

Climate change and resilient practices for coastal agriculture

S. K. Rautaray^{1*}, B. S. Satapathy¹, Swati Sucharita² and A. Sarangi¹

¹ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha 751 023

²SOA University, Bhubaneswar, Odisha 751 030

Adverse effect of climate change is likely to be more in coastal areas with high density of population, ports, cities, trade centres, industries and plantation crops. Waterlogging during monsoon, while water scarcity, salinity build up and sea water intrusion during the dry season is likely to affect cropping season and yield. The cyclonic storms and depressions which affect India, originate and/or intensify mostly over the Bay of Bengal. Incidents of lightning and thunderstorms have also increased in recent years. East Coast of India is vulnerable to flood, drought, moist heat, cyclones, and thunderstorms mandating integrated and multi-purpose resilient practices. Rainwater management is the key to tackle the excess and deficit water stress. Land modification for rice-fish-horticulture system, pond based farming system, and alternate raised bed and sunken bed with farming system are useful in coastal areas. Agroforestry using Casuarina, Eucalyptus, Acacia, palms and bamboo as part of land modification based farming system has multiple uses such as windbreak, bird shelter, biodiversity promotion, and bird guano collection for soil conditioning and fish feed. Palmyra palm trees help in arresting the enhanced menace of lightning and thunderstorms, and providing nutritious fruits and timber. Bamboo groves with high tenacity are useful in saving lives against high speed winds and high tides.

Keywords: Biodiversity promotion, Coastal areas, Land modification, Windbreak

Asia was worst hit by weather, climate and water-related hazards in 2023 (World Meteorological Organization, 2024). The adverse effects of climate change include rise in temperature, changes in rainfall amount and distribution, and increased frequencies of extreme weather events. The major problem with climate change is related to spatio-temporal water availability in which the rainfall plays important role, especially in rainfed ecosystem. Under climate change scenario, 10 to 15% more rainfall is expected in tropical areas with less number of rainy days, more number of dry days, decreased frequency of light to medium rainfall events and increased frequency of high rainfall events. This may lead to increased deficit or excess water stress. The mean rise in temperature may be

little, but high temperature during heat waves and low temperature during cold waves causes huge loss and sufferings to crops, animals and human beings. High temperature and deficit rainfall in July-August creates unbearable hot humid conditions in coastal areas. The mean annual rainfall amount may not change much, but a few high intensity rainfall events and/or dry spells cause huge damage to crops. For example, a record one-day rainfall of 825 mm, more than the annual rainfall for a large part of India, happened on 28 July 1991 from Th. Rampur Block of Odisha. Early or delayed onset of monsoon interferes in crop planning and puts the farmers in difficult situation, as is the case with early or late withdrawal.

Coastal area and the climate change problems

The coastal ecosystem represents the transition from terrestrial to marine influences and *vice versa*. It includes shoreline, the near-shore sub-littoral area and upland watersheds draining into coastal waters. Due to abundant natural resources and fast urbanization, high population density is common near coastal areas. Most of the big cities, airports, seaports and industrial and trade centres around the world are situated in coastal areas. Coastal areas provide livelihood to millions of people around the world. India's north-west to the south eastern coastal waterlogged region may receive higher than average rainfall. As per Geological Survey of India, Odisha in Eastern Coast is one of the most flood prone regions of

India. This problem of waterlogging is expected to increase further due to sea level rise with the melting of glaciers under climate change effect. The projected sea level rise is about by 50 cm by the year 2100. In addition to waterlogging during monsoon season, coastal areas are very susceptible to water scarcity, salinity build up and sea water intrusion during the dry season. Tropical cyclones often ravage the field crops, trees and infrastructure. Most of the cyclonic storms and depressions affecting India, originate and/or intensify over the Bay of Bengal mainly during May to November. High tides associated with tropical cyclones, and earthquake result in surface ingress of saline water resulting in salinization of the existing water and land resources. The areas located within 0-10 km zone from the coast line are threatened by salinity due to pumping of saline groundwater. In recent years, due to rising atmospheric humidity and temperature, increased incidents of lightning and thunderstorms are taking a toll of human and animal lives.

