

## Agricultural Management in Coastal Agro-ecosystem Problems and Prospects

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Coastal areas are commonly defined as the interface or transition areas between land and sea, including large inland lakes. Coastal areas are diverse in function and form, dynamic and do not lend themselves well to definition by strict spatial boundaries. Unlike watersheds, there are no exact natural boundaries that unambiguously delineate coastal areas (Anon., 1998).

The coastal agro-ecosystem, more than any ecosystem, plays a significant role in controlling the overall ecological balance on earth. It is also critical in terms of food, nutrition, and sustainability of the entire coastal region. This is a unique ecosystem blessed with the potential to meet many of the demands in agriculture, horticulture, fisheries and livestock. It is also biologically highly productive and physically variable in space and time. However, the coastal ecosystem, wherein there is a tremendous scope for the production of many high value and export oriented commodities, is facing many location specific problems.

The coastal agro-ecosystem of our country is recognized as one of the five important ecosystems. It comprises hinterland, which has varied geometric and topographical features of mountains, valleys, coastal plains, riverine systems, climatic conditions, different soils and water bodies, vegetations ranging from rich tropical rain forests to coastal mangroves and a wide range of crops that are cultivated in this region. India has got a large coastal region stretching over a length of 8129 km from East coast to West coast, covering the states of West Bengal, Orissa, Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Kerala and the Andaman & Nicobar group of Islands (Anon., 2003).

### Coastal ecosystem in India-classification

The National Bureau of Soil Survey & Land Use Planning (NBSS & LUP) of India (Sehgal *et al.*, 1992) has brought out a 21-zone agro-ecological regional map of the country, essentially based on physiography, soils, bioclimatic types, and growing period which influences the supply of water for plant growth. The zones coming under coastal ecosystems are:

- a. Eastern Coastal Plain, Hot Sub-humid Ecoregion with Alluvium - derived Soils: It covers the Eastern coastal plain extending from Cauvery Delta to Gangetic Delta and occupies 2.5% of the land area. It has hot summers and mild winters, with an annual rainfall of 1200 to 1600 mm. The growing period ranges from 150 to 210 days. The soils are mainly clayey with slight acidity. Rainfed and irrigated rice farming are practised. Imperfect drainage and salinity are the major constraints.
- b. Western Ghats and Coastal Plains, Hot Humid - Perhumid Ecoregion with Red, Lateritic and Alluvium - derived Soils: It constitutes Western coastal plains of Maharashtra, Karnataka, and Kerala States covering 3% of the land area. It has hot summers, with rainfall exceeding 2000 mm. The growing period is more than 270 days. It has red, lateritic and alluvial soils. Water logging and severe erosion are the major problems. It has high potential for export-oriented plantation crops.

### The economic and environmental importance of coastal areas

Many of the world's major cities are located in coastal areas, and large portions of economic activities are concentrated in these areas. The coastal zone is an area of convergence of activities in urban centres, such as shipping in major ports, etc. Thus, traditional resource-based activities, such as coastal fisheries, aquaculture, forestry and agriculture, are found side by side with activities such as industry, shipping and tourism.

Among the various ecosystems, the coastal ecosystem is the most diverse and most productive zone. Agriculture in coastal areas often plays an important role and, as elsewhere, it occupies the major share of available land. Coastal areas often provide excellent soil and climatic conditions for agriculture. Apart from its evident function in providing food to coastal populations, agriculture

also often provides raw materials to industry, which may be established in the area to make the most of port facilities. Agricultural products may find markets in the tourism sector, although this is not always as strong a link as is sometimes assumed.

Agriculture, horticulture, agroforestry and silviculture are the various activities practised in this ecosystem. The agroclimatic conditions of the coastal zones are congenial for growing horticultural crops like mango, cashew, pine apple, banana, plantation crops like rubber, coconut, pepper, arecanut, tea, cocoa, oil palm, etc. This is the only system where agriculture and aquaculture co-exist. Marine, estuary and coastal wetland areas often benefit from flows of nutrients from the land and also from ocean upwelling, which brings nutrient-rich water to the surface. They thus tend to have particularly high biological productivity. It is estimated that 90 percent of the world's fish production is dependent on coastal areas at some time in their life cycle. In addition, these areas support large numbers of migratory and non-migratory birds and other organisms.

India has a vast potential for marine fisheries development with 2.02 km<sup>2</sup> area of exclusive economic zone along the coastline. Besides, about 1 million hectare of brackish water area in the form of estuaries for brackish water fish and prawn farming is available. The region occupies commendable position in the export of horticultural produce, spices and marine products to the international market. It supports the livelihood of several million people whose socio economic conditions are very much dependent on the system (Anon., 2003).

