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MUD BANKS AND COASTAL EROSION IN RELATION TO FISHERIES*

Introduction

The mud banks and coastal erosion are two contrasting phenomena that occur along the west coast of India during the south west monsoon season. Though independent of each other, both have a profound impact on the socio-economic conditions of the coastal population. While the mud bank with their calm waters facilitate operation of country crafts by the coastal fishermen, the coastal erosion deprive them of their lands, houses, and personal effects, in addition to hampering their fishing activities. Thus, two extreme conditions of nature are in operation along this coast line during the monsoon season. Both the phenomena are quite unpredictable as to where they would appear and at what time. The causative factors are also different. In fact, although mud banks, the fishery associated with them and the coastal erosion are all independent of each other, they are to be considered together for an integrated approach to the monsoon fishery and the coastal economy.

A regular monitoring of the features of the mud bank has been carried out by the Institute from 1968 onwards in order to understand the phenomena of mud bank and coastal sea erosion with particular reference to the monsoon fishery and based on these studies a brief account is presented.

The mud banks

During the south west monsoon season while rough seas prevail all along the coast, at some parts of south west coast of India, especially along the Kerala coast, the nearshore waters become very calm over limited areas of varying extent ranging from 10 to 25 sq. km in somewhat semi-circular form on account of the fine clayey mud of 1 to 2 metres thickness, the surface layers of which are kept in a thixotropic colloidal solution that absorbs all the wave energy. Such quiscent areas are called the mud banks, popularly known as 'Chakara'.

Mud banks have been reported to have appeared at several places between Mangalore in the north and Quilon in the south (Fig. 1). They can be classified mainly into four types based on the source of mud for their formation.

1. Mud banks formed of subterranean mud

Eg. Alleppey–Thottappally mud bank

Here, the mud supply is from the underground sources. The Vembanad lake system provides the mud for this mud bank. A hydrostatic pressure is exerted on the side of the backwater on account of heavy rains and floods during the south west monsoon. The nature of subsoil strata of the narrow coastal stretch separating the backwater from the sea is porous at various places in this region or consists of water bearing strata to allow discharge of loose mud from the lake side towards the sea during the mud bank season. Simultaneous to the above process, with the onset of the south west monsoon winds, and the subsequent wave action, a shoreward pressure is developed which in combination with the backwater pressure causes the upward lifting of mud in the form of mud cones (Plate–1, figs. 1–2) at the weakest areas of the shore. It is at these places, that the mud bank as we see at Alleppey–Thottappally region is formed. Here the area of the mud bank will be very much restricted.

2. Mud banks formed by the aggregation of coastal mud

Eg. Parapanangadi–Tannur mud bank

In this case, the mud bank is very extensive, stretching over several kilometres along the shore and are purely temporary. There may not be perfect calmness as the quantity of mud in suspension may not be enough to absorb all the wave energy. By the beginning of the south west monsoon, the bottom mud present in the coastal mud belt is churned up and at this time if the prevailing environmental conditions such as force and direction of wind, current, offshore movement of the surface waters and the resulting onshore movement of the bottom waters are favourable to the formation of the mud banks, the mud will be brought in suspension very near to the shore and thus a mud bank will be formed. Once such favourable conditions cease to exist or reverse, such mud banks will disappear suddenly.

