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AUTHOR'S PROOF

14. Halophytic coastal marsh vegetation in East Africa

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Abstract. The Indian Ocean coasts of the East African mainland and the Madagascar subcontinent have estuarine and brackish water coastal marshes that support significant vegetation which is predominantly mangrove. The anthropogenic impacts on mangrove vegetation in all these countries are similar and are mostly due to urbanization, sewerage disposal, solid waste and toxic waste disposal, threats due to oil pollution, dredging operations, damming of rivers, salt and prawn farming, and over cutting of wood for building materials and for fuel. This paper reviews the distribution and utilization of coastal marsh vegetation of the East African region with special reference to mangroves.

Key words: Agroforestry, Aquaculture, Biodiversity, Fuelwood, Irrigation, Mangroves, Review, Salinity, Salt marsh

Introduction

The vegetation along the coasts of the East African mainland is predominantly a forest savanna mosaic in some alternating with dry savanna, except in Somalia where it is classified as sub-desert steppe (Figure 1).

A feature of the coastline is the extensive area of estuarine and brackish water coastal marshes that support significant vegetation which is predominantly mangrove (Figure 2).

Because of the aridity, nomadic grazing is a common land use, notably in Kenya and Somalia on the East African mainland and on parts of Madagascar, especially the north and south of the island where the vegetation is typically wooded steppe (Figure 3).

The rapid rise in human population in the East African region requires increased food production, shelter and fuel wood. Climatic conditions do not favour rainfed agriculture in most of the region and therefore food production can only be increased through irrigation and aquaculture.

The region is not well endowed with fresh water supplies and a significant proportion of the underground water is saline. In some areas the meagre supply of freshwater is reserved for domestic use. Water potentially available for irrigation is saline. Successes have already been reported in some parts of the world where cultivation, of halophytes on saline soils or using saline water has been undertaken (Glenn & Watson 1993). Most success has been from using indigenous plant species. The halophytic coastal marsh vegetation of East Africa represents a major resource.

This paper reviews the distribution and utilization of coastal marsh vegetation in the East African region with special reference to the mangrove communities.

Coastal marsh vegetation

Coastal saltmarsh plants have been categorized into various associations (Schimper 1891) whose structural distinctiveness however may vary regionally depending on climatic factors (Macnae

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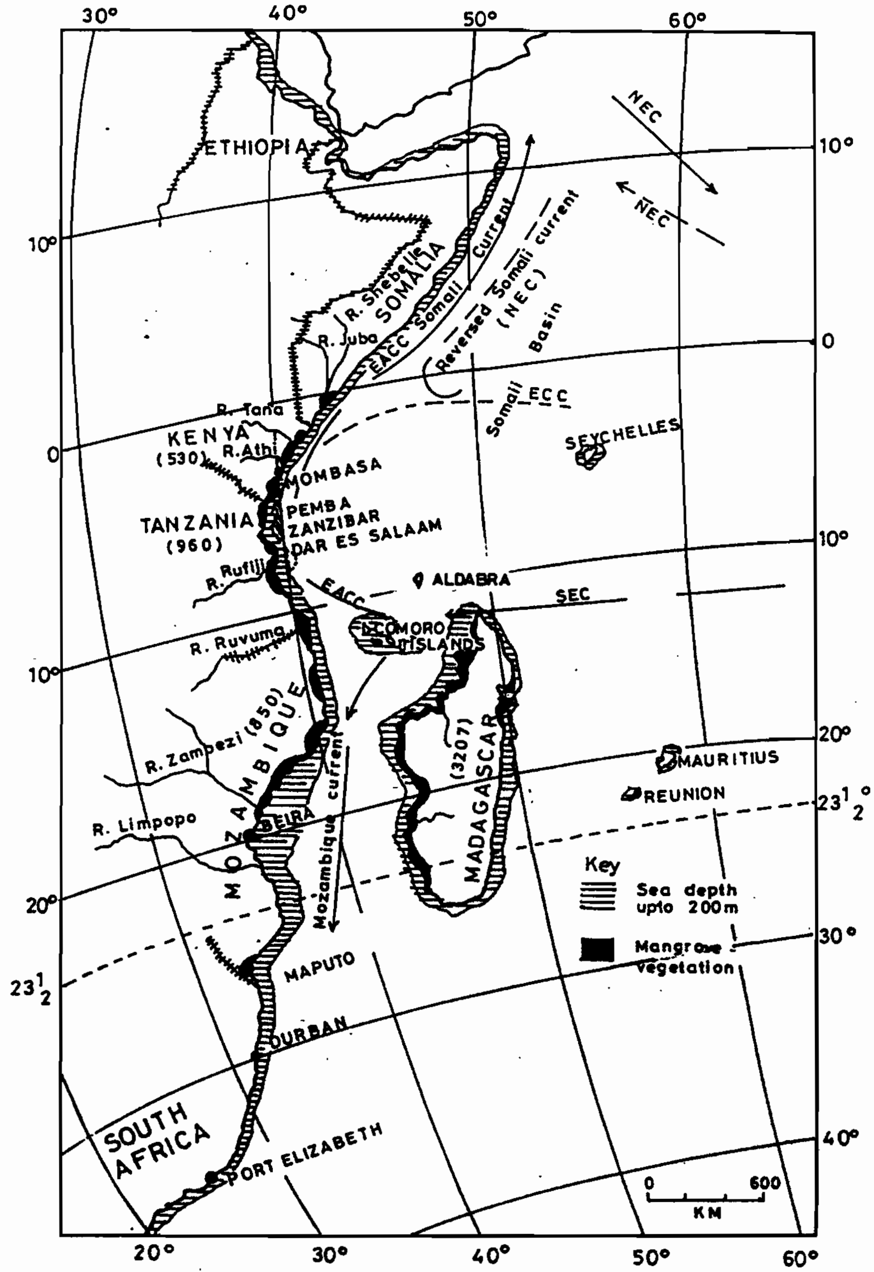

