

# Agricultural Vulnerability at Bhitarkanika Wildlife Sanctuary, Orissa

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**Abstract:** *Bhitarkanika wildlife sanctuary is the second largest mangrove forest of India with 70 mangrove species, caters a unique faunal composition including Estuarine crocodile, Olive Ridley, Otter, Dolphin and Birds. However, in spite of having a totally protected National Park at the core, the sanctuary hosts nearly two hundred fifty five inhabited villages under the administrative jurisdiction of Rajnagar CD block. The residents of the region depends mostly on aquaculture and agriculture, both of which is dependent on the mangrove ecosystem.*

*The present investigation explores the relationship of productivity of paddy with external factors like climate, fertilizer use and soil quality. The study reveals a decreasing productivity of paddy, perhaps due to enhanced soil salinity, and climate change scenario. It is analysed that, if the present trends of landuse and climate changes continue for a few years, then the regional demand for paddy will exceed the production potential. Thus, the system, if considered to be closed one will soon reach it's carrying capacity.*

## Introduction

Bhitarkanika wildlife sanctuary, the second largest mangrove forest of India, after Sundarbans, is spread over an area of 672 sq. kms in Kendrapara district of Orissa, at the confluence of River Bramhini and Baitarani (20°35' to 20°50'N and 86°45' to 87°05' E). Out of the 672 sq. kms, 145 sq. kms dense forest, hosting nearly 70 mangrove and mangrove associate species (Banerjee & Rao, 1999), have been declared National Park in 1998 followed by the declaration of being wetland of international importance or RAMSAR site (65000 ha) in August 2002. Although the National Park area is totally protected for wildlife, the outer sanctuary area is densely inhabited rural area. The sanctuary includes nearly two hundred fifty five inhabited villages under the administrative jurisdiction of Rajnagar CD block. The residents of the region depends mostly on fishery and coastal agriculture, both of which are dependent on the resourceful mangrove ecosystem.

However, due to lack of irrigational facilities and freshwater resources, the mostly a mono-cropping pattern of paddy cultivation is common in the region. Although, three different seasons of harvest are reported, but the Kharif or more specifically November to February (winter) harvest comprises of nearly  $95 \pm 4$  per cent of the annual yield of the area. Thus, any analysis with only the winter yield (Nov-Feb) is expected to indicate the overall trend of agricultural production of the region.

In this paper, thus, all the analysis has been done on the basis of threats or vulnerability assessment of agricultural production for the Kharif season.

## Data Sources & Methodology

The present study for agricultural threat assessment has been done primarily on the basis time series data from secondary sources followed by mathematical and statistical analysis.

The productivity data were collected from the Directorate of Economics and Statistics of Govt. of Orissa, Bhubaneswar, which calculate per hector paddy yield at harvest by choosing suitable samples from different agricultural fields under jurisdiction of different CD Blocks. The climatic data were collected from the Indian Meteorological Department, Bhubaneswar office for the station Chandbali, nearest of the sanctuary area.

All the data collected thereafter were tabulated in Microsoft-Excel worksheets and analysed mathematically and statistically using standard formulae.

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In the other part of the study, soil samples were collected from various agricultural fields of the forest adjacent villages from a depth of 10-15 cm to exclude the O-horizon humus layer by metallic soil collector.

The samples were then brought to the laboratory and air-dried before crushing and grinding the same in mortar pestle. All the impurities are excluded during grinding and sieving the soil sample.

For salinity or electrical conductivity and pH measurement, 1:5 soil suspension were made by mixing five times volume distilled water with the onetime weight sample and shaking the same continuously for two hours in mechanical shaker. After two hours, the reading were taken by EC meter and pH meter.