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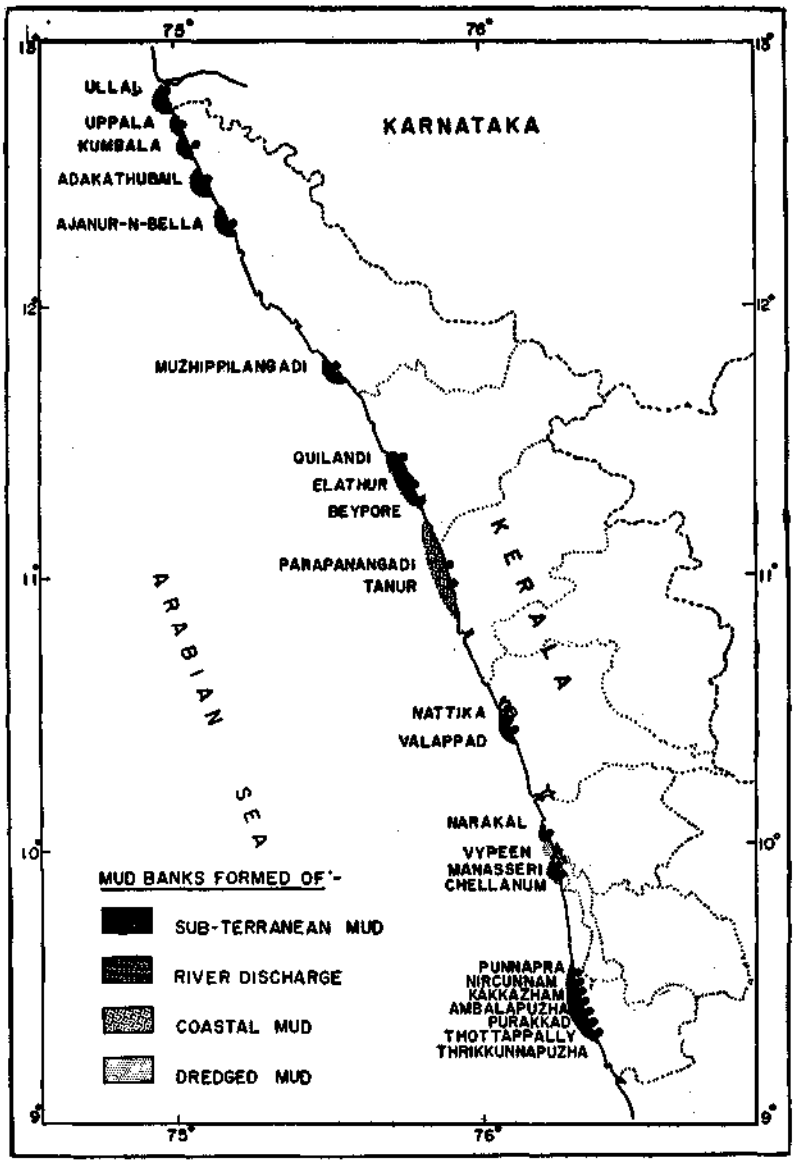

Fig. 1. Places of recorded occurrence of mud banks along the Kerala and Karnataka coasts.

3. Mud banks formed by the sediments and organic debris discharged from rivers and estuaries

Eg. Chellanum-Manassery (Cochin barmouth), Narakkal (Azhikode barmouth), Valapad-Nattika (Chetwai river mouth), Elathur (Korapuzha river mouth), Quilandy (Kuttiyadi river mouth) Muzhippilangadi (Dharmadam river mouth), Kottikulam, Ajanur-N-Bella, Adakathubail (Chandragiri river mouth), Kumbala (Kumbala river mouth), Uppala (Uppala river mouth) and Ullal (Netravati river mouth).

The flood waters coming down from rivers and lakes during the heavy rains of the south west monsoon bring huge quantities of sediments and other organic matters. These are aggregated at the estuary and barmouths, usually, south of their openings. These sediments are held in position by the southerly flow and the local eddy currents without being spread out. Once the water force from the lakes and estuaries is reduced, the already deposited mud is spread out and the mud bank suddenly disappears. Thus these types of mud banks are also of transient nature.

4. Mud banks formed by the accumulation of mud resulting from dredging operations.

Eg. Mud bank at Vypeen, Cochin.

At Vypeen, north of Cochin barmouth, accumulation of mud has been observed right from the shore

(Plate-1, fig. 6). The source of this mud is from the dredging operations, periodically done for deepening the navigation channel. Here the water over a wide area is calm due to this mud accumulation.

Whatever may be the type of mud bank and the source of mud for its formation, the immediate visible effect is calmness.

Calmness associated with the mud banks

The reasons for the prevailing calmness at a very restricted region near the coast when all other places are highly wave beaten are to be considered. Several theories have been put forward to explain this phenomenon.

It is an established fact, that when concentrated pasty mass of ferric oxide is mixed with suitable quantities of electrolyte in aqueous solution and shaken, a colloidal solution is formed. This phenomenon is known as thixotropy. This property was also observed in other colloidal systems such as alumina, silicic acid, vanadium pentoxide, zirconium dioxide, stanic oxide and even with suspension of fine clays.

The analysis of the mud collected from the mud cones showed that it contained ferric oxide in finest clayey form. Further, the mud contained certain amounts of petroleum ether soluble lipoid fraction, organic decomposed humus matter and volatile matter which also favour the formation of colloidal systems. From the nature of the samples collected, it is found that the colloidal system formed by this mud has the mixed characters of lyophobic and lyophillic sols. Hence, the colloidal system tends to be of a longer lasting nature.

