farmers. Development of submergence-tolerant varieties with high-yield is the priority area for rice research in this area. There is also a need to introduce crop insurance scheme for rice crop in this area.

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Introduction

Rice is the staple food of the people of Orissa. Presently, rice is grown in an area of 45 lakh hectares with annual production of about 62 lakh tonnes. Rice is mainly grown in the *kharif* season, which accounts for 94 per cent of the total rice area and 92 per cent of the total rice production in the state. Due to a variety of unfavourable growing situations, yield of upland (covering 18 per cent area) and lowland (covering 75 per cent of area) rice during the *kharif* season is 0.85 and 1.46 tonnes, respectively in the state. Further, out of the total holdings in Orissa, 82 per cent are small and marginal; 36 per cent of the main workers are cultivators and 22 per cent are agricultural labourers. Therefore, increasing the production and yield of rice, the main crop of the state, is a matter of great concern for researchers and policymakers.

The diffusion of high-yielding varieties of rice in South Asia is well documented (Dalrymple, 1986). Though the Green Revolution technologies for rice developed during 1960s could increase rice production significantly in the irrigated areas, they have bypassed, to a large degree, the unfavourable rice-growing regions of Eastern India (Khush, 1990). This is due to the fact that *kharif* season rice of Eastern India is grown under a variety of unfavourable situations like drought, flood, submergence, salinity, toxicity, and nutrient deficiency (Singh, 1991; Mohanty *et al.*, 1995), resulting in low and uncertain yields. Uncertain yields of rice present an important and additional challenge to the agricultural researchers and agricultural technology generators as well as in technology transfer (Evenson *et al*., 1978; Anderson and Hazell, 1994; Anderson, 1995). The element of risk and uncertainty may increase with the application of new technology for all types of farmers, but, its consequences are more severe for the small farmers (Rao, 1974). Farmers in the developing world through their long experience have adapted certain varieties and agronomic practices to cope up with the risk they face under the situations to reduce substantial income-losses (Pandey, 1996; Pandey *et al.*, 2000; Kshirsagar *et al.*, 2002). Therefore, a study of the existing management practices, varieties chosen under different land situations, structures of the farmhousehold economy, and income diversification of various categories of farmers is essential before developing new technologies. Such a study will be helpful to researchers in developing less risky technologies.

Rice production in Orissa is marked by low productivity and wide fluctuations in output (Samal and Patra, 2003; Samal, 2004) due to various abiotic and biotic stresses in various rice-growing situations. It has been recorded that droughts and floods occur almost in the same year or every

alternate year in Orissa (Reserve Bank of India, 1984). The flood-prone rice lands in India account for 50 per cent of the total flood-prone rice lands of the world. Out of about 3 million hectares of flood-prone rice lands of India, the eastern India accounts for 2.4 million hectares. This flood-prone region has been largely covered by the traditional varieties. In olden days, rice was the major source of income for the farmers of these areas. With the development of industrial and service sectors, the income source has diversified over time. However, rice is important from the point of food security. It is necessary to know the rural livelihoods and importance of rice as a source of income before development of any new rice technology for the farmers in a particular region. It is in this context that the climatic risk the farmers face, the yields of rice they obtain and the rural livelihoods have been analysed in this paper.

The main objective of this study was to analyse the climatic risks encountered by the farmers at the site and the coping strategies they adopted when loss of rice production occurred. It will help in the development of rice technologies for these unfavourable ecosystems.

Data and Methods

The village Kaudikol of the Cuttack district (Mahanga block) in Orissa was selected for the study as the land under this village represented flood-prone ecology and this was also selected as a site for the IRRI-funded rainfed lowland project. The farmers were stratified by the farm-size categories as marginal (up to 1 ha), small (1-2 ha), medium (2-4 ha), and large (> 4 ha) farmers. Then they were selected through the stratified random sampling technique with probability proportion to size. In total, 60 farmers were selected for the study, comprising 25 marginal, 13 small, 19 medium and 3 large farmers. Data collection started from the farmers in the year 1996-97 and continued up to the year 1999-2000. The risk analysis was facilitated, if panel data for several years were available. In the absence of data for several years, the above 4-year data were analysed to reach some broader conclusions. The rainfall data were also collected from the block headquarters for the period and were used in this study. The income data for each farmer were collected for the period 1997-98 to 1999-2000. The incomes from different crops were computed by deducting the paid-out costs from the gross income. The average income per household at constant 1997-98 prices was computed by deflating the nominal values using the consumer price index for agricultural workers of Orissa.

