Natural Hazard Research

HUMAN ADJUSTMENT TO CYCLONE HAZARDS
A CASE STUDY OF CHAR JABBAR

by

M. Aminul Islam
Department of Geography
University of Dacca
Dacca-2, East Pakistan
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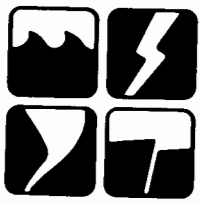

Working Paper #18

PREFACE

This paper is one in a series on research in progress in the field of human adjustments to natural hazards. It is intended that these papers will be used as working documents by the group of scholars directly involved in hazard research as well as inform a larger circle of interested persons. The series is now being supported mainly from funds granted by the U.S. National Science Foundation to the University of Colorado, Clark University and the University of Toronto.

Further information about the research program is available from the following:

Gilbert F. White
Institute of Behavioral Science
University of Colorado
Boulder, Colorado 80302,
U.S.A.

Robert W. Kates
Graduate School of Geography
Clark University
Worcester, Mass. 01610,
U.S.A.

Ian Burton
Department of Geography
University of Toronto
Toronto 181, Ontario
Canada

Requests for copies of these papers and correspondence relating directly thereto should be addressed to Toronto.

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1. INTRODUCTION

Char Jabbar is situated at the mouth of the delta of the Ganges-Brahmaputra-Meghna rivers almost in the northern end of the Bay of Bengal some 16 miles away from the Noakhali mainland in East Pakistan (Fig. 1). A comparatively flat land, being exposed to the sea, the island has been subjected to a set of natural hazards posed by the onshore movement of wind and water generated by the energy component of atmosphere and ocean.

With the rising toll of storm damages and annual coastal flooding, public pressure has increased for better protection, relief and insurance against waves and associated wind damages. Expensive protective measures are being encouraged to the neglect of possible alternatives. It is imperative that before taking final action the relation that exists between man and the hazardous aspects of the natural environment as applied to this area be understood. The purpose of this paper is to study the processes which have led to the present pattern of occupance subject to coastal flooding. Its special concern is to study the degree to which these hazards are recognized by those who live adjacent to the shore, and the range of adjustments which have been practised or which might be practised in dealing with the cyclone flooding problem.

Study Design

In order to arrive at the desired objectives an attempt was made to get a sufficient number of interviews to cover a wide range of hazard perception - if any - and modes of adjustment to be found at the study site.

Thus, over two hundred interviews were taken from a variety of coastal dwellers in Char Jabbar, the study site. Of this, 139 interviews were made with the owners of permanent residences who belonged to different walks of life which included farmers, shop keepers or owners of tea shops, labourers and public servants. For this study, the 139 interviews will be considered as a group of characteristic users of the coastal land at the study site.

The study itself is divided into five major sections. The first of these, treated in section II, deals with the personality of the area in terms of socio-economic, morphology and hazard characteristics, while section III is devoted to a discussion of the perception of storm hazard as noted in the area. In section IV an account of the human adjustment to coastal flooding is given. Section V deals with the choice of adjustment in the public sector; finally, in section VI the results obtained in the study are summarized.

II. STUDY SITE: CHAR JABBAR

Geographic and Socio-economic Characteristics. Agriculture is basic to the economy of the area. Homogeneity in occupation is another outstanding characteristic of the population. Information gathered during survey of the area revealed that approximately 90 per cent of population in the adult group are agriculturists, 5 per cent are in business and the rest are in such occupations as fishing. But many of the fishermen are part-time farmers. In addition, a large number of farmers are either share croppers or employed as labourers on others' land. Moreover, there is also a sizeable group of landless labourers. Industry being totally absent, this is an island community depending entirely on the land for its survival.

