Info Note

Climate change induced salinity intrusion and its implications for agriculture

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Key messages

- Salinity intrusion leads to the contamination of surface water and groundwater reserves, loss of wetlands such as the Sundarbans, and causes various public health risks.
- The livelihoods of a large section of people who are dependent on agriculture and fisheries are becoming increasingly uncertain.
- The densely populated coastal regions of Bangladesh and India are especially at risk.
- Effective implementation of adaptation measures requires a strategic investment plan which identifies priority areas of intervention to allocate limited financial resources.

An estimated 1.06 million hectare of arable land in Bangladesh and 6.7 million hectares in India is affected by salinity (Rabbani 2013). Salinity intrusion adversely affects the livelihoods of farmers, especially rice cultivators and fisherfolks, vegetations, soil quality, and infrastructure in these areas (Habiba et al. 2014). The net cropped area in coastal Bangladesh has been decreasing over the last few years due to several factors and many studies have identified salinity as the chief cause for yield reduction in coastal agriculture (Baten 2015). Groundwater contamination due to saline water and similar adverse impacts on agriculture and livelihoods are also increasing in coastal India, especially in Kerala, Karnataka, Odisha, and Andhra Pradesh (Naidu et al. 2013). The extent and intensity of salinity in the coming years are likely to increase due to climate change induced saltwater intrusion. The special report on the impacts of global warming of 1.5 °C above pre-industrial levels, released by the Intergovernmental Panel on Climate Change (IPCC) in October 2018, warns that the "risks associated with sea level rise for many human and ecological systems" are likely to be amplified in the wake of increased warming. Recent media reports about the sinking islands of Kerala and the disappearing villages of Odisha indicate the severity of this issue and demands immediate and prompt action.[1] [2]

Research and development

Developing salinity tolerant cultivars requires a multi-pronged approach involving (a) preservation and purification of traditional varieties; (b) screening traditional landraces for salinity tolerance traits; and (c) biotechnological approaches towards modification of genetic characteristics of cultivars. One such example is mangroves, by virtue of its salt tolerance, can act as a gene donor for other crop varieties. It is critical to enhance our understanding of molecular mechanisms of stress response (drought stress, salt stress, etc.) in leaf and root tissues of plant species. This will pave the way towards development of cultivars that can tolerate varied levels of salinity. Salt-tolerant varieties offer cheap, long-lasting, sustainable, and ecologically beneficial strategy to manage saline soils.

As weather-related uncertainties are likely to increase with climate change, a single region may witness drought in one season and stormwater surge in the other. Therefore, there is a need to develop cultivars that are not only tolerant to stresses caused by salinity but also to

[1] https://www.huffingtonpost.in/village-square/how-this-coastal-odisha-village-has-drastically-reduced-water-borne-diseases-through-simple-interventions_a_23349225/

[2] https://www.thehindu.com/news/national/kerala/the-sinking-island-of-kerala/article25802177.ece

other abiotic stresses. Advanced biotechnological tools such as Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) will go a long way in developing such cultivars.

Climate-smart agriculture and water management

Climate-smart agriculture (CSA) is an approach towards sustainable increase in productivity and incomes, strengthening resilience to short-term climate variability and long-term climate change, and reducing agriculture's contribution towards greenhouse gas emissions. The success of CSA, more so in coastal regions, is contingent upon effective use of available freshwater resources.

Elevated dykes, sluice gates, and bunds are few examples of elementary structures that are used to regulate the flow of saline water in and out of the arable land in coastal regions. Management and regulation of water flow from these structures, especially sluice gates, are the major challenges due to conflicting interests of various groups. Currently, catchment area of these structures is demarcated based on the regional administrative limits that leads to conflicts amongst communities due to conflicting interests of paddy cultivators and shrimp farmers. There is a need to shift the division of catchment area based on hydrological limit of the structures rather than administrative limits. The formation of farmers' organizations must also be done using similar criterion. Few polder areas of Bangladesh have set an exemplary example in this kind of community management of sluice gates and have reaped huge benefits. However, it is far from being a well-established model and its potential needs to be explored further.

