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Integrated Approach for Improving Water Productivity in Groundwater Exploited Areas of Coastal Odisha

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This study explores the background scenarios of an over-exploited coastal aquifer in the lower Subernarekha river basin of north Odisha, and highlights the socio-economic benefits through technological interventions. The change in vegetation (i.e. NDVI) between the year 2000 and 2009 shows a notable shift from other land-use classes to agricultural practices, with a 15% increase in area under vegetation during the pre-monsoon summer season. This indirectly point to the increased groundwater utilization, because farmers use their own shallow tube well or purchase water from others to grow the summer paddy. As a case study, a tank-cum-well system, with a tank of 80 m length, 60 m width and 2 m depth, has been created. In 2014, with delayed arrival of monsoon rainfall and persistent dry spells, the harvested volume of 10000 m^3 of water provided the life-saving irrigations. To improve the water productivity, fish farming was undertaken with a stock of about 2000 fishes, each grew to about 450 grams within 3 months. Moreover, a 2 m width and 0.15 m depth earthen platform was made around the recharge structure in which 500 banana plants were grown, along with perennial fruit crops. In the first year, a gross return of Rs. 75,000 has been estimated.

*(**Key words:** Ground water recharge, Integrated farming, North Odisha, Over exploited aquifer)*

Situated in the north-eastern part of Odisha, the district Balasore, with latitude 20 4 0 to 21 58 30N and longitude 86 16 to 87 29E and geographical area of about 3774 km^2 (Fig. 1) is known for its diverse agricultural and fishery activities. Specifically, the northeastern tip of the district, comprising of the administrative blocks Bhograi, Baliapal, Basta and Jaleswar, is the core region where water productivity is high. This is because of the endowment of natural resources, particularly the availability of replenishable groundwater and the alluvial soil. While the region belongs to the subtropical humid climate with an average rainfall of 1752 mm, two physiographic classifications, such as the coastal belt and the inner alluvial plain are the noteworthy features. Within 5 to 10 km from the coastline, the fresh water strata and saline water zones occur at different intervals up to 400 m from the surface. Intensive agriculture and aquaculture of the district has resulted in resource deterioration. More than 10000 private bore wells have been developed which feeds the water requirements for around 30,000 hectares of rice-rice-rice cropping system.

Ground water exploitation for agriculture is 14607 ha-m (hectare meter), which is around 60% of the total assessed groundwater resource of the region. Consequently, there is a phenomenal decline in ground water resources due to unscrupulous abstraction (Panda and Kumar, 2011). The other problems are salt water ingress and water quality deterioration due to rampant pesticide use in the rice-rice-rice cropping system (Rejani *et al.*, 2003). The mean pH of Bhogorai block was more than the neutral range *i.e.* 6.5 - 7.5, indicating a degree of salinity of groundwater due to the proximity of the sea. However, all the blocks had mean and maximum pH close to the upper limit of the neutral range. The salinity level may increase in future if groundwater overexploitation remains unabated. The mean EC of all the blocks were more than the safe limit of less than $0.75 dSm^{-1}$. Particularly, a high salinity was observed in Baliapal. Precarious situation like this can be tackled by proper ground water management strategies and planned development techniques for enhancing water productivity. The primary objective of this study was to investigate the spatio-temporal changes in the groundwater-irrigated agriculture, and to present the case study of a water-productivity-enhancing intervention in this region.

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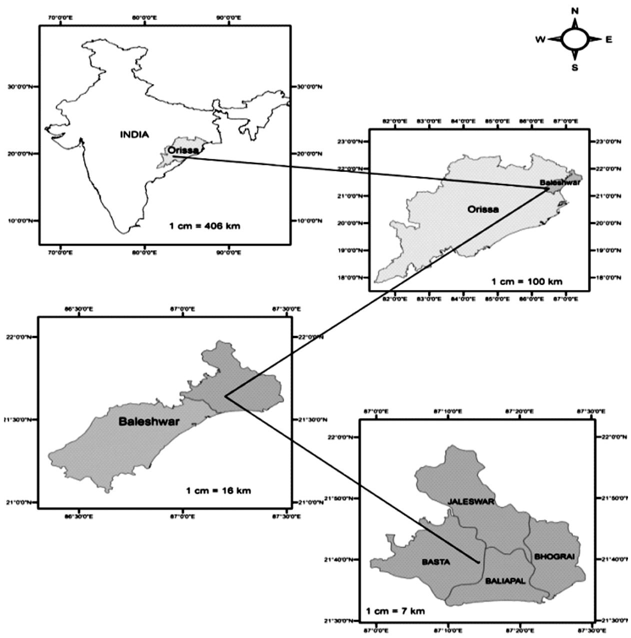