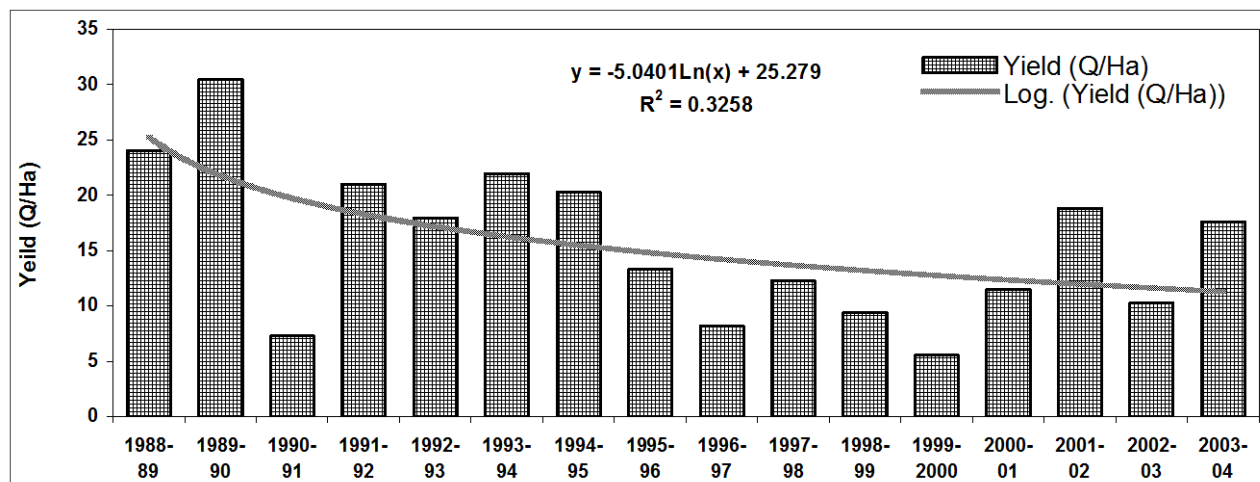
## Results and Discussion

Paddy is the prime production and consumable of the area, and is considered as an indicator of the regional economy. Preliminary socioeconomic survey was conducted with a sampling population of 180 in 14 forest neighbouring villages. This revealed 85.56% population depends directly on the mangrove forest for livelihood supports mostly for energy sector (fuel wood), fodder and ranching. Other minor forest products like crab, vegetables (mostly *Sauda sp.*), and Nalia grass for basket manufacture are also being exploited. The survey indicated dependence of 92.78% of the population on the agriculture either solely or in combination with the marine or estuarine capture fisheries. Thus, anything harmful to agriculture or marine fish availability, will no doubt, adversely affect the villagers.

As the tendency of consuming cereals from external sources was hardly observed, the chances of internalization of externalities could also be excluded and the paddy 'production – consumption' system can be considered closed in this study.

Detailed appraisal, of the paddy productivity (Q/Ha) showed a steep decrease in production rate since 1988-89 for the area following the logarithmic equation:

$$y = -5.040\text{Ln}(x) + 25.279 \quad [R^2 = 0.3258]$$



**Figure 1:** The year wise productivity of paddy at Rajnagar block since 1988-89

The area under study, being a coastal zone is witnessing a land transformation from agricultural to aquaculture in recent years. Introduction of aquaculture farms within the sanctuary area requires saline water transport to the aquaculture ponds through feed channels. These, in turn, are the carrier of irrigation water for the agricultural fields of the area and may have bearing on the soil salinity of the region. The present study, in the agricultural fields from different sampling sites recorded soil salinity ranged between 0.48 and 6.18 dS/M. It is worthwhile to mention that aquaculture practices promote salinisation of agricultural soil mostly by means of salt leaching even resulting salt encrustations at times. Our study with 18 soil samples, 16 from agricultural fields and 2 from aquaculture

embankments revealed a strong statistically significant (at 1% level) negative correlation ( $r = -0.62771$ ) between soil salinity and the distance of aquaculture from the sampling site, which is indicative of the role of aquacultures in the agricultural soil salinity (Table 1).