The least intrusive and most cost-effective measure for addressing salinity intrusion is the application of horizontal wells or skimming wells. Doruvu technology and sub-surface skimming well system (improved Doruvu), used in coastal Andhra Pradesh, apply these measures to extract freshwater lying above a saline zone.

Coastal aquaculture systems

Aquaculture is a promising alternative for rice-based systems in coastal areas affected by salinity. Depending on the seasonal variations of salinity and regional ecological considerations, various systems – shrimp-shrimp system, shrimp-rice system, prawn-rice system, shrimp-fish systems – can be deployed to secure livelihoods. Integrating fish culture with floating bed agriculture can help tackle excess waterlogging during high tides. There is also a need to develop comprehensive database on salinity tolerance of freshwater fish species to promote them in coastal aquaculture. The challenge posed by salinity intrusion can be made as an opportunity to sustainably enhance aquaculture productivity and, consequently, incomes of people living in these regions.

Mechanization and application of ICTs

Agricultural and related activities in the era of climate change face a tripartite challenge of reduction in gross cropped area, stagnating productivity and incomes, and increased weather uncertainties. This has caused large-scale migration of the labour force and consequently created scarcity of labour for agriculture. Although, mechanization has substituted animal labour up to a large extent, there are still ample opportunities to replace human labour from cultivation. In addition, information and communications technology-based tools must be used to disseminate timely and accurate information to cultivators to facilitate decision making. These tools can be used to broadcast customized advisories with respect to nutrient requirement, fertilizer use, stress forecasting, etc.

Conclusions

Our suggestions for future research and policy recommendations emphasize the adoption of a multi-sectoral approach to minimize the risks posed by salinity intrusion. These include:

- The three main categories of adaptation measures (technological solutions, management practices, and institutional capacity) provide a workable starting point towards building long-term strategies related to climate change induced salinity intrusion.
- There is a need to develop multi-stress tolerant cultivars, in addition to the existing salt-tolerant varieties, in the wake of increased weather uncertainties due to climate change.
- The exercise of varietal development shall go hand-in-hand with salinity mapping of coastal areas for promoting soil health. This can help in assessing the location-specific needs of cultivars according to the concentration and nature of salinity.
- Water is vital to agriculture and the success of climate-smart agriculture (CSA) depends on the availability and management of freshwater in coastal areas. An integrated water resource management approach must be adopted to reduce the stress on available resources and prevent them from contamination.
- Improved Doruvu technology has proved to be an efficient technology in coastal Andhra Pradesh in India. The limitations of Doruvu technology, especially its limited applicability in sandy regions, must be further studied for its upscaling.
- Sluice gates hold the key to contain salinity and at the same time, operation of sluice gates is a reason for

conflicts due to conflicting interests of people engaged in rice farming and shrimp farming. Therefore, Community management of sluice gates in a mutually beneficial manner that optimizes the interests of people in that area is vital to adapt to salinity intrusion. Many polder regions in Bangladesh are using this opportunity to efficiently manage the water flow.

- Farmers' organizations should be formed based on catchment area and hydrological limit of sluice gates rather than the administrative limits, as is done currently in most areas.
- Scope of application of eco-technological concepts such as Tidal River Management (TRM) can be explored in areas where natural flows are suitable.
- Any new intervention for the farmers in the coastal region must be studied from the cost-benefit perspective from upstream to downstream for a comprehensive risk assessment. Similarly, issues related to strengthening of grassroot-level institutions and gender roles must be incorporated at the project stage itself to ensure sustainability of new interventions.
- Non-availability of labour for agricultural activities is one of the major constraints in salinity affected areas. This is due to migration and overlap of public programs with the cropping season. Although Bangladesh achieved substantial growth in mechanization to replace animal labor, more emphasis must be given on human labor substitute mechanization for crop cultivation.
- Climate change is a dynamic phenomenon and our understanding of it is continuously expanding. The adverse impacts of climate change are likely to increase in the next two to three decades as the world is headed towards 1.5 to 2-degree Celsius warming. This demands immediate, coordinated, and a recursively dynamic approach towards policy making in coastal Bangladesh and India to safeguard the livelihoods of millions of people living in these regions.

Further Reading

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