Fig. 1. *Study area comprised of Bhograi, Baliapal, Basta and Jaleswar blocks of the district Balasore, Odisha*

MATERIALS AND METHODS

The ecological degradation of the study area due to anthropogenic intervention can very well be perceived through: (1) abandonment of numerous bore wells as it yields no water; (2) spectacular drop in area of cultivation from individual bore well in comparison to the area at the time of digging (Table 1). Thus, we first examined the land use and land cover changes, which plays an important role in agricultural policy decisions. The land use classification was done using image processing software ERDAS IMAGINE ver. 9.1. The supervised clustering algorithm is examined in the pixel. ERDAS IMAGINE was chosen to implement the ISODATA algorithm in unsupervised classification. The maximum likelihood technique was used for supervised classification tests. As this algorithm assumes a Gaussian distribution of pixel values within each training class, it tends to be somewhat more accurate in regions with high surficial variability. Image pixels that fall within the specified standard deviation of the training class mean are assigned to that class. This method also allows for a weighting factor; image pixels are less likely to be classified as ground cover types with lower probabilities of occurrence within the scene. The training sites such as paddy, current fallow (rainfed agricultural land), water body and settlement were identified with the help of ground truth sites marked on false colour composite (FCC) map. These were used for the supervised classification for 2000, 2009 and 2014 March data.

For the NDVI data set, the 16-day composite MODIS 250 m NDVI data (MOD13Q1) has been used, which was downloaded from USGS Glovis in HDF format. The data was converted from HDF to IMG format using ERDAS IMAGINE software. The time series consisted of 16-day composite periods, and one tile (h26v6) of the MODIS data were required for state-wide coverage. For each composite period NDVI data were extracted by tile and re-projected from the Sinusoidal to UTM projection.

RESULTS AND DISCUSSION

The change in vegetation between the year 2000 and 2009 shows a notable conversion from other land-use classes to agricultural land practices; there was a 15% increase in agricultural land in 2009 compared to 2000 (Fig. 2). The other class such as built up also shows a positive change. The red colour in image shows a negative trend of vegetation cover. This negative change includes the conversion of agricultural land into built up area that includes in others class i.e. 5911.2 ha, whereas green colour represents positive trend that includes conversion of rain-fed crop area, dry sand and others

Table 1*.Cases of water table and irrigated area declines in the study area*

Well	Year of construction	Decline (m) by 1996	Initial area irrigated (ha)	Area irrigated (ha) by 1996
1	1981	2	10	3.2
2	1992	2	4	2.4
3	1988	2	3.2	1.6
4	1990	2	1.6	0.4
5	1990	2.5	4	2
6	1989	3	4	1.6
7	1987	2	2	0.4
8	1985	2	2.8	1.2
9	1993	4	1.6	0.6

classes to dry season irrigated cropland area, i.e. 10536 ha, 86.49ha, 8065 ha respectively.

The proportion of increase was highest in Bhogarai and it also represents the highest land under dry summer irrigated cropland. The proportion of land under cultivation to total study area has been estimated to be 8.6% for Bhograi, 8.3% for Jaleswar, 3.3% for Baliapal and 6.7% for Basta (Fig. 3). In 2014, Jaleswar shows the maximum land under cultivation to its total land area at 32.15% (i.e. 10633 ha). It increased from 18.71% in 2000 to 32.15% in 2014. In Bhogarai, the percentage increased from 21.88% (9087 ha) in 2000 to 26.63% (11053) in 2014. Baliapal has the lowest land under cultivation to its total land area at 8% (2753 ha) in 2000 to 12.61% (4305 ha) in 2014. The trend of increasing land under cultivation was proportionate in Bhograi (21.88% in 2000 to 24.19% in 2009 to 26.63% in 2014) and Baliapal (8% in 2000 to 10.9% in 2009 to 12.61% in 2014). Whereas, there was a huge leap in Jaleswar and Basta, that is from around 18% in 2000 to above 30% in 2009 and 2014. The rate of increase from 2000 to 2009 was more in every block compared to that from 2009 to 2014.