Figure 1. Distribution of mangrove vegetation along the coasts of the African mainland Facing the Indian Ocean and its islands. The total vegetation cover (km^2) in each country is shown by the number in paranthesis.

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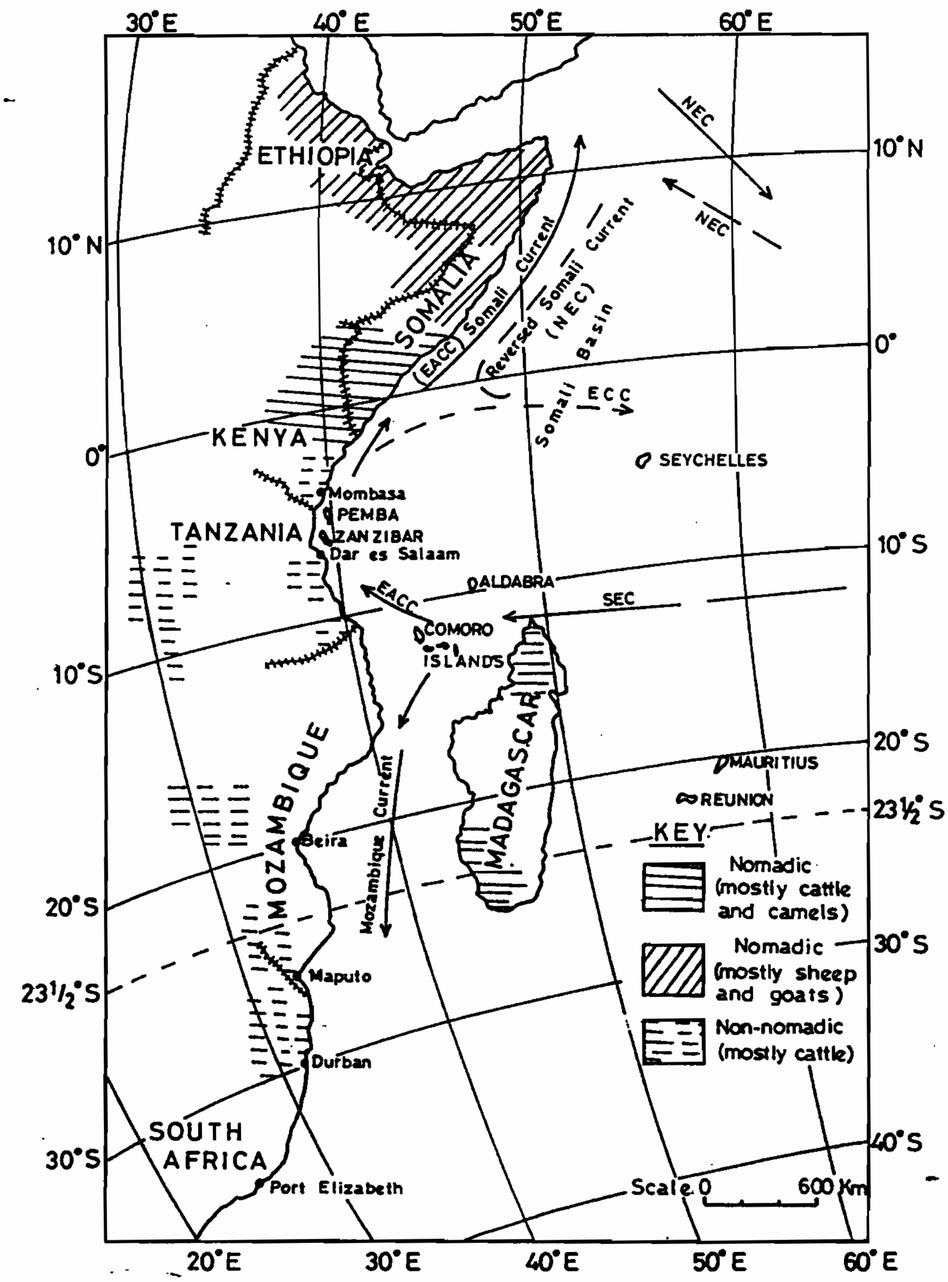

