

Recommendations

On the basis of the climatic conditions, prevailing agricultural practices during pre-tsunami period, the degree of damage after tsunami and the four main principles that guided us in framing the strategies, following recommendations are made:

A&N Islands

1. To ensure connectivity to the new rehabilitation sites, a large network of roads and dykes has been constructed. A number of dykes have also been constructed to save agricultural lands from inundation during high tides under the cash-for-work program. While the efforts are laudable, the team visualizes a profound change in the hydrology of the islands as a result of these structures. As such, it is time to look back and provide adequate size culverts and/or one-way sluice gates to allow rainwater to flow from inland to the sea during low tides. The team also visualizes that the dykes constructed from locally available earth need to be strengthened through mechanical and biological means such as soil binding salt tolerant grasses and tree species (*Casuarina*, coconut, banana etc.). The grasses grown on these dykes would provide green fodder to the cattle. The dykes strengthened in this manner would serve the purpose for which on these have been constructed. Besides, following actions could be initiated to improve drainage in the these dyked area.
 - Borrow pits dug to provide earth for embankment construction should be interconnected so as to result in a continuous drain along the embankment. It would facilitate efficient drainage to the adjoining lands. Such drains could be made almost free of cost.
 - Mud crabs are playing havoc in some of the newly constructed dykes. As such, the dykes are failing to control the ingress of seawater completely. It is recommended that a drain/reservoir along these newly constructed embankments be planned to minimize the damage due to seawater ingress into the farmlands through the mud crab cracks. Besides saving the land from resalinization, these drains/structures could be used for brackish water aquaculture.
2. Based on limited soil sampling and analysis carried out at various locations in South Andaman (Chouldari, Guptapara, New Manglutan, Lohabarrack & Mitha khari), Little Andaman (Brakewater, Netajinagar and RKPuram) and Car Nicobar (Chukchuka, New Kakana, TeeTop, Arong and Tamalu), it has been observed that most of the agricultural lands in South Andaman are still suffering with various degree of soil salinity. Contrarily pH of these soils is low. Moreover, the concentration of sodium (Na^+) is low in comparison to chloride (Cl^-) and sulphate (SO_4^{2-}). As such, there is no need to apply gypsum to reclaim these lands. Leaching of the hot spots through bunding and storage of rainwater is recommended. However, Little Andaman and Car Nicobar soils are having low degree of salinity. Due to low pH at few sites, addition of organic material, lime and rock phosphate will be helpful.
3. With more than 3000 mm rainfall during the monsoon season, most of the land under Situation I where seawater intruded in to the cultivated area but receded completely soon thereafter are reclaimed as a result of washing of the soil due to rainfall of one rainy season following tsunami. Rice cultivation on these lands should be possible. The land under Situation II where seawater intruded and continued to intrude and recede during high and low tides particularly during full moon and new moon days, need appropriate surface drainage and leaching. Flushing through rainfall and cultivation of salt tolerant rice varieties seems a viable alternative to reclaim and cultivate these lands. The flushing would be effective only if appropriately located and adequate sized one-way sluice gates are provided in the dykes.
4. ActionAid should initiate action on field demonstrations of salt tolerant rice varieties in areas of Guptapara and New Manglutan identified as model development sites in the South Andaman. For this purpose varieties from CSSRI/CARI could be procured for demonstration purposes.