#### **Agriculture in coastal areas**

Coastal agriculture in lowlying areas consists primarily of rice, pulses as rice fallows and sugar cane as rotational crops. The horticulture consists of plantation crops like coconut, arecanut, cocoa, spices like pepper, clove, nutmeg, ginger, turmeric and fruit crops like mango, banana, pine apple, guava etc. Tuber crops mainly, tapioca, sweet potato and elephant foot yam are also grown to a great extent. The agroclimatic zones of coastal regions are rich in natural resources and occupy a commendable position in the export of horticultural and marine produces to the international market. Hence it is quite evident that the agricultural production in the region should attract the highest priority as foreign

exchange earner of improving the national economy. Appropriate crop management practices and cropping systems aiming at optimum use of land and water resources will go a long way in increasing production and rural economy.

Planning for coastal agricultural activities must consider the wide range of farmers' interests and activities, including non-farm activities, the limited flexibility that farmers have in production decisions, their high vulnerability to adverse environmental change etc. The complexity of these factors makes farmers' participation or consultation with them particularly important in coastal area planning.

#### **Potential harmful effects of agricultural activities on coastal ecosystems**

Agriculture is the main use of land, and as a result, agricultural activities can have a significant impact on natural resources in coastal area. Many of the external effects of agriculture on coastal ecosystem and other sectors are associated with the intensification, expansion or marginilization of agricultural activities. The potential harmful effects of agriculture on the coastal environment are given in Table 1 (Anon., 1998).

The table shows the main ways in which coastal agriculture can adversely affect the ecosystem. The impacts may result from resource depletion, from loss of habitat, from hazards to human health or from loss of protection against coastal erosion or sand dune migration.

#### **Potential benefits of agricultural development for the coastal environment**

There are a number of ways in which appropriate agricultural development can have positive impacts on coastal ecosystems. The details are furnished in Table 2 (Anon., 1998).

An appreciable contribution can come from reducing the competitive and antagonistic effects of existing agricultural activities, for instance by the adoption of irrigation systems or crops that use less water, or crop protection methods that do not rely on insecticides. Higher and more sustainable productivity on existing agricultural land may reduce pressures to bring new land under cultivation.

Appropriate agricultural development can also have positive secondary effects, for instance, providing improved livelihoods for rural people can reduce pressure on coastal fisheries and wetlands. Agricultural development may increase the general

**Table 1.** Potential harmful effects of agricultural activities on coastal ecosystems

Activity	Environmental change	Impact of social concern
Estuary flood control, impoundment or diversion of coastal rivers	Increased estuarine salinity, reduced circulation, sediment trapping, decreased supply of beach material to shoreline, shoreline erosion	Reduced crop yields, reduced fish yields, increased water-borne diseases
Agricultural pesticides	Toxic pollution of estuaries and inshore waters	Killing of fish, reduced fish yields, potential human consumption of toxic fish, coral pollution and loss
Fertilizer use	Increased amount of nutrients, eutrophication and pollution of estuaries	Killing of fish, reduced fish yield, coral pollution and loss
Over cropping or grazing in coastal watershed	Watershed erosion, estuary sedimentation and increased turbidity, increased deposition in flood plains	Corals and beaches covered with sediment, coral death, decline in fish yields, decreased recreation and tourism attraction, obstruction of navigation channels with sediments
Irrigation from coastal aquifers	Depletion of coastal aquifers	Saltwater intrusion, contamination of groundwater
Coastal wetlands reclamation	Draining or dyking, physical destruction of habitat, toxic (acid) drainage, change in sedimentation patterns, change in water circulation/drainage, loss of coastal protection (mangroves), increased water-borne diseases	Loss of wetland and forest/wildlife production, loss of biodiversity, biological diversity, loss or rarefaction of endangered species, killing of fish, reduced fish yields, increased storm damage and coastal erosion
Intensive livestock activities	Organic effluent, eutrophication and pollution	Killing of fish, reduced fish yields, coral pollution and loss, reduction in recreation and tourism attraction
Agro-industries	Organic and toxic effluents, eutrophication and pollution	Killing of fish, reduced fish yields, coral pollution and loss, reduction in recreation and tourism attraction
Overgrazing	Destabilization of grazing areas	Initiation or increased migration on to agricultural or urban areas