Figure 2. Patterns of livestock keeping in the East African region.

1968). According to Schimper (1981) there are four categories namely: (a) the mangal i.e. mangrove tree species and non-woody herbaceous plants; (b) the Nypa Association which occurs to the landward and upstream of a mangal and is dominated by the rhizomatous *Nypa* with isolated trees e.g. *Heritiera*; (c) the Barringtonia Association which may be dominated by either *Barringtonia* when it occurs behind a pes-caprae Association, or by *Barringtonia. Heritiera* spp if the association occurs behind a mangal; (d) the Pes-caprae Association which is dominated by *Ipomea pes-caprae* Roth and may be mixed with *Casuarina* and other woody halophytes. Macnae (1968)

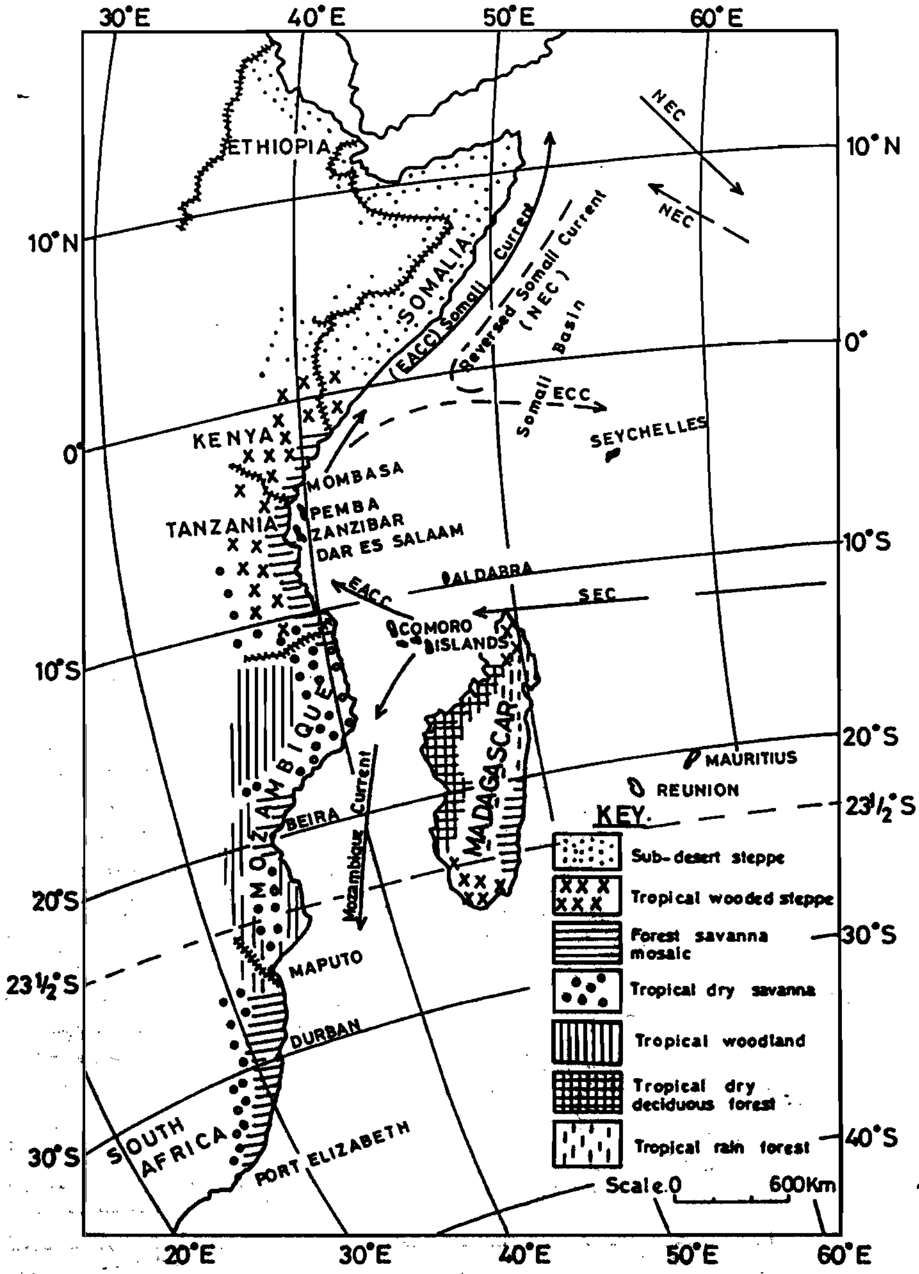

Figure 3. Types of terristrial vegetations in the East African region.

introduced a further category, the Saltwart Association which is typical in situations where evaporation comes to exceed availability of freshwater. The Saltwort association is dominated by bushes or low shrubs of species of perennial *Arthrocnemum* and the annual *Salicornia*.

Unlike the mangal which is always littoral the pes-caprae and barringtonia associates are always supralittoral according to the shore terminology of Lewis (1964). The nypa association tends to occur from the ordinary spring tides and above extreme high water mark and is therefore more supralittoral in its occurrence.

Macnae (1968) recognized two associations for

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the Indo-west Pacific which includes the Eastern Africa region. The two distinct associations are:

1. The Ipomea pes-caprea Association: It extends from semi-desert shores to ever wet areas where rainfall may be abundant at all seasons. In humid tropics this may be associated with a Baringtonia associations;