Results and Discussion

The general characteristics of the study village are listed in Table 1. The small and marginal farmers dominated the village and accounted for 63 per cent of the total farmers. The average farm-size was 1.62 ha and the average family-size was 9 in the village. The size of family and the years of schooling of a household head increased with increase in farm-size. The average age of household heads was 52 in the village. The average number of parcels per farm family was 5 at Kaudikol. The number of parcels increased with increase in the farm size. The maximum number of parcels a farmer possessed was 13. The cultivated land available at the site was broadly classified into two categories by the farmers, viz. medium lands (0-30 cm water depth), and low lands (> 30 cm water depth). The medium and low lands in the village constituted 64 and 36 per cent of the total cultivated land, respectively. The upper reaches of the medium lands are valuable at the site, as farmers grow jute during the *kharif* season and urdbean and vegetables in the dry season. Only 22 per cent of the lands are irrigated during the *kharif* season through lift irrigation, road-side ditches, etc. During the *rabi*/ summer season, 16 per cent of the total land is irrigated. Above all, the irrigated area varies from year to year, depending on the rainfall received during a particular year, repair/ maintenance of lift irrigation points and power supply to the lift points available in the village.

Table 1. General characteristics of village Kaudikol, district Cuttack, Orissa

S. No.	Particulars	Farm type				All farms
		Marginal	Small	Medium	Large	
1.	No. of selected households	25	13	19	3	60
2.	Average family-size	6	8	11	15	9
3.	Average age of household-head	49	53	54	60	52
4.	Average years of schooling of household-head	3	4	5	7	4
5.	Average owned area (ha)	0.64	1.36	2.5	5.26	1.62
6.	Proportion of landtype					
	i) Medium land, %	65	73	64	56	64
	ii) Lowland, %	35	27	36	44	36
7.	Average number of parcels/ household	4	5	7	9	5
	Minimum	2	2	3	4	2
	Maximum	6	12	11	13	13
8.	Irrigated area (%)					
	Kharif season	31	20	20	21	22
	Rabi / Summer season	24	15	13	19	16

Rainfall and Abiotic Stresses

The erratic rainfall had caused different abiotic stresses like drought, flood, and submergence of different degrees at the site in different years in the *kharif* season (Table 2). The major problems at the site was submergence and flood. They were observed during 5 out of 8 years. The intensity of flood and submergence was so high that the farmers could not harvest a single grain of rice during the years 2001 and 2003. During 1997, the submergence and flood wiped out rice plants from many fields and more so from low lands. The droughts occurred in 3 years at the site, viz. 1996, 2000 and 2002. During a drought year, the major problem the farmers encountered at the site was insufficient water for beushening (an intercultural operation) in medium lands, which caused yield reduction. In addition to floods and droughts, the cyclone of 1999 also caused large scale damage to the standing rice crops at the maturity stage. Besides the above stresses, strong winds during the flowering period of lowland varieties in 1998 also caused yield losses. The frequency of occurrence of natural calamities at the site was collected through Participatory Rural Appraisal technique, taking a period of 15 years into consideration. The probabilities of each calamity by land type were computed. It was found that the probability of occurrence of flood and submergence was 53 and 80 per cent in medium and low lands, respectively in a year. The probabilities of occurrence of drought in medium and low lands were found as 20 and 13 per cent, respectively. The probability of occurrence of cyclone was 13 per cent. Thus, it was confirmed that the occurrence of flood and submergence was more frequent than the drought and cyclone at that site.

Major Crops

Farmers choose different crop sequences according to their land type and availability of irrigation. The per cent area under different crops taken

Table 2. Abiotic stresses during different years

Year	Abiotic stresses
2003	Submergence (3 times) and flood
2002	Drought
2001	Submergence (2 times) and flood
2000	Drought
1999	Excessive rains during sowing, submergence (twice) and cyclone followed by submergence
1998	Submergence (once); Strong winds during October (last week) and November (first week) (Flowering stage)
1997	Submergence (once) and flood
1996	Drought

in the *kharif* and *rabi*/summer seasons during 1996-97 to 1999-2000 has been presented in Table 3. Rice covered maximum area (58-79%) followed by jute in the *kharif* season in all the years. The jute area varied from 21 to 32 per cent over years, depending on prices during the previous season and weather conditions at the sowing time. Jute is cultivated in the upper reaches of medium lands. Urdbean occupied major *rabi*-season area followed by mungbean. During the super cyclone year, to increase household food-security, farmers increase the area under *rabi*-season rice due to free supply of water through lift points. Besides the above major crops and vegetables, farmers also grow, though to a lesser extent, crops like wheat, horsegram, coriander and redgram in the study village in the *rabi*/summer season.