5. Water management in the island would be the key to the success of agriculture. As such, there is a need to go for an integrated approach that should consist of the following activities:
 - Construction of ponds for in-situ storage of rainfall
 - Construction of wells to tap groundwater particularly in Car Nicobar
 - The small rivulets, which carry runoff from the hills, should be provided with check dams to make water and nutrients available to crops grown around these check dams
 - Diversification of rice crop to vegetables. For this purpose, popularization of raised beds and sunken furrows technology is recommended.
 - Provision of drip irrigation for vegetables using stored/groundwater
6. Construction of farm ponds for in-situ rainwater storage is in full swing in South Andaman and Little Andaman. These ponds should be developed as multiple enterprise system from the very beginning. Some funds for this purpose could be earmarked. The team suggests that water in these ponds could be used for aquaculture, irrigation during post monsoon season and to meet the water requirement of the livestock and for daily chores. Besides, the dykes could be used to cultivate vegetable crops, banana, coconut and other horticultural plantations. This would provide the farmers with enhanced and sustainable income at regular intervals. Pumping equipment to use these ponds for irrigation and drip irrigation systems to conserve water should be made available. A part of the areas where tsunami water has accumulated permanently and drainage of that water is not practically and economically feasible could be promoted for multi-enterprise agriculture comprising of saline aquaculture, salt tolerant forest and fruit trees, grasses, medicinal and aromatic crops etc.
7. Recommendations have emerged that A&N Islands should be declared as organic islands. The team recommends that actions be initiated in this regard by encouraging the farmers to apply organic manures to arable crops besides the plantation crops for which recommendations have already been made. This will help build-up fertility of the soil over the years and moderate salinity effect. Moreover, for truly organic cultivation, actions should also be initiated to popularize integrated Pest Management (IPM) technologies for which expertise of CARI could be explored. Besides, following activities should be undertaken under the cash-for-work program:
 - Debris brought out by tsunami has yet not been cleared from many far off fields. These debris materials and weeds germinated and proliferated after tsunami particularly the sedges should be removed properly to start agricultural activities in these fields.
 - The agricultural and plantation crop residues and other wastes generated at the farm level are good sources for conversion into valuable organic manure through composting. As such compost pits should be dug and compost making activity be popularized in the islands. Besides providing organic manure at the site, it would boost up the campaign to make the islands organic. Some of the residues and byproducts can also be used to promote alternate livelihood opportunities such as mushroom production.
 - Fears have been expressed in certain quarters that tsunami has accelerated the soil borne diseases. Although the team could not find any evidences of this nature, to be on safer side, neem cake or such other organic materials that help to control soil borne diseases could be applied to targeted fields.
8. An organic agriculture wing should be established in the administration with organic resource coordinator as the key person in the wing. The wing should be repository of information on organic demand and supply, develop strategies to increase local production of organic manures/compost, keep track of problems and needs of organic growers and design public policies to encourage organic farming. An advisory committee consisting of experts of different disciplines should assist the coordinator.

9. Coconut, arecanut and spices hold the key for the economic development of these islands as these crops are ecologically compatible. However, the productivity of these crops is quite low in comparison to other coastal state in the mainland. The following measures can be taken up for enhanced productivity of these crops:
- Replacing the age-old tall and low bearing plantation by the identified high yielding palm (e.g. “Samruddhi” variety of arecanut)
 - Utilization of high yielding mother palm (identified from Katchal Tall) for production of seedlings and their distribution to farmers.
 - Proper management practices like integrated nutrient management and integrated pest management.
 - Supplementing irrigation during dry periods

As sufficient inter-spaces are left unutilized in these plantations, profitable multi-species models should be adopted. Some of the models are:

- Perennial spices like clove, nut meg, cinnamon and pepper
 - Semi perennials like papaya and banana
 - Annuals and biennials: pineapple, vegetables, grasses and fodder legumes
 - Floriculture crops like orchids, potted plants etc.
10. Funds under the cash-for-work program should be utilized to manually remove the creeping weed *Ipomoea biloba* that has infested few fields in the Little Andaman.
11. Since coastal areas are prone to a number of natural disasters and it would be uneconomical to construct seawall at all the vulnerable points, it is recommended that all vulnerable seashores should be provided with multi-species shelterbelts/bio-shields of adequate width and design. Mangrove and terrestrial species could be a good combination.
12. Since the land holdings are small, power tillers could play a vital role in increasing the productivity of agricultural lands particularly when vegetable cultivation is being popularized. It would also help to mix the sand that has been brought by tsunami on to the fertile lands. Power tillers with few accessories related to tillage and transport could be provided.
13. Post harvest value addition could help the farming community to fetch a better price of their produce. Traditional copra drying strategy could be slowly replaced with improved solar coconut driers. For this purpose, some of the machines such as coconut driers, rice dehuskers etc. should be introduced.
14. Agriculture of A&N is quite dynamic and it might lead to an overall structural change in the island agriculture and ecology. As such, soil and water, the two limited resources of agriculture, would be key elements for bringing scientific changes in agriculture. It is recommended that few soil and water testing laboratories be established at selected islands where farmers could get their soil/water sample analyzed and get recommendation on land reclamation and nutrient management.
15. Although the team realized that the agriculture of the islands differs in many ways with that of the Mainland. Nonetheless, it would be a novel experience for the community of the island to look at the developments in agriculture in the mainland. For this purpose, team recommends that traveling workshops be organized to cover various states specifically covering coastal areas including the Regional Research Station of CSSRI at Canning in West Bengal.
16. During any disaster, local people are the first to arrive and provide help to the victims. Therefore, there is an urgent need to constitute local area and village committees of the stakeholders for ever ready alertness. The members of these committees should be trained in multifarious activities including rescue, first aid and agriculture. To keep these committees alert, some regular meetings could be arranged with experts from various disciplines and organizations.