Compounded problems under climate change: Some experiences

The problems associated with climate change are often complex and compounded. Early rainfall during April to June causes a series of problems in farming. Usually in these months, summer rice is at grain filling to maturity stages. Short to medium duration high-yielding rice varieties are cultivated in summer season and these varieties have no seed dormancy. With 2 to 3 days of continuous rainfall, the matured grains germinate on panicle itself (vivipary germination). Harvested grains in field or barnyard, sprout and cause economic loss to farmers. Record one-day rainfall of 400 mm on 30 April 2012 in Nuagada Block, 336 mm on 14 May 1995 in Puri Block, and 350 mm on 10 May 1995 in Nuagada Block are examples of early season extreme rainfall. Devastating summer cyclone *Fani* in 26 April 2019 and *Amphan* in 19 May 2020 caused heavy rainfall. Crop



Vivipary germination

lodging and grain shattering are common with such speed of wind and rainfall.

Unseasonal rainfall and heat waves in summer affects vegetables, pulses and oilseed crops. Pulses such as green gram and black gram are prone to quick germination and loss in field or barnyard. Summer cyclones affect aquaculture and livestock also. The branches, twigs, leaves and other vegetation carried by wind fall into aquaculture ponds and deteriorate the water quality. In 1986, pre-monsoon heavy rainfall and flood in Mahanadi and its tributaries affecting Bolangir, Cuttack, Dhenkanal, Kalahandi, Phulbani, Puri and Sambalpur districts affected 16 lakhs people leading to loss of livestock, houses and public property. Paddy seeds

responded to high humidity and subsequently lost viability. Dry direct seeding of rice was not feasible due to early season flooding. Sprouting of paddy seeds failed and the expenditure on seeds and nursery bed preparation went waste. Farmers had to lose *khari*f paddy in the year.

Post-monsoon tropical cyclones over Bay of Bengal are common during October to December. Extreme rainfall events with ‘record one-day rainfall events’ are more in October (20 events) after the monsoonal August (28 events) (Table 1). Cyclone induced unseasonal rainfall and high speed wind cause damage to crops, livestock, human and property. Paddy, the primary source of livelihood in coastal areas, remains in reproductive to harvest stage during October to December. Unseasonal rainfall during these months, thus, affect the crop through lodging, vivipary germination and rotting. High-yielding varieties without seed dormancy suffer most due to vivipary germination compelling farmers to opt for local rice varieties with strong seed dormancy and kneeling ability.

Delayed monsoon results in delayed sowing and planting resulting in increased pest and disease problem besides reduced paddy yield. Insufficient rainfall after sowing result in partial

Table 1. Record one-day rainfall events in Odisha in different months during 1991-2014

Month	No. of ‘record one-day rainfall’ events	Rainfall amount (mm)
April	1	400
May	2	336-350
June	10	280-660
July	10	259-700
August	28	263-486
September	5	259-355
October	20	297-455
November	1	450

Source: Derived from Pasupalak et al. 2017

sprouting and subsequent death of such sprouts. In coastal saline soils, the problem is further aggravated due to plasmolysis of sprouts. Surface crusting of soils rich in silt and clay particles is another problem due to insufficient rainfall. In such situations, sprouts remain below the soil crust and die off. Sometimes, with initial good rainfall, seedlings grow well. However, with a long dry spell thereafter, the seedlings cannot regain growth even if the optimum soil moisture is maintained with subsequent rains. In general, young seedlings are prone to both excess and deficit moisture stress due to succulent tissues. Excess and deficit moisture stress due to flood and drought are particularly harmful in reproductive and grain filling stages.

Apart from rain related problems, other factors that affect agriculture, aquaculture, livestock and human beings are high temperature and heat waves. Pollen and grain sterility happens due to high temperature at flowering stage. High chaff percentage and light weight grains result from such stress. Indian coastal areas are more vulnerable to heat stress in the context of climate change, with associated physiological stress in the working environment of workers including agricultural labourers.