The adoption of modern varieties (MVs) of rice was mainly confined to upper reaches of midlands in the study village. Among the modern varieties adopted, *Parijat*, a short-duration variety, dominated all other MVs. This is due to the fact that submergence-tolerant rice varieties are not available for the study area for medium and low lands. These types of lands were largely covered by local or traditional varieties (TVs) of rice during the *kharif*-season. The percentage coverage of MVs fluctuated between 8 and 13 per cent of total rice area in the village. The predominant method of crop establishment of rice was direct sowing. The percentage coverage over the 4-year period varied from 96 to 100 per cent. This was due to the fact that labour availability was a major problem in the study area during the time of transplanting, as this period coincides with the harvesting and retting of jute.

Table 3. Percentage area under different crops in Kaudikol: 1996-1999

Crops	1996	1997	1998	1999
***Kharif* Season**				
Fallow	2	0	0	10
Rice	76	79	73	58
Jute	22	21	27	32
***Rabi* / Summer Season**				
Fallow	40	33	52	50
Mungbean	17	33	5	14
Urdbean	29	29	33	25
Vegetables	5	1	4	1
Rice	2	-	3	7
Others	7	4	3	3

Others during the *rabi* / summer season include wheat, horsegram, coriander and redgram

Table 4. Mean yield* of modern and local varieties of rice by land type in different years : 1996-1999

(t/ha)

Year	Local varieties		Modern varieties	
	Medium land	Low land	Medium land	Low land
1996	1.39	1.42	1.82	NA
1997	1.31	0.12	1.91	NA
1998	2.12	1.81	3.69	NA
1999	0.61	0.58	2.77	NA

* Yield in terms of paddy, i.e. rice with husk;
NA: Not available

Rice Yields

The yield data for the four years under study by the land type and by the modern and traditional varieties are presented in Table 4. Submergence and flood affected the yields of varieties grown in the medium land during 1997 and 1999. The average yields of local and modern varieties varied from 0.6 to 2.1 t/ha and 1.8 to 3.7 t/ha, respectively. As mentioned in the earlier section, the modern varieties grown in the medium lands are confined to upper reaches. The predominant modern variety grown in the village was *Parijat* and this variety was affected in 1997, as the flood period coincided with the maturity period, leading to germination of paddy in the field itself. The cyclone of 1999 during October caused substantial yield losses in both types of lands.

The lowland yields were mostly affected by submergence during 1997, 1998 and 1999. The yields of local varieties varied from 0.1 to 1.8 t/ha over the 4-year period. During 1998, the lowland yields were also affected due to blowing of a strong wind for one week during the flowering period of the crop. Though the yield data were not recorded from individual farmers in subsequent years, it was a general observation that due to severe floods in 2001 and 2003 farmers could not harvest a single grain from their fields.

Household Income

The household incomes from different sources in percentage terms for three years have been presented in Table 5. The actual average income data of the farmers by farm type for 1997-98, 1998-99 and 1999-2000 have been presented in the table in the last row. The income sources were found to be more diversified in the village. On an average, the contribution of income from annual crops to total income varied from 30 to 41 per cent

Table 5. Sources of income by farm type at Kaudikol, district Cuttack, Orissa: 1997-1999

(in per cent)

Source of income	Marginal farms			Small farms			Medium farms			Large farms			All farms		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Kharif rice	10	18	6	19	18	6	31	25	8	17	21	6	21	20	7
Jute	6	8	11	5	7	10	10	14	15	8	8	11	7	10	12
Mungbean	7	1	4	2	0	2	8	1	2	0	0	3	5	1	3
Urdbean	3	5	4	5	5	4	5	6	5	10	4	2	5	5	4
Vegetables	0	1	0	0	5	2	2	4	0	1	4	1	1	3	0
Other crops	0	0	1	0	1	0	5	2	3	0	1	1	2	1	1
Rabi rice	0	1	4	0	0	1	0	1	3	0	0	0	0	1	3
Sub-total	26	34	30	31	36	25	61	53	36	36	38	24	41	41	30
Perennials	5	2	1	3	1	1	2	3	2	4	9	7	3	3	2
Livestock	9	9	5	10	10	7	4	6	4	3	4	3	7	8	5
Wage	16	12	17	3	4	7	1	3	4	0	0	0	6	6	8
Service	25	26	20	34	33	35	18	21	27	57	40	46	28	27	30
Business	17	17	17	19	16	17	14	14	21	0	9	16	15	15	18
Relief	0	0	10	0	0	8	0	0	6	0	0	4	0	0	7
Sub-total	74	66	70	69	64	75	39	47	64	64	62	76	59	59	70
Total income (Rs)	23329	25725	32736	37112	37339	42763	46013	52375	49726	83747	84072	80869	35527	38903	42696