The mud which is brought from underneath, in the form of mud cones, comes in contact with more quantities of electrolytes from sea water. This clayey mud by thixotropic effect of the sea water forms a colloidal solution in the vicinity of the mud bank. The dampening of the waves is largely controlled by the 'kinematic viscosity of the medium' in which the waves are travelling. Kinematic viscosity is the ratio of the true viscosity of the medium to its density. The calming effect of the wave motion is due to the mud particles in colloidal solution in water and not due to mud itself. The behaviour of mud in solution is typical of thixotropic mud; as the stress (violent wave action) falls the properties of mud in colloidal solution resemble those of a jelly. When the strong waves and swells during the monsoon reach the shore-bottom at the seaward fringe of the mud bank, the alternation of stresses associated with the ridge and trough of the waves brings the mud into suspension, thus progressively building up the thixotropic and kinematic viscosity effects. The monsoon swell provides a continuous source of energy to maintain the mud in suspension. The effect of a thixotropic solution on wave action is thus a cumulative one. At higher stress the kinematic viscosity of the agitated mud suspension produces a higher rate of dampening than in mud-free water and the stresses are reduced. Then the thixotropic effect comes into play, and the remaining stress is rapidly absorbed and dissipated by the jellylike behaviour of the colloidal solution.

Maintenance of the mud banks

It is observed that during the south west monsoon, the mud in colloidal solution is generally kept confined to the region of the mud bank, pressed to the shore, without being carried away in any other direction except towards south in a very slow pace. Let us examine, what all factors are in operation for maintaining a mud bank in its place. First of all, the south west monsoon with its westerly winds, having more northerly components causes monsoon swells in the inshore region which along with the waves produce a constant thrust from the sea to the shore. This thrust helps in keeping the colloidal solution of mud from spreading into the sea. The monsoon swell provides a continuous source of energy to keep the mud in suspension. It was found that the sediments of the Purakkad mud bank contained more volatile matter than the sediments of the other mud bank regions along the coast during the season. This may possibly be due to the subterranean origin of the sediments in the Purakkad mud bank region. The volatile matter in this subterranean mud is formed by the decomposition and decay of organic matter. It is kept in interstitial state until it comes in contact with seawater as in mud cones. This volatile matter helps in the stabilisation of the thixotropic colloidal solution of clayey mud by its lyophobic effect, thus imparting a long lasting nature of calmness for the mud bank at Purakkad. In the case of fine silt brought down by the rivers (mainly gravel) from Western Ghats, the decomposed organic matter and volatile matter will naturally be less as it has to travel long distances until the barmouths. During its travel, the fine silt mud is more thoroughly washed by fresh water thereby reducing the interstitial volatile matter content. Naturally the mud bank formed by this type of fine silt mud brought down by rivers and deposited south of their barmouths has to be of a very transient nature as far as the maintenance of calmness is concerned. Again, the mud banks formed during the south west monsoon season by aggregation

of mud already settled during the previous years along the coastal belt, are also of transient nature, as by course of time they are deprived of their volatile content. Thus, it seems that the combined effects of south west monsoon winds, swells, wave action and concentration of volatile matter are together responsible for the maintenance of the mud banks.

Movement of the mud banks

The mud banks formed on the southern side of the river/barmouths remain only for a few days and then disappear. But the behaviour of the Alleppey mud bank is quite different. This mud bank exhibits a slow movement from one place to the other, in course of time and this movement has been mostly southward in direction. The investigations by the authors showed that the mud bank moved by about 0.5 to 1 km in a season southward from the place of its incidence.

Dissipation of the Purakkad mud bank

By the end of the south west monsoon, the onshore thrust from the sea and from the backwater reduced due to the decline in intensity of the monsoon. By the decline of monsoon winds, the heavy swells and waves which help in keeping the mud in suspension also decline in their intensity. In addition to this as the north east monsoon starts, the southerly drift reverses along the coast. The current observations made by the end of the south west monsoon, showed that the northerly and onshore components of currents had slowly set in. The combined effect of the decline in the shoreward winds, waves, swells and the setting in of the northerly and onshore components of currents help in dissipating away the superficial loose mud in colloidal solution and also in the settling of the mud. This primarily causes the dissipation of the mud banks. Thus, it is seen, why the mud banks are observed during the south west monsoon season only.