Palmyra palm as lightening arrester, wind break, and minor fruit crop with timber value

Resilient farming practices

Rainwater management is central to the resilience of agriculture, ecosystems and societies in coastal areas. Land modification is of particular use in harvesting surplus rainwater and reducing the flood menace.

Integrated rice-fish-horticulture based farming system: Integrated farming systems with multiple enterprises, high land and water productivity, recycling and reuse of by-products besides reduced emission of greenhouse gasses are some of the climate resilient practices. Rice-fish-duck-goatery-azolla-horticulture-farming system in one-hectare area in

waterlogged ecosystem with 67% area undisturbed for rice-rice sequence, 13% area for pond refuge and trenches and remaining 20% for field bunds proved very effective. Composite aquaculture, 50 ducks and 12 goats were part of the farming system. Lady finger+amaranth-brinjal-radish and Lady finger-tomato/French bean/chilli/radish cropping system were effective on pond dyke. Mushroom cultivation was done by using the harvested paddy stew. About 12.6 t of organic residues like paddy straws, mushroom spent straw, weeds, vegetable residues, dried leaves, duck litters, goat droppings, fruit crop residues produced and 3 t of cow dung were recycled as vermi-compost (6.2 t), compost (2.2 t) and vermiwash (500 litres). Rice yields were 5.2 t/ha and 5.8 t/ha in *kharif* and summer, respectively. Lady finger + amaranths-brinjal-radish produced 35.5 t/ha vegetables. Also, 320 kg of fish, 200 kg of duck meat, 600 eggs, 50 kg of goat meat and 260 kg of mushrooms were produced.

Land modification with one-third area each for farm pond, raised bed, and undisturbed area for paddy: A saline low lying rice field measuring 3600 m² was modified to a farm pond, a raised bed (using the excavated soil) for vegetables, and an undisturbed field for rice, each 1200 m². The net annual returns were ₹ 9,690, ₹ 9,500 and ₹ 4,620 from fish, vegetables and paddy, respectively, much higher than the traditional single lowland rice cultivation.



Diversified food production and improving resilience with rice-fish-horticulture based system

Alternate raised and furrow bed, aquaculture and agroforestry integrated system: Traditionally, alternate raised and furrow bed are adopted in waterlogged areas for crop diversification and also, to cope with the irregularity in rainfall amount and distribution in rainfed lowlands. For more resilience and income enhancement, aquaculture and agroforestry components were introduced. Agroforestry with bamboo and casuarina are useful as windbreak and palm as lightning arrester in cyclone and lightning prone coastal areas. Aquaculture with Indian Major carps and air breathing fish species (*Anabae*s and *Magur*) in farm ponds and shallow

sunken beds can cope up both in drought and flood years. Higher net return was accrued from vegetables grown on raised beds as compared to fish in sunken beds and farm pond. A net return of ₹ 168,481 was obtained from 1 ha model tested in a coastal waterlogged area in Ersama Block under Jagatsinghpur District, Odisha.

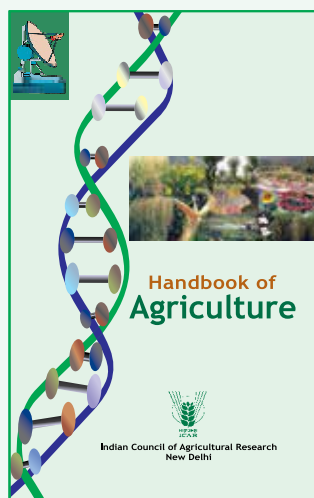
SUMMARY

Climate change and variability have compounded the adverse effects on crop production, aquaculture, animal husbandry and human beings. The effect is likely to be more in coastal areas with high density of population and economic

activities. Rainwater management using land modification and multiple use of harvested water in a system approach is the key for resilience of agriculture, ecosystems and societies in coastal areas. Land modification for 'integrated rice-fish-horticulture based farming system', 'pond and raised bed system', and 'alternate raised and furrow bed, aquaculture and agroforestry integrated system' are suitable for coastal Odisha serving additionally the purpose of windbreak, bird shelter and harvesting guano.

*Corresponding author email:
Sachin.Rautaray@icar.gov.in

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