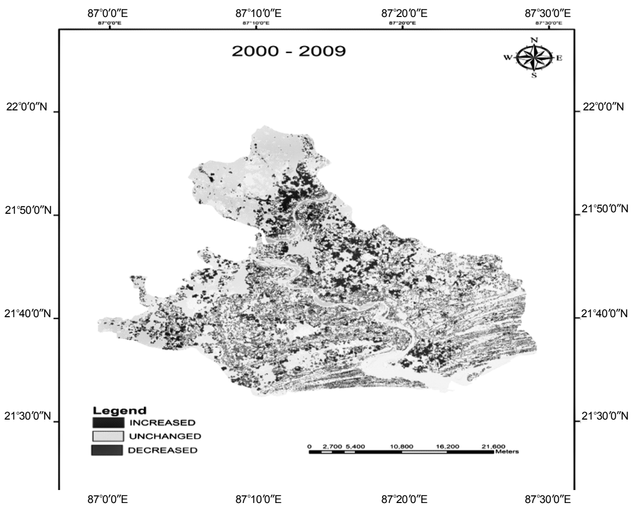

Fig. 2. *Change in vegetation during April (peak summer time rice) 2002 vs. 2009*

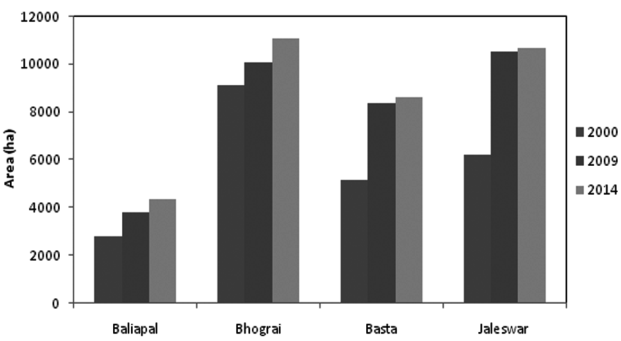

Fig. 3. *Groundwater irrigated summer season rice cultivated area of the studied blocks during 2000, 2009 and 2014*

Fig. 4 illustrates the representative groundwater level of a monitoring well in the Jaleswar block of the study area to highlight the declining level in the month of January due to over-withdrawal of groundwater to irrigate the summer season rice cultivation. It can be noticed that the groundwater level is lowering at the rate of about 0.5 m per decade. Monitoring wells are generally situated away from the water withdrawal wells to reflect the neutral pattern. It can be argued that the water table of the running wells might be declining at a higher rate.

During the last 15 years, *i.e.* 1999 to 2014, groundwater resource has been more relied upon because of the erratic behaviour of the rainfall. It can be observed from the Fig. 5 that rainfall deficit years with large deviations have dominated the time series, with an overall decreasing trend. In contrast, the NDVI values have increased, suggesting more vegetation during the dry period of the year *i.e.* January to April. This indirectly provides clue that groundwater has been used to compensate the moisture stress of the dry years. Therefore, our results show that the aquifer water table is

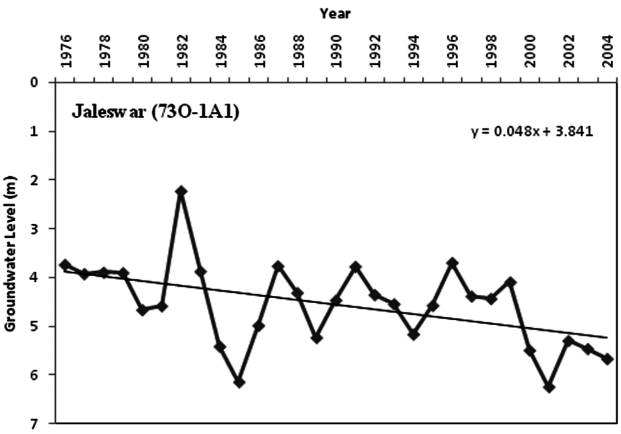

Fig. 4. *Groundwater level during 1976 to 2004 in Jaleswar recorded in the intensely irrigated month of January for the summer season rice cultivation*