The mud banks and the coastal monsoon fishery

During the south west monsoon season when fishing is almost suspended all along the Kerala coast, the mud banks formed at certain places close to the shore are real blessings to the fishermen. The mud banks provide ideal harbouring facilities to their canoes. Since perfect calmness is always assured at the mud bank regions during the south west monsoon season, fishermen from distant places bring their canoes to the mud banks. Usually there are aggregations of several hundreds of canoes at the mud bank landing centres. The canoes are brought by hand carts or trucks from distant

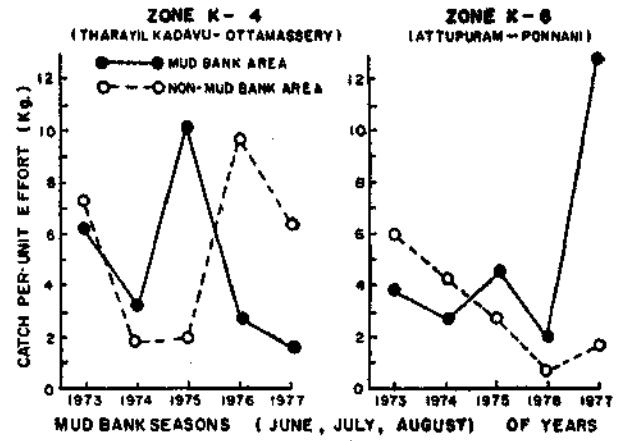

Fig. 2. The catch per unit effort of fishes landed at the mud bank and non mud bank areas of Zones Kerala–4 and Kerala–6 during the years 1973–1977.

places and it is usual sight on the road during the mud bank season. The canoes launched from the mud banks often bring very good catches. Naturally the question arises as to whether the mud banks harbour a fish stock of their own or whether the fishes come in search of such habitats. The fishing of the mud bank area during the monsoon season is often called as the mud bank fishery and the public opinion has also developed centered on this. Such a terminology could be used only, if the fishes and prawns landed at the mud bank area are fished exclusively from within the mud bank. Usually this is not the case. Direct observations have shown that majority of the catch landed at the mud bank area is the result of fishing in areas far away from the limits of the mud bank. After being launched, taking advantage of the calm water the canoes go in all directions in search of fish shoals. On several days the boats return without making any catch either from inside or outside the mud bank. On the contrary, there has been occasions when good catches were obtained from within as well as outside the mud bank areas. Everything depends on the movement of fish shoals and how well the fishermen detect and catch them.

There is a common belief that the mud bank and fishery are interdependent and if the former occurs the latter should follow. To many, a good mud bank or 'Chakara' means a good fishery. ('Chakara' is a malayalam term derived from the words 'chatthakara' or dead land, indicating figuratively the calm waters). Many fishermen believe that if there is a good mud bank formation they are destined to get a good catch. The success or failure of a mud bank is judged from the quantity of fish caught during the season. No consideration is given to the degree of calmness of water or

to the mud accumulated at the bottom and therefore the real mud bank as such is usually forgotten.

With the onset of the south west monsoon, the process of upwelling starts mainly between Mangalore in the north and Quilon in the south in the shelf region. The oxygen deficient colder sub-surface waters replace the waters of the shelf area and this brings in a radical change in the environment. Such a situation makes the fishes and prawns to leave their original habitats. They remain either pressed against the shore or migrate to deeper waters. Such a condition occurs throughout the coast where upwelling is intense. During their migration the fishes and prawns may come to the mud bank area also, as to other places along the coast. Thus what the fishermen get from the mud bank and nearby areas is likely to be obtained from other coastal areas also, if fishing could be undertaken there. Unfortunately fishing is not possible at all places on account of the rough sea. Launching and landing of the canoes are the main difficulties experienced by the fishermen. Besides, the sea erosion along this coast leaves no ground for fishermen to launch and land their canoes in some areas. In certain areas, sea walls constructed to save the coastal community poses problems in launching and landing of the canoes. Even the outlets provided on such sea wall for launching and landing of canoes are subjected to sea erosion. This is one of the reason for high congregation of canoes and fishermen and high landings at mud bank areas during the monsoon months. On some calm days fishing done at non-mud bank areas during the monsoon season turns out to be very successful as may be the case at the mud bank areas. But while accounting for the huge landings at the mud bank, people conveniently forget about the catches landed at other places all along the coast when calm sea prevailed during the monsoon season.