2. The Mangal as the principal vegetation with the Nypa association, Barringtonia association and Saltwort association categories as mangal associates: The Nypa association and Barringtonia association are typical mangal associations in areas under freshwater domination where evaporation and transpiration are more than balanced by a high rainfall and/or supply of freshwater from large rivers. In arid areas however the Nypa and Barringtonia associations are not distinct in structural composition and may even lack. The saltwort association occurs where evaporation and transpiration are in excess of the supply of fresh water.

The mangal

The estuarine and brackishwater coastal marshes in East Africa predominantly support mangroves. Mangroves are evolutionarily terrestrial plants that adapted to life in estuarine brackishwater and saline biotopes (Chapman 1976). They are still not fully aquatic plants and survive in semi-terrestrial or semi-aquatic conditions that are well provided for in the intertidal zone, making them true intertidal flora with respect to their rooting whereas their canopy is always above the high water tide and therefore exhibiting a terrestrial bias. *Avicennia* and *Rhizophora* genera are argued to be the first mangrove genera to evolve (Chapman 1976).

The adaptations of mangroves to estuarine brackishwater and saline biotopes have been variously well documented (e.g. Chapman 1977a) and from this knowledge of their certain terrestrial and aquatic qualities, clues into the practical possibilities of how to undertake mangrove agro forestry have been derived. From our knowledge of the natural history of mangroves it is necessary that consideration of mangroves as a resource should be done from a two pronged approach point of view, first as a land based resource and secondly as a water based resource. It is in view the latter points that the foregoing review was done.