**Table 1: The agricultural soil quality at Bhitarkanika**

Sample	Soil type	pH Values	Soil Salinity (EC <sub>e</sub> ) (dS/m)	Distance from Aquaculture (Mt)
1	Agriculture	6.45	3.14	150
2	Agriculture	5	4.65	800
3	Agriculture	5.5	6.18	50
4	Agriculture	5.05	3.955	50
5	Agriculture	5.25	0.485	Not in close Vicinity
6	Agriculture	5	1.485	Not in close Vicinity
7	Agriculture	4.5	3.63	50
8	Agriculture	5.1	5.39	10
9	Agriculture	4.75	5.13	10
10	Agriculture	5.05	1.58	Not in close Vicinity
11	Agriculture	4.85	3.735	50
12	Agriculture	5.8	2.8	500
13	Agriculture	5	1.595	Not in close Vicinity
14	Agriculture	5.55	5.325	20
15	Agriculture	5.65	4.815	Not in close Vicinity
16	Agriculture	4.6	4.77	Not in close Vicinity
17	Aquaculture	5.47	8.61	0
18	Aquaculture	6.04	8.05	0

In the area, among all the soil samples only 25% of the agricultural soils represented salinity less than 2 dS/m<sup>2</sup>, while nearly 25% had a value more than 5 dS/m<sup>2</sup>, which was found to be the minimum salinity range of nearby mangrove soils.

But strikingly, in all the cases, agricultural soils showed lower pH, which may be attributed to the fact that in such areas the soils are alluvial in origin and have acid sulphate or potential acid sulphate characteristics, which may again lead to a rapid reduction in rice production within a few years due to acidity, iron and aluminium toxicity and lack of available nutrients (Bennet & Reynolds, 1993 and Macintosh & Zisman, 1995).

Laboratory studies have confirmed the susceptibility of specific rice variety to high salinity. Even at the 1.9 dS/m salinity level the seedling growth is reduced followed by significant reduction in survival of the same at salinity of 3.4 dS/m (Zeng & Shanon, 2000). Several other studies on exploration of possibilities in yield reduction due to saline water intrusion have also confirmed that salinisation and subsequent acidification of agricultural soil renders considerable reduction in rice yield (White et al, 1996). Even with moderately saline (EC 3.5dS/m) water irrigation, the yield has been found affected (Asch et al, 2000). However, as rice is the only cash crop of the study area, such an enhanced salinity of the soil is expected to impart adverse effects on local economy. For better yield, with the normal rice varieties the salinity should be minimum i.e. nearly 1.9dS/m or less, which has been set up as the threshold salinity of rice production, contradicting the general guidelines of 3.0dS/m threshold value (Grattan et al, 2002). Genetically modified salt tolerant rice varieties, can even tolerate 9 -10 dS/m salinity level and high soil alkalinity (Mishra et al, 2000). But, here in absence of such use, the soil quality data indicates possibilities of decrease in rice yield with the increasing salinity.

However, the reducing productivity of the agricultural land may or may not be solely dependant over the soil

quality. Instead, external factors like use of fertilizers, climatic conditions etc. may also have some roles to play. In this context fertilizer supplementation also plays a pivotal role and thus need consideration, for productivity. Farmers of the area have been found to use both chemical fertilizers and organic compost as well. But, for the last 7 years data, no significant relationships could be established between higher chemical fertilizer consumption and increased paddy yield of Kharif season, imposing further limitations in agricultural sustainability. However, the consumption of organic compost showed a positive relationship with productivity ( $r = 0.4274$ ).