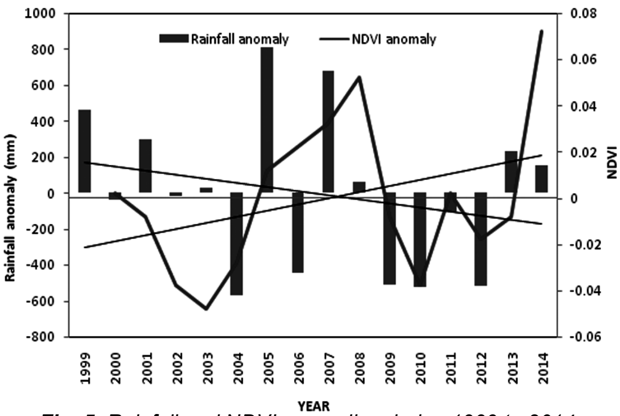

Fig. 5. *Rainfall and NDVI anomalies during 1999 to 2014, averaged over the four blocks of the study area*

declining fast, and will continue to decline if the current rainfall pattern does not change to a stable one. The only measure for the present scenario is to undertake projects for improving the recharge to arrest, to some extent, the declining water table and simultaneously increase the water productivity.

Keeping this requirement in view, a tank-cum-well system of 80 m length, 60 m width and 2 m depth, has been created in the over exploited aquifer in lower Subernarekha river basin (Fig. 6). This system, with harvested volume of 10000 m^3 of water, has helped to irrigate the crops during the dry spells of 2014 monsoon

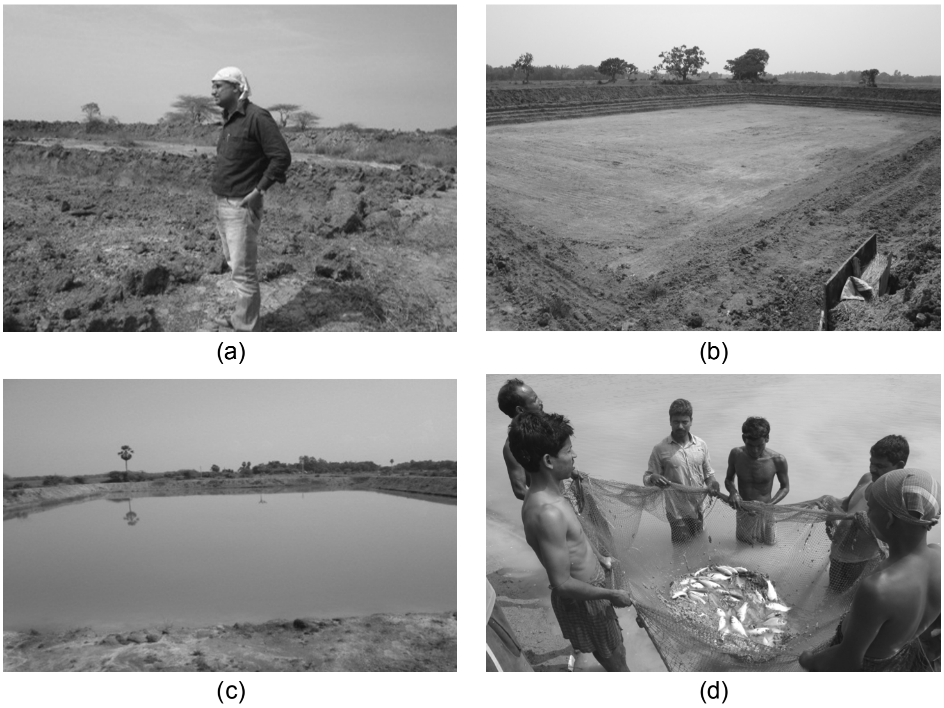

Fig. 6. *The tank-cum-well system for groundwater recharge and enhancing water productivity; (a) a waste land is used to create the system, (b) with 80 m length, 60 m width and 2 m depth (c) to harvest 10000 m^3 volume of water, which has been used for (d) fish farming.*