**Table 2.** Potential benefits of agricultural development for coastal ecosystems

Action	Benefit
More efficient irrigation systems	Increased water availability for other sectors
Cropping varieties and practices giving higher and/or sustainable yields on suitable land	Increased land availability for other sectors: less cultivation of steep erodable slopes and less clearing and drainage of wetlands
Less cultivation on steep slopes, controlled grazing, conservation practices, appropriate manuring methods, integrated pest management methods	Improved water quality: reduced erosion and nutrient leaching, reduced organic and chemical pollution
New enterprises or higher productivity leading to improved livelihoods from agriculture	Reduced exploitation and more sustainable use of fisheries and wetlands
Increased food supplies, demand for agricultural inputs and services, supplies of raw materials for processing, export	Increased incomes, nutrition, employment and wealth in other sectors reducing pressure on fisheries and wetlands

level of economic activity in a coastal area. Increased demand for agricultural inputs and services and consumption goods and services, and increased supply of food, export of crops or industrial raw materials will all contribute to the local economy and stimulate growth and employment in other sectors, with positive secondary effects.

While increasing levels of economic activity in rural coastal areas lead to increasing pollution problems without any reduction in the pressure on coastal fisheries and wetlands, higher levels of economic activity in coastal areas can lead to improved livelihoods and reduced pressure on coastal fisheries and wetlands. This can also generate wealth for investment in the protection of coastal ecosystems. Similarly, higher sustainable crop yields can reduce the demand for new land for cultivation, but they can also make crop production more attractive and in turn increase the demand for agricultural land. The effects of agricultural development are thus very sensitive to the nature of development and to economic, social and political structures and circumstances.

#### **Problems and prospects of coastal agro-ecosystem**

The coastal agro-ecosystem is an important production system in terms of diversity of crops, vegetation, soil and topographic features, supporting several million people whose socio-economic conditions are very much dependent on this system. It faces problems of multidimension in nature, which calls for strategic integrated technology development with a view to augment the overall productivity of varied types of enterprises.

Coastal regions suffer from problems of water scarcity, soil erosion and depletion of biological diversity and possible threat of rise in sea level due to global warming. The coastal areas suffer both in monsoon and post-monsoon seasons. In monsoon season, excess rainwater, prolonged water stagnation, high water table, high humidity, impeded drainage and loss of nutrients are some of the problems. In the post monsoon season, high salinity of soil and ground water and also scarcity of fresh water limiting crop productivity are the common unfavourable factors. The production is further constrained by extensive occurrence of problem such as saline soils, clayey soils, eroded soils, pest and disease problems etc. Over and above this, natural calamities like cyclones, floods, currents and tides are common features of these areas.

#### **Issues of concern**

Some of the major issues of concern regarding agriculture in coastal agro ecosystem are as follows.

##### *1. Soil degradation*

Soil degradation is the decline in soil productive capacity of land due to processes induced by human intervention. The human-induced processes like deforestation and encroachment of forest land for cultivation etc. have resulted in over-exploitation of natural resources, leading to degradation of soils. Degradation can occur through displacement of soil material by wind and water erosion, or soil deterioration resulting from soil accumulation and loss of nutrients thorough physical processes including water logging. In India, it is estimated that out of total geographical area of 329 million ha, 187 million ha representing 57 % presently suffers from various kinds of degradation problems (Paroda, 2003).

##### *2. Physical deterioration*

Waterlogging is another major physical deterioration process, which alone accounts for degradation of 11.6 million ha land (Paroda, 2003). Vast areas of physically degraded common grazing lands, uncultivable waste lands and degraded forests pose a serious threat to adjoining productive crop land. The degradation takes place mainly due to over grazing and foraging far in excess of the carrying capacity of the land.

##### *3. Chemical deterioration*

Soil deterioration due to chemical process includes accumulation of excess salts and loss of organic matter and plant nutrients. The estuaries and back waters of the coastal region permit the flow of tidal water into the low lying areas causing salinity that increases in summer. Problems of salinization and alkalization are most serious in the canal-irrigated areas where indiscriminate use of water results in rising of ground water table. The gravity of chemical degradation through loss of nutrients has become quite visible in recent years with the incidence of multi-nutrient deficiencies, particularly in intensively cultivated areas without addition of proper amounts of organic manures. Deficiency of boron noticed in many parts of coconut growing areas is a classic example for this.

##### *4. Water crisis*

The challenge of growing water scarcity is becoming increasingly serious due to over exploitation of already depleting ground water

sources and wasteful use of already developed water resources. Water gets misused by farmers for various reasons including lack of realization of cost of water, lack of concern for damage and deprivation to the down stream farmers from the overuse of water in upstream, lack of awareness about scientific water management programmes etc. Hence all efforts should be made for the effective rainwater harvesting and judicious use of such conserved water for sustainable agriculture.