The catch per unit effort (CPUE) worked out for the Alleppey mud bank area and the non–mud bank areas south and north of it between Tharayilkadavu and Ottamassery (Zone: K-4) and for the Nattika mud bank and the non-mud bank areas south and north of it between Attupuram and Ponnani (Zone: K-6) during a five year period shows an interesting picture (Fig. 2). It reveals the independent nature of the mud banks and the so called mud bank fishery and also gives some insight into the real picture of what is happening in the non–mud bank areas during the south west monsoon seasons. During the 5 year period under consideration there was good mud bank formation at Alleppey (Ambalapuzha–Thottappally) and at Nattika (Nattika–Valapad). The CPUE first of all shows that there was considerable variation in the catch rate from year to year at the mud bank and at the non mud bank areas. Further, it shows that in the years 1974 and 1975 when the fishes landed at Alleppey mud bank was of a higher rate the CPUE at the non mud bank during these years was less. Similarly when the catch rate showed a decline with regard to the landings at the mud bank area the same was of an higher order in the non mud bank areas in 1976 and 1977. The CPUE worked out for the Nattika zone also presented a varying picture in that during the years 1973 and 1974 the catch rate at non mud bank registered higher values than in the mud bank areas. But a reverse trend was observed for the non mud bank and mud bank areas during the years 1975, '76 and '77. Thus a contrasting picture is obtained with regard to the resources availability in the mud bank or in the non mud bank areas and points to the fact that the fishery during the monsoon season is highly variable from place to place and year to year and that the mud bank has no role to play in the availability of the fish stock. Therefore no direct relationship could be attributed between the mud bank formation and the fishing activities inside or in the neighbourhood of the mud bank. Good catches could be made anywhere in the coastal areas, provided fishing is possible. The apparent relationship between the mud bank and the monsoon fishery is brought about by the fact that most of the fish landings of the region in the monsoon takes place at the site of the mud bank due to the calmness of the sea in the region even though fishing is conducted both inside and outside the area.

Changing pattern of fish distribution

The pattern of fish distribution in the coastal grounds during the south west monsoon season has been found to change very frequently, even daily. For example, if prawns dominate the catch on one day, the oil sardine may be the major catch on the next day. On some other days, *Ambassis* sp. only may be present in the fishing grounds. On yet another day, the catch may be of a mixed type. These characteristics are not only found in the mud bank areas but also in other regions along the coast during the monsoon months. This is obviously due to the shoaling behaviour of fishes. As the fishes and prawns move in shoals, a portion may pass through the mud bank area also, and they are caught by the numerous canoes operating in and outside the mud banks. If one such shoal is not caught anywhere on their way, it moves off giving room for another shoal of entirely different composition.

The daily changing pattern of the fish landed at the mud bank area at Alleppey mud bank was studied in July 1971 and the results are given in fig. 3. Of the major

FIG.3. THE CHANGING PATTERN OF FISHERY IN JULY 1971
(BASED ON FISH LANDED AT MUD BANK AREA IN ZONE K-4)

SPECIES / DATE	JULY-1971												
	1	5	13	14	16	17	19	23	25	26	28	29	30
METAPENAEUS DOBSONI	●	+	●	●						●		●	●
PENAEUS INDICUS	+												
SARDINELLA LONGICEPS		●											
LEIOGNATHUS SPP.			+	+	●	●			●				
STOLEPHORUS SPP.							●	●		+		+	
MISCELLANEOUS					+	+	+	+	+		●		+

●MOST ABUNDANT SPECIES +SECOND ABUNDANT SPECIES
* NO DATA AVAILABLE FOR MISSING DATES

species studied for 13 days in the month, *Metapenaeus dobsoni* dominated the catch for 6 days. During these 6 days, the second dominant species were *Penaeus indicus* for one day, while *Leiognathus* spp. and *Stolephorus* spp. were the major catch on three and two days respectively. On one day, the catch was of mixed type without having any predominant species. Some scenes of fishing activities at the Alleppey mud bank are given in Plate 2.