Maldives

1. Few hot spots were observed in the islands visited by the team. To reclaim these hot spots farmers need to be guided through mass media on the technologies to leach down the salts. The identified fields be dyked to store rainwater or if needed groundwater to leach down the salts. Since the soils are neither acidic nor alkali, there is no need to add any amendment to these soils.
2. There is a need to establish benchmarks in all the islands, which were subjected to tsunami for periodic mapping of soil salinity and water quality status.
3. The excessive use of groundwater for irrigating agricultural crops may prove counterproductive for the naturally growing fruits, forest and other plantation crops. Accordingly, crops and cropping systems should be designed and planned in such a way that they complete their life cycle during the rainy season. The rainwater stored underground should be used only for protective and life saving irrigations. There is a need for large-scale promotion of precision irrigation techniques like drip and sprinkler irrigation for efficient use of scarce fresh water resource. There are numerous low water requiring but high profit making crops, which need to be promoted.
4. The team could not see any surface water storage structure. Because of the land resource constraints, to construct ponds for rainwater harvesting might not be feasible. Yet there is no harm to test the multi-enterprise system comprising of fresh water fish, horticulture-vegetables-flowers around few rainwater harvesting ponds on few big islands.
5. The aquifers contaminated by tsunami need special attention, as individuals would not be able to play a significant role in this clean-up operation. It is recommended that the outflow from the rooftop rainwater harvesting structures be diverted to the household wells on the island. Only through community efforts, it would be possible to cleanup the salinity albeit slowly over a few years depending upon the quantum of flow diverted and the extent of community participation.
6. Since the existence of septic tanks and soak pits is endangering the quality of groundwater, more so during disasters where overflow from the pits gets mixed up with undergroundwaters, sewerage collection, treatment and reuse would be more appropriate. A beginning could be made with few big islands and the experience could later be replicated on other islands.
7. A nationwide land and groundwater quality-monitoring programme needs to be initiated. For this purpose, reasonably equipped soil/water testing laboratories should be established in each atoll initially which could later be extended to each island. The soil/water samples from backyard farms of smaller islands could also be tested in these laboratories under the natural resource quality-monitoring programme. For soil and water quality monitoring system on time scale, the proposed laboratories could be empowered to prepare soil and water quality health cards for the farmers to promote soil test based fertilizer recommendations.
8. Salt tolerant high yielding varieties of crops/plants should be encouraged as the islands are prone to salinity stress due to their proximity to the sea.
9. Multi-story scientific cropping is recommended for diversification of food intake and to increase income of the backyard farmers. Demonstrations and capacity building on standard package of practices for raising crops needs to be promoted.
10. Owing to limited fresh groundwater and land resources, Maldives has ample scope to promote polyhouse technology for off-season and year the round production of vegetables, fruits, spices and medicinal crops. The technology to suit local conditions be developed and promoted through training of the rural communities to build low cost but effective polyhouses. High value crops like cut flowers cultivation in polyhouses can generate livelihood opportunities, as there are ample outlets for exporting flowers to west Asia and Europe.
11. Watermelon, chillies, brinjal, tomato, cucumbers and bitter gourd etc. are cultivated as commercial crops under irrigated conditions. Except few of the above commercial crops, most of the crops

grown or naturally occurring are traditional type having low productivity. There is a strong case to introduce improved seeds and saplings of the promising crops. Establishment of model nurseries through participatory community efforts in large sized islands is recommended to make available elite planting material to the farmers. Some new spices, pulses, oilseeds, maize (baby corn, pop corn, sweet corn), ginger, turmeric, colocasia, onion and energy crops needs to be tried at few locations as demonstration plots.