### Future strategies

#### 1. *Ecoregional approach*

More than 50% of the growth rate in yield of any crop has to come from research efforts by developing location specific low input use and eco-friendly technologies. In this context, emphasis is to be given for eco-regional planning. Research activities have to be formulated and implemented within the eco-regions and by interlinking R&D priorities between and within eco-regions. Farmer participatory research planning and implementation will be very useful in this regard. Farmer-Extension personnel-Scientist interfaces and discussions will be also very helpful in this regard (Rajagopal *et al.*, 2004 a).

#### 2. *Farming system approach*

Farming system approach assumes greater importance from the point of view of both ecological and balanced nutrition aspects as well as maximum utilization of resources such as sunlight, land and water. Changing consumption and demand patterns and new trade opportunities provide impetus to the trends towards diversification of farming system through more emphasis on other enterprises such as horticulture, animal husbandry, pisciculture, bee keeping, etc. Crop diversification is of utmost importance in mitigating the problems arising on account of crop failures and price fall of crops due to monoculture. Emphasis is to be given for identifying suitable crop combinations for different situations and development of cropping system models with higher and stable yield and/or profit in different agro-ecological regions and popularization of appropriate model is necessary. Central Plantation Crops Research Institute has developed high-density multispecies cropping system models for plantation crops such as coconut and arecanut (Bavappa, 1995). Introduction of suitable medicinal and aromatic plants with high market potential and high value low volume spices like vanilla as inter/mixed crop not only enhances

the employment potential but also increases the net return from unit area (Krishnakumar, 2003). Studies on complimentary and competitive interaction effects between crop/livestock/aquaculture components are also required.

#### 3. *Integrated Nutrient Management (INM)*

It is the supplementary as well as complementary use of organic manures, crop residues, green manures, bio fertilizers and rural and industrial wastes (preferably after composting) along with chemical fertilizers to meet the nutrient demand of crop plants. It is important to work out models for conjunctive use of organic manures and fertilizers for sustaining the biological productivity of soil. The reduction of soil fertility due to over mining of nutrients and inadequate replenishment through fertilizers can only be controlled by adoption of INM. Application of *Glyricidia* leaves as green leaf manure @ 30-40 kg per coconut palm in littoral sandy soil of the coastal area is found to reduce the inorganic nitrogen requirement by around 25% (Subramanian *et al.*, 2004). Technologies have also been developed and transferred to farmers for recycling of biomass from coconut and arecanut plantations through vermicomposting (Thomas *et al.*, 2003).

#### 4. *Integrated Pest Management (IPM)*

Indiscriminate use of pesticides often adversely affects ecological balance resulting in complex problems such as pest resurgence, pesticide resistance, pollution of soil and water and accumulation of pesticide residues at toxic levels in the food chain. Integrated Pest Management (IPM) technologies that are environmentally friendly involving all available pest control measures such as host plant resistance, pest specific bio control agents, botanical pesticides, cultural and mechanical control methods are to be integrated and adopted for cost-effectiveness and ecological security.

#### 5. *Precision farming*

Precision farming or site-specific farming is an emerging technology that allows farmers to have most efficient use of inputs and agronomic practices. It has the potential not only to reduce cost of cultivation through more efficient and effective application of crop inputs but also protects the fragile environment. Precision farming is very essential because inputs in agriculture such as fertilizers and pesticides are based on non-renewable source of energy.

### 6. Value addition through post harvest management

The increased agricultural production warrants better post harvest management programmes to reduce losses and value addition to increase the income to farmers. To generate employment opportunities and to enhance profitability of the farmers, on-farm agro-processing activities and product diversification are to be encouraged.

### 7. Watershed approach

Integrated watershed approach for management of resources is considered as the most appropriate approach in preventing degradation of ecosystem, restoration of degraded lands, efficient water harvesting and utilization as well as improving the overall productivity of cultivated land. On-farm water harvesting and its efficient use through appropriate irrigation systems and crop diversification programmes as well as efficient and timely adoption of crop management operations will definitely help in realization of higher economic returns. Central Plantation Crops Research Institute in association with the District Panchayath of Kasaragod has successfully organized a series of training programmes for watershed based integrated development of wastelands of the district and necessary action plans were also prepared (Rajagopal *et al.*, 2004b).

### CONCLUSIONS

About 25 % of the world's population lives in coastal areas and most of the largest urban concentrations are on the coast. The current urban population of 220 million is projected to almost double in the next 20-30 years. Unless appropriate actions are taken by government and users of coastal resources, population pressure and associated levels of economic activity will further increase the already evident overexploitation of coastal resources and environment degradation of many coastal habitats. An integrated coastal area management with respect to agriculture and other related enterprises offers a means for balancing the demand for limited resources and optimizing the benefits to be derived in a sustainable manner.

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