Mud banks and coastal erosion—their impact on coastal economy

The coastal erosion is something which has been existing from time immemorial. During the south west monsoon period, a tendency for eroding the coastal lands exist throughout the west coast except at the mud bank regions. The public become aware of the problem only when there is some loss and damages to the houses and cultivation. In recent years, due to the mounting population pressure towards the inland side, more and more coastal areas are encroached for constructing houses and for cultivation. Therefore, now-a-days, the coastal population are more prone to the hazards of erosion. Plates 3 and 4 show the severity of beach erosion experienced at Chellanum, south of Cochin, Edavanakad and Kuzhupilly, north of Narakkal; Arattupuzha, Kallikad and Thrikkunnapuzha, south of Alleppey. Even though some relationship has been established between the formation of mud banks and coastal erosion, ample evidences are lacking for a positive correlation. The mud bank formation has not been found to increase the intensity of erosion anywhere near to it. On the other hand cases of severe coastal erosion have been observed at places where there were no signs of mud banks. However, both the phenomena are significant when viewed from the point of view of coastal economy.

The high waves striking hard against the coast during the south west monsoon season not only cause damages to the coastal lands but also prevent the fishermen from going out for fishing in a season when fish and prawn shoals appear very near to the coast. It is true that on days of slightly calm weather some fishermen venture to go out and get good catches. But this is an exception rather than a general rule. Hence the south west monsoon period becomes a somewhat closed season as far as indigenous fishing is concerned. Such a condition brings in lot of hardships to the fishermen community, who seldom go for alternative jobs. Thus, they are left entirely to the mercy of the nature for their livelihood.

During the south west monsoon period the only hope for the fishermen community is the mud banks, formed very close to the coast. The mud banks act as safe harbours for launching and landing their canoes and from there the fishermen can go peacefully for hunting fish shoals.

Control of coastal erosion by artificial mud banks

It has been found that wherever there is formation of mud bank, whether due to natural process or artificial means, the contour of the coast line would be maintained, being protected by the calm waters. This quality of the mud bank points to the possibility of using artificially made mud banks as an effective measure against coastal erosion and it will serve the dual purpose of protecting the coastal area and also providing ideal conditions for the operation of fishing crafts during the monsoon periods. However, artificial nourishment of beaches has not yet started in India but will undoubtedly become the most widely used method for shore protection in the near future. There is hardly any place in the world where it is better justified than India because of the heavy population pressure on some highly developed shores of India. Nourishment, then, will have to come mostly from the sea. Along the south west coast of India in the nearshore waters there is a belt of mud of laterite origin. This mud can be effectively used for creating artificial mud banks. Whenever and wherever severe erosion takes place, the mud from the coastal belt can be dredged out and deposited to form a thick layer of loose mud in suspension (thixotropic suspension) very near to the shore. Such a suspension would absorb the wave energy and protect the coastal areas.

Errata: Mar. Fish. Infor. Serv. T & E Ser. No. 16, 1980. Page 1, column 2, Paragraph 3, Line 12. Rs. 1.17 crores instead of $1.17 crores.

PLATE I

Fig. 1. Subterranean mud is the cause for the Alleppey mud bank. A mud cone found on the beach at Kakkazham near Ambalapuzha.

Fig. 2. Several mud cones noticed on the beach and at intertidal zone at Kakkazham.

Fig. 3. A coconut tree stump planted by fishermen in a mud cone to ward off people from plunging into it.

Fig. 4. Solid mud pellets were also thrown out by the mud cones at Kakkazham beach—pieces of mud pellets washed ashore.

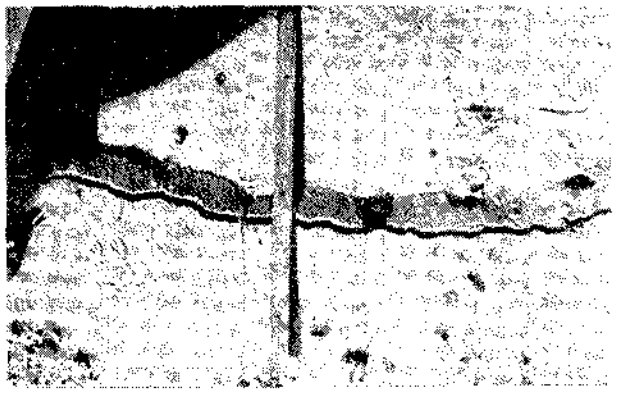

Fig. 5. Crack on the beach formed due to ejection of subterranean mud which result in land subsidence at Kakkazham.