over the three years. It is evident from the table that rice contributes 21 per cent to the total income, if the natural calamities are not severe. The other important sources of crop income were income from jute and urdbean. Service was found to be the most important source of income followed by rice and business. Dairying and wage earnings also contributed 5-8 per cent of the total income during the period under study. During 1999-2000, the government relief due to super cyclone accounted for 7 per cent of the total household income.

Analysis of different sources of income by farm type was conducted and these results have also been presented in Table 5. The average annual income of farmers varied from Rs 23,329 for marginal farmers to Rs 80,869 for large farmers over the period 1997-98 to 1999-2000 at constant prices of 1997-98. Rice was found to be an important source of income for medium farmers than marginal and small farmers. For large farmers, the income from service was found to be the most important source of income. The marginal and small farmers augmented their family income from sources like service, wage earnings, business and livestock activities.

Risk Coping Strategies

Risk coping strategies can be classified as *ex-ante* and *ex-post*. The major *ex-ante* strategies adopted to cope-up with the erratic rainfall pattern in rice production are crop establishment methods, area of rice planted, changes in rice varieties at the beginning of the season; and cultural and input management practices during the mid-season. But, the scope of adjustment late in the season is very limited, as the major costs have already been incurred. The *ex-ante* strategies followed by farmers in the study village were choosing a rice variety of purple base to combat wild rice menance and weeding out the lowland rice fields before 45 days of seedling age to allow the seedlings to grow faster before submergence, irrespective of farm types.

Various *ex-post* strategies adopted to prevent shortfall in consumption when losses occur during the *kharif* season rice are off-farm wages, expanding area under other crops, including rice wherever possible in the following *rabi*/summer season, consumption loans, migration, sale of assets, other non-farm activities, etc. The strategies followed by the farmers in the study village, for which income data were available have been discussed below.

All the three years for which income data were available, were observed to be the stress years for *kharif* rice. Rice production losses occurred in

various magnitudes during these three years. The maximum loss in rice production occurred during *kharif* 1999. During this year, the major income augmentation was through wages from public works for the peasants. Marginal farmers compensated a part of income loss from rice through higher income from *rabi*/summer rice and wages. Increased income from jute also helped in compensating a part of income loss from rice for all types of farmers. Government relief contributed 10 per cent to income during 1999 for marginal farmers. The large farmers compensated the production loss from rice through income from jute and other non-farm activities like service which was the major source of income. Business activities, to some extent, mitigated the yield loss from rice for large farmers during 1999. During 1998, the income losses from rice were compensated by growing of vegetables by all types of farmers during the *rabi*/summer season. During 1997, income from mungbean and perennial crops like bamboos and coconuts compensated the production loss from rice partially for marginal farmers.

Conclusions

Rice is the main crop during the *kharif* season in Orissa and contributes, on the average, one-fifth of the total income of farmers. Submergence has reduced or eliminated plant population from many rice fields during 5 out of 8 years surveyed during the *kharif* season. Drought and cyclone have also affected yields of *kharif* rice in three years and one year, respectively out of 8 years. Efforts should be intensified to develop and test submergence and drought-tolerant varieties with high yield in comparison to the local cultivars so that rice income and food security can be increased. Diversification of income from other crops, *rabi*/summer rice and non-farm sources has helped in stabilizing of the farm income during stress years. The small farmers have compensated income loss from *kharif* rice through off-farm wages, growing *rabi*/ summer rice, mungbean and vegetables in different years. The larger farmers compensated the rice income loss from sources like business, service, *rabi*/summer rice, mungbean and vegetables. Policies by the Government that encourage further diversification of income sources from both non-farm and on-farm activities during *rabi*/summer season could play an important role in reducing the impact of income losses from the *kharif* rice. Researchers need to be aware of these coping mechanisms so that interventions in rice crop that complement these sources could be developed. There is also a need to introduce crop insurance scheme in the area for rice crop on priority basis.

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