Geographical disatribution

There are eight species of mangroves in the Eastern African region. These are *Sonneratia alba* J. Sm., *Rhizophora mucronata* Lam., *Bruguiera gymnorhiza* (L.) Lam K., *Ceriops tagal* (Perr.) C.B. Rob., *Xylocarpus granatum* Koening, *Avicennia marina* (Forst.) Vierh, *Heritiera littoralis* (Dryand.) Ait. and *Lumnitzera racemosa* Presl.

The distribution of these species and the total mangrove cover in each country in the region is summarized in Table 1. The ocean current systems shown in Figure 1 are responsible for the distributions of the mangrove species and other halophytes with floating seeds in the region.

Except for *Heritiera littoralis* the small islands and atolls off the coasts of East Africa mainland equally support the species of mangroves encountered on the coasts of the East African mainland and the Madagascar coastline. Seychelles, being a country composed of several islands and an atoll supports the highest number of mangrove species than other country islands. the Aldabra Atoll has the highest species richness of mangrove species and supports all the species in Table 1 except *Heritiera littoralis* (Macnae 1971).

Along the coasts of the East African mainland, disparities in the distribution of species of mangroves is evident just as similarly shown in the mangrove vegetation cover from country to country (Figure 1). Mozambique and Tanzania support the most significant mangrove vegetation cover on the mainland but the largest mangrove cover in the region is found in Madagascar. The Durban area (South Africa) which represents the southern most extent of the mangrove distribution supports only 3 species (Day and Morgans 1956). The southernmost extent of the mangrove distribution is inhibited by the change of the climatic conditions to sub-tropical type (Chapman 1977a). The arid areas in Somalia supports a very poor mangrove vegetation structure which is confined around the estuary of R. Juba/Shebele (Figure 1). The lack of significant mangrove vegetation may be explained by the lack of estuarine or brackishwater conditions to provide the lower salinities required by the seeds to root. Like with other halophytes, mangrove seeds require salini-

Table 1. Distribution of mangrove species and cover in the East African region: Seychelles (Sey), Mauritius (Mau), Reunion (Reu), South Africa (S. Af. Durban), Madagascar (Mad.), Mozambique (Moz), Tanzanla (Tan), Kenya (Ken) and Somalia (Som) including crab and prawn fisheries production. MSY = maximum sustainable yield

	Sey	Mau.	Reu.	S. Afr.	Mad.	Moz.	Tan.	Ken.	Som.
1. *Sonneratia alba*	+	–	–	–	+	+	+	+	–
2. *Rhizophora mucronata*	+	+	–	–	+	+	+	+	+
3. *Bruguiera gymnorhiza*	+	+	–	+	+	+	+	+	–
4. *Ceriops tagal*	+	–	–	+	+	+	+	+	–
5. *Xylocarpus granatum*	+	–	–	–	+	+	+	+	–
6. *Avicennia marina*	+	–	–	+	+	+	+	+	+
7. *Heritiera littoralis*	–	–	–	–	+	+	+	+	–
8. *Lumnitzera racemosa*	+	–	–	–	+	+	+	+	–
Total number of species	7	2	–	3	8	8	8	8	2
Total Mangrove are (km^2)	–	–	–	–	3207	850	960	530	
Annual MSY (tonnes) for crabs	–	–	–	–5760	1530	1728	1057	–	
Annual landings of prawns (tonnes)	–	–	–	1700	1000	979	350	–	

Source: Mangrove species: Seychelles (Macnae 1968, 1971); Mauritius (Fagoonee 1990); South Africa (Day & Morgans 1956); Madagascar (Macnae 1968); Mozambique (Macnae & Kalk 1962); Tanzania (Chapman 1977b), Kenya (Isaac & Isaac 1968), Somalia (Chapman 1977b); Mangrove area: Madagascar, Mozambique and Tanzania (SW10P 1989a); Kenya (Doute et al. 1981); Crab and prawn fishery yields: Madagascar, Mozambique, Tanzania and Kenya (SW10P 1989a,b; 1990).