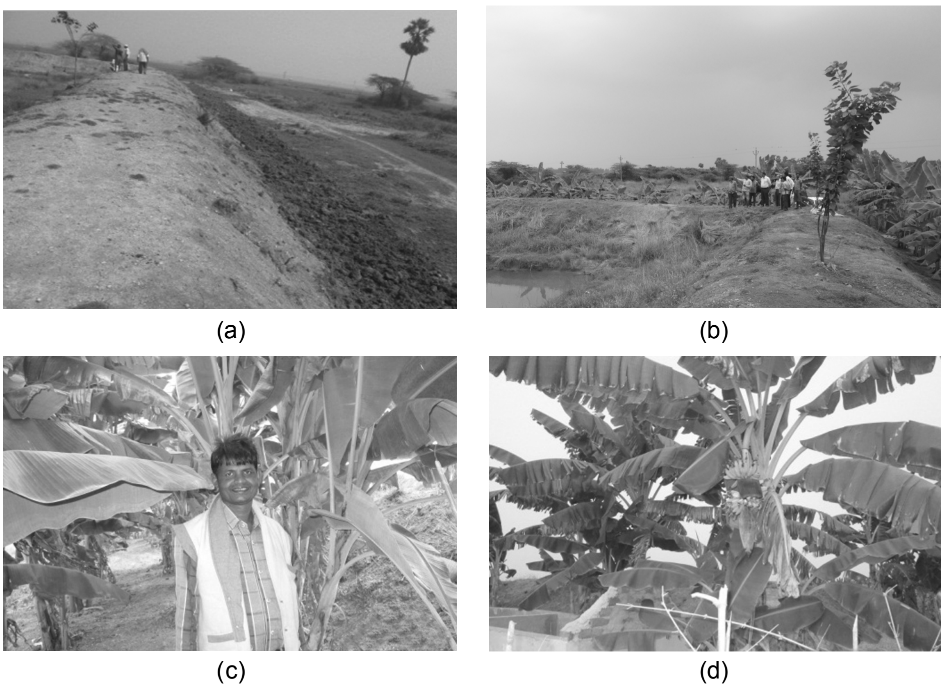

Fig. 7. *Bund area utilization (a, b) with construction of a basement around the pond, where banana plantation (c, d) is undertaken in two rows.*

season. Moreover, to improve the water productivity, fish farming was undertaken, showing a growth of about 450 g of individual fish within a span of 3 months.

To make the system profitable, a 2 m width and 0.15 m depth earthen platform was made around the recharge structure (Fig. 7). This area was used for plantation of banana; around 500 plants are grown around the recharge structure. A gross return of Rs. 20,000 was been achieved by March 2016. Moreover, around the border perennial horticultural crops, such as bael, mango and guava have been taken. On the bund of the water harvesting structure, no crop was taken in the first year to ensure better fish productivity. In the second year, however, with the amendment of the soil, suitable crops will be taken on the bund that will not obstruct the air and light for the fishery activity.

CONCLUSION

This study has not only created a tank-cum-well structure in an over exploited aquifer of coastal Odisha, but also has created awareness among the groundwater users that the fast declining water table needs to be checked through conservation of surface water. Multifarious agricultural options, such as fishery and horticulture would improve the return from unit volume of water, in addition to its use for providing life-saving irrigations during dry spells as required in 2014 early monsoon failure. Finally, a general awareness of importance of water to recharge groundwater, to tackle drought and raise farm income through multiple activities, and feeling of possessiveness of the participating local farmers are the notable observations.

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REFERENCES

Panda, D. K. and Kumar, A. (2011). Evaluation of an over-used aquifer (Orissa, India) using the statistical approaches. *Hydrological Science Journal* **56**(3): 486-497.

Rejani, R., Jha, M. K., Panda, S. N. and Mull, R. (2003). Hydrologic and hydrogeologic analysis in a coastal groundwater basin, Orissa, India. *Applied Engineering in Agriculture* **19**: 177-184.