Fig. 6. Knee-deep mud even on the shore – a scene on the beach at Puthuvypeen. The rope line in the figure is used to drag canoes towards the shore through the mud.

PLATE II

Fig. 1. Hectic fishing and fish landing operations putting on a festive appearance.

Fig. 4. A rain of prawns that reign the market—a scene at Purakkad.

Fig. 2. The fishing net *(Thangavala)* is being carried to the canoe.

Fig. 5. When heavy catches are landed, a part goes for sun-drying.

Fig. 3. Canoe full of oil sardines landed at Adakathubail mud bank at Kasargod.

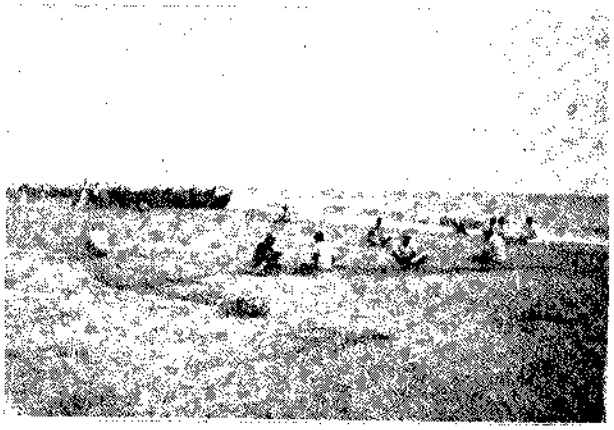

Fig. 6. Not free in the afternoon—The fishermen mend their nets everyday for maximum efficiency.

PLATE III

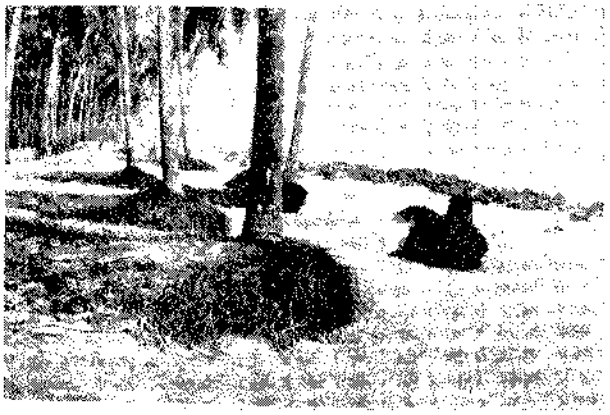

Fig. 1. Uprooted coconut trees at Chellanum due to coastal erosion.

Fig. 2. Sea walls are not enough to prevent the fierce waves.

Fig. 3. A light feed to the hungry waves—sand dunes made by the coastal inhabitants.

Fig. 4. A temporary protection—heaps of sand bags piled at heavily eroded area at Edavanakkad near Narakkal.

Fig. 5. The sand bags piled up have been shattered by the huge waves at many places at Edavanakkad.

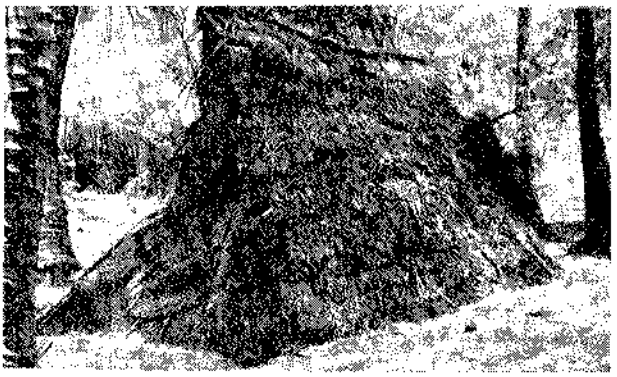

Fig. 6. A cruel joke of the high waves—one of the many huts destroyed at Kuzhuppilly near Narakkal.

Fig. 1. The last resort—The falling coconut trees are supported by ropes and cables. A scene at Kallikadu near Arattupuzha.

Fig. 2. A scene of shattered sea wall at Thrikkunnapuzha.

Fig. 3. Another scene of coastal erosion at Thrikkunnapuzha.

Fig. 4. Was a motorable road! This road at Arattupuzha was eroded at several places.

Fig. 5. Coming over the barrier—a weak sea wall at Arattupuzha.

Fig. 6. Got engulfed—vast areas of land have gone under water at Arattupuzha.