ties lower than seawater for them to produce roots and grow (Ungar 1982) but thereafter the tolerance to higher salinities increases with age of the plant. The ecological significance of this inhibition is that root damage during the dispersal period is avoided (Ungar 1982). In the semi-arid Kenyan coast it has been observed that most of the major mangrove vegetation cover occurs far away from estuaries but such areas receive submarine groundwater discharges that create the required lower salinities for rooting of the seeds and development (Ruwa and Polk 1986). The coastal and maritime halophytes and the saltmarsh saltwort associations have not yet received much attention in this region except for records in Mozambique by Macnae and Kalk (1962). The supralittoral fringe supports *Juncus* spp, clumps of *Acrostichum* spp. *Chenolea* spp. and *Sporobolus* spp. Where a pes-caprae Association occurs, it is characterized by *Ipomea pes-caprae* L. (Sweet), *Vigna* spp, *Casuarina* spp and *Pandanus* spp. The saltwort associations in this region are mainly composed of the following: *Sesuvium* spp, *Salicornia* spp and *Arthrocnemum* spp.

Socio-economics

Structural labour divisions found in communities living around mangrove forests allow, to varying degrees, members of such communities to generate incomes from consumptive and non-consumptive use of mangrove resources. For example, not everyone is a woodcutter, a charcoal burner, a honey gatherer, a boat builder, fisherman or a livestock farmer but in such communities there are different experts for these different occupations and who ever demands their services pays, thus minimizing competition if everybody was a Jack of all trades. At a such humble organization centered on the mangroves it is almost axiomatic to postulate that economic derivatives from man-mangrove interaction have been nurtured and cherished since the time such communities started living around such biotopes. A further initimate man-mangrove interaction is the demarcation of certain portions of mangrove forests for use as tribal shrines for worshipping, giving offerings and where traditional medicinemen sometimes treat their clients for special ailments.

Impacts

The mangrove biotopes in Eastern Africa are threatened by: (a) pollution mostly from industrial wastes, solid wastes and sewage disposals from urban areas, oil pollution from ships and storage tanks in mangrove creeks; (b) physical destruction of the habitat: through overcutting of mangroves which consequently increase shore erosion; clearing of mangroves or creation of salt farms and prawn ponds; reclamation of salt marshes for housing estates, harbour development, etc.; (c) diversion of rivers to create dams for production of electricity has caused salinity stresses in estuaries. The activities that presently threaten mangrove vegetation are not the historical types of activities practiced by village communities that have interacted and coexisted with mangroves (Ruwa 1985) but new developments unrelated to the lifestyles of the village communities e.g. industries, hotels, harbours that have brought influx of immigrants to provide labour etc. Such activities have transformed the villages to urban areas causing increased exploitation of mangroves for wood and degradation of the environment. The degradation of the environment further reduces the chances of successful rehabilitation of destroyed areas and reforestation of new areas.

In situ and exsitu management of mangroves

The mangrove forests in the East African region are not adequately protected by any form of law and there are no management guidelines being practiced except for a few pockets of mangroves that benefit protection through tribal religious practices that prohibit exploitation of trees from shrines. The mangrove cutters come from villages surrounding the mangrove forests although the middlemen who buy the mangrove wood include residents from elsewhere. Honey gatherers freely keep their beehives in the forests. There is need that management strategies are geared to:

a) discourage environmental degradation of marshes e.g. through pollution, overexploitation of mangroves, unplanned reclamations etc.;
b) providing legal provisions that will allow prosecution of abusers of marsh biotopes and make them responsible for rehabilitation of such places they have destroyed even if that has happened by accident;
c) maximize economic benefits for surrounding villagers, e.g. using profits from park charges and allowing non-consumptive type of uses like honey gathering, aiding non-destructive type of aquaculture projects like oyster farming, cage culture, algae culture etc. so that they can appreciate the extensive values of mangroves;
d) encourage replanting programmes by villagers by providing them with seedlings and providing tokens of appreciation to those who will look after their trees carefully;
e) initiate agroforestry programmes aimed at commercial exploitation for fodder and other forest products. Besides agroforestry, initiate plantations of herbaceous halophytes, e.g. *Sesuvium*, *Salicornia*, *Juncus* etc. The most preferred mangrove species for fodder by livestock is *Avicennia marina* which has further advantages due to having wider salinity tolerance and temperature ranges;
f) introduce and encourage use of mangrove species and other halophytes for landscaping, thereby also allow their ex-situ preservation while at the same time enhancing panoramic views. Tree heights of mangroves can even be controlled by using irrigating water of appropriate salinities. Being evergreen and halophytic, mangroves are pleasant plants for landscaping in semiarid and arid area where vegetation is scanty and soil salinities are prone to changes when irrigation is practiced. Such strategies will ensure substainable use of mangrove vegetation and other halophytes while allow marsh biotopes to maintain their functions, encourage eco-tourisms with economic benefits to surrounding populations arising from agroforestry.