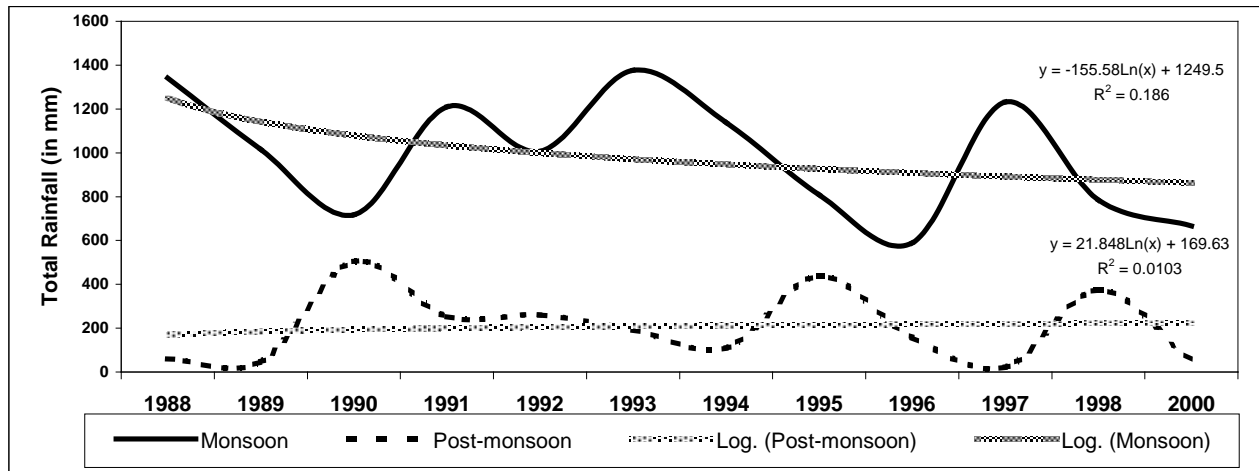
Among other factors, climate plays most vital role in agricultural productivity. Alike other coastal zones, Bhitarkanika too, cannot depend on the irrigation water for agricultural practices, as the estuarine water, if irrigated, may make the soil saline. Timely and the desired level of rainfall thus are very critical for the region. Strong correlation of the productivity of kharif season with monsoon rainfall ( $r = 0.70307$ ) could be established in our study, which was even statistically significant at 1% level. But, in this analysis the year of super-cyclone, i.e. 1999-2000, was excluded, because sudden storm surges destroyed most of the crop, resulting, a meager 5.56 quintal/ha production of paddy that year, in spite of having good crop growth. The higher post-monsoon rainfall was found to impart negative effects, although in none of the cases, any statistically significant result was recorded. But, if the super-cyclonic surge is included in the analysis, then it made the relation ( $r = -0.6334$ ) statistically significant at 5% level, confirming the adverse effect of post monsoon rainfall over productivity of paddy.

In addition, as it has been reported earlier that, a shift in highest rainfall months from June and October during 1980-84 to August and October during 1995-99, is noticed (Mitra & Hazra, 2003), since 1988-89 the monsoon rainfall excluding the super cyclone year, has been found to decline rapidly (Figure 1) following the equation:

$$y = -155.58\text{Ln}(x) + 1249.5 \quad [R^2 = 0.186]$$

where as, the post monsoon rainfall for the same period excluding the year of super cyclone showed an increasing trend (Figure 2) following the equation:

$$y = 21.848\text{Ln}(x) + 169.63 \quad [R^2 = 0.0103]$$



**Figure 2:** The year wise monsoon and post monsoon rainfall since 1988-89

However, in the contrary, temperature has been found to have least impact on the paddy productivity. Although a negative relationship of productivity was inferred with the average temperature of pre-monsoon, monsoon and post-monsoon period, none of the relationships were statistically significant. It remains to be explored further after what level of temperature increase the productivity shows perceptible decrease with increasing temperature.

## Conclusion

Thus the present work demonstrates that the agricultural production vis a vis food security of the Bhitarkanika area is under stress and is vulnerable for climate change related impacts.

While paddy production remains unaffected in soil salinity below 2dS/m<sup>2</sup>, nearly 75% of the studied soil samples showed the value above 2. The increasing conversion of land to aquaculture farms also poses a threat to the eco-system, as soil salinisation has been proved to be directly dependent over the presence of aquaculture at the vicinity. Moreover, the use of fertilizer is increasing every year, without any perceptible increase of yield.

In addition to the soil quality degradation, the trend of changes in the monsoon rainfall pattern is noteworthy for the area. For example while the necessary rainfall of monsoon is reducing, the rainfall at harvesting season is increasing, which may adversely affect productivity of paddy. The impact of heavy rainfall in post-monsoon on productivity can be illustrated with the considerable reduction of yield in the year of the super cyclone.

The study shows that unless high yielding salt resistant grains are introduced in the area, the system will soon reach it's agricultural carrying capacity, given the present trend of soil salinisation, increasing post monsoon rainfall and increasing population density. As a consequence, the regional economy will be adversely affected, leading to over-exploitation of the existing natural resources like mangroves. This may lead to further degradation of the sensitive ecological niche.

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