12. Actions should be initiated to declare the islands as organic islands. The communities be prepared to switchover to integrated nutrient and integrated pest management technologies during the intervening period so that objective could be achieved in a time bound manner. Composting techniques needs to be demonstrated by establishing frontline demonstrations.
13. Green manure crops like *Sesbania* and *Glyricidia* could be widely adopted to the Maldives conditions and needs to be promoted for cultivation as green manure crops to increase soil fertility and as a source of fuel wood.
14. Many big farmers and private companies are entering the islands for commercial agriculture. This option looks lucrative in the short-term but may prove highly counter productive in the near future if appropriate controls on slash and burn system are not exercised. In the fragile coastal ecologies, replacing forest and fruit trees following slash and burn system to grow agricultural crops may not be a desirable practice in the long run. Lot of wood is being harvested to be used as fuelwood to dry the fish for processing and marketing. The best option to slash and burn system would be to adopt thinning/pruning practice in various areas to promote cultivation of agricultural crops in association with trees. Several crops such as turmeric, colocasia, ginger, guinea grass, etc. which give good yield in shade as understorey crop could be grown. Similarly, there are several spice crops, which can be grown in association with naturally growing forest and fruit trees. The team recommends for a sound forest policy to consider issues of deforestation/slash and burn agriculture in Maldives.
15. There is an urgent need to replace the trees damaged during the tsunami. Due care be exercised to ensure appropriate quarantine arrangement for imported species of plants.
16. The rate of soil and water erosion has increased significantly after tsunami. Lot of soil is getting eroded with rainwater and deposited on the sea shore/coast. As a result lagoon area is increasing. All denuded areas should be planted with soil binding grasses such as Bermuda grass (*Cynodon dactylon*), Rhodes grass (*Chloris gayana*), Paragrass (*Briachiari mutica*), Vetiver grass, and Cyprus spp. etc.
17. Tsunami is reported to have hit the eastern side of the islands first. But it appears that later it wrapped around the north and south and hit from the west shortly afterwards. It means that no division can be made on safety angles and all sides need adequate protection. Therefore, a bio-shield strip of about 10 m or more all around the islands is recommended to minimize the damage due to natural or man-made disasters in the future. Proper mechanism to raise saplings of bio-shield species for timely and assured availability at the individual Island must be developed.
18. Almost all the agriculturally important islands lack agro-meteorology/ weather station facility. Farmers are unable to plan weather based agricultural activities to increase productivity through judicious use of inputs. The team recommends establishment of few agro-meteorology laboratories in the representative islands. These laboratories with little bit of expertise and upgradation could be used as local agro-met advisory unit to moderate risk in agriculture.
19. Progressive farmers and private companies are venturing into cultivation of fruits and vegetables at commercial scale. Most of these crops/commodities are of perishable nature and sizeable quantity gets rotted and spoiled by the time the produce reaches Male. The team strongly recommends establishment of post-harvest processing, value addition, cold chain and marketing network facilities in agriculturally important islands.

20. Since the farmers face lot of problems in markets at Male, the resort markets be developed with a direct contact between the resort and the farming communities at one or more nearby islands including fish farmers. It would ensure steady support price and higher income to the farmer.
21. The team recommends capacity building of developmental departments, NGOs and local communities in the following areas:
 - Soil and water quality monitoring and analysis
 - Reclamation and management of saline soils and judicious use of saline groundwater
 - Ex and in-situ rainwater harvesting, storage and reuse through precision irrigation techniques
 - Raising saplings of salt tolerant forest and fruit trees, commercial high value crops (fruits, vegetables, flowers, etc.), mangrove and bio-shield species, homestead crops and agro-techniques for cultivation
 - Conversion of organic materials into Vermi compost and raising mushroom etc.
 - Polyhouse technology and small scale agro-processing units
 - Weather data recording, analysis and agro-met advisory service
 - Do's and Don'ts before, during and after the disaster
22. There is a need of close cooperation between India, Sri Lanka and Maldives in the field of agriculture. The apex organizations in these countries should dwell upon an appropriate MOU to share knowledge and extend the technologies after location specific tests.
23. In a World Bank report submitted by Er. Smedma and his team, it has been recommended that there is a scope of mutual cooperation between Maldives, CSSRI in India and Bio-saline Research Institute in Dubai. We are building up ties with BRI, Dubai. Indian Council of Agricultural Research could take up the issue with Ministry of Fisheries and Agriculture in Maldives for a larger cooperation under which CSSRI could associate in land/water reclamation.