Towards agroforestry

There are no agroforestry plantations using mangrove species in this region. Overcutting indicates that the output can not suffice the demand. The high demand for mangrove wood for various uses is a clear manifestation that mangrove wood is popular and therefore marsh biotopes that support them should not be considered as wastelands.

Both terrestrial and intertidal biotopes can be used for mangrove plantations but terrestrial plantations require irrigation. In most coastal areas, the underground water is saline and can be used for irrigation of halophytic plants. Saline underground water aquifers are therefore impor-

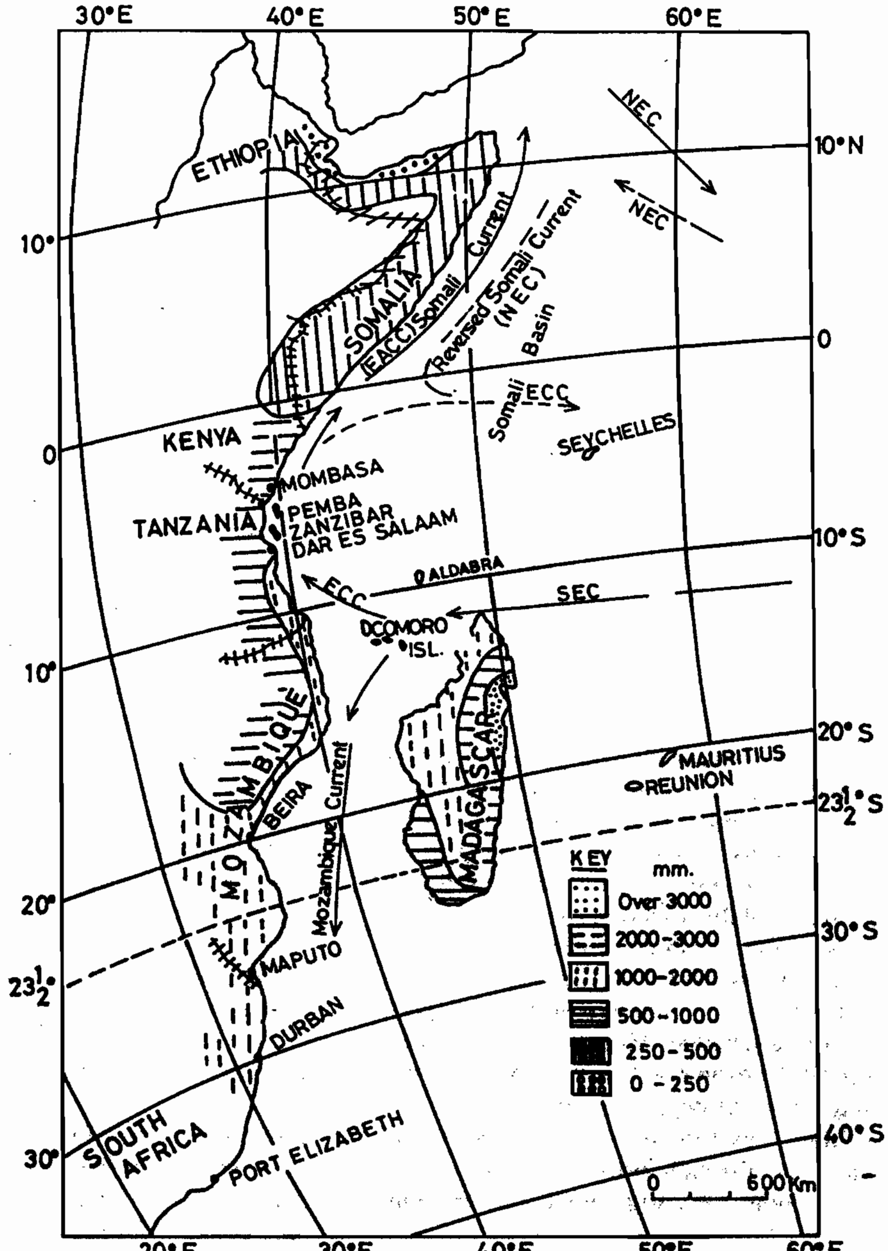

Figure 4. **Rainfall zones in the East African region based on mean annual rainfall.**

tant resources in the farming of halophytic plants. Both inland and semi arid areas with saline or brackish water can be utilized for farming of halophytes.

Nomadic grazing is common especially in Kenya and Somalia on the African mainland and in some parts of Madagascar.

On Madagascar Island the west coast supports most of the mangrove vegetation which is characterized by tropical dry deciduous forest. The eastern side supports a tropical rainforest and a tropical woodland savanna.

Potential areas for fodder cultivation. The coastal semi-arid and arid areas from northern coast of Kenya to Somalia where the vegetation is too sparse for adequate grazing offer high potential areas for fodder cultivation and grazing by livestock. This will reduce nomadic pastoralism and preserve the delicate vegetation structures in these drylands. The herbaceous halophytes and the woody halophyte *Avivennia marina* are suitable fodder plants for these areas because of their wide temperature and salinity tolerance ranges. The semi-arid western coast of Madagascar has also a high potential for fodder cultivation and grazing thereby also reduce dangers of habitat destruction through nomadic pastoralism on the island and to maintain the uniqueness of its biodiversity.

Potential areas for timber plantations. The halophytic mangroves grow luxurianty to large and tall sizes in places with high rainfall (e.g. Macnae 1968). In arid and semi-arid areas they are dwarfed and remain mostly as shrubs and do not provide high quality wood due to high soil salinity but are, however, useful for fodder and landscaping. For timber production, irrigation of plants with saline water is unsuitable if there is not enough freshwater to flush out any build up of salts in the soil. For mangroves, successful plantations for production of timber can be located in the intertidal zones where the tide helps to flushout salts daily. In the Eastern Africa region the tides which are described as macrotidal because the tidal range is more than 3 m (Stoddart 1971) low gradient shores provide large area for planting of mangroves.

The potential areas for planting mangroves for timber which have adequate rainfall in this region are coasts of Southern Tanzania, Mozambique and eastern Madagascar (Figure 4). The preferred species for wood products in this region are: *Rhizophora mucronata*, *Bruguiera gymnorhiza* and Ceriops tagal. In saline soils in the supralittoral zone and further inland *Casuarina* spp and *Eucalyptus* can be grown. *Casuarina* spp and *Eucalyptus* spp thrive well in this region and can also be grown in the semi-arid areas such as those in Kenya where they equally provide wood of good quality.

Besides wood production, plantations of mangroves in the intertidal zone provide further advantages e.g. (a) the trees increase the species richness or biodiversity in the intertidal zone (Ruwa 1990); (b) the increase in mangrove vegetation cover increase crab and prawn catches (Martosubroto and Naamin 1977) as also indicated in Table 1; (c) reduce shoreline erosion.

Conclusions

The need to foster the cultivation of coastal halophytic plants to provide fodder and wood requirements to meet demands placed by burgeoning human populations.

Because halophyte farming is new to the region, some pilot projects should be set up. These will form the nuclei for demonstration farms in the region. There is a clear need for international cooperation at both global and regional level to ensure the transfer of appropriate technology. Rewards for such efforts will not only be the increase in food, fodder, fuelwood, timber and honey production but also enhanced fisheries production.

To generate more public awareness about halophytes evergreen herbaceous or grass halophytes can be used for landscaping purposes in streets and public parks. These can be irrigated with saline water. Other ways of enhancing public awareness is through organized ecotourism activities in mangrove forests by conducting guided educational walks on boardwalks and building bird watching platforms for birdwatchers. It is also important that legal provisions are made to protect and preserve mangrove forests from overexploitation and environmental degradation so that people or institutions that abuse such biotopes are made to rehabilitate them at their own cost.

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