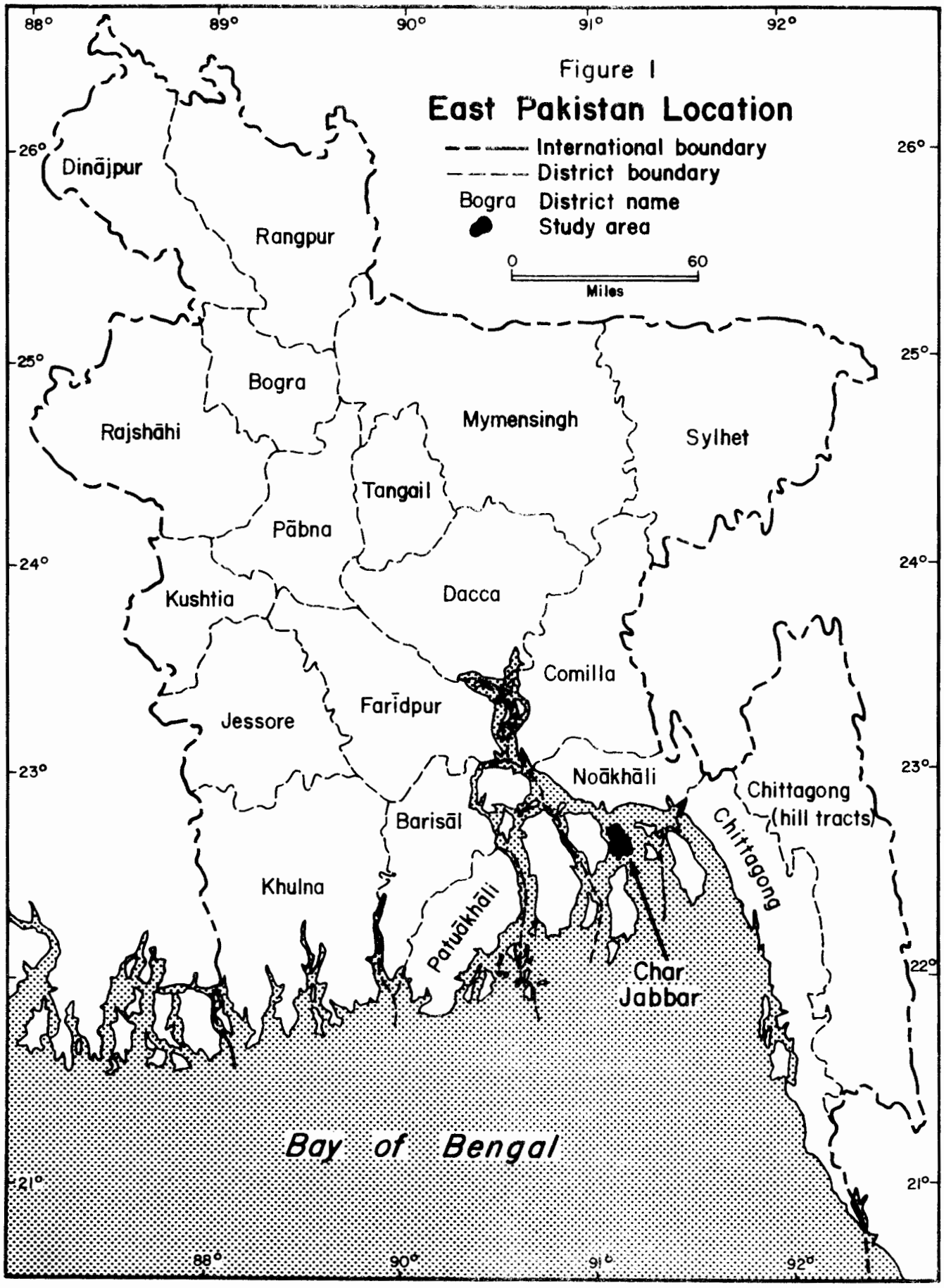


Figure 1
East Pakistan Location
International boundary
District boundary
Bogra District name
Study area
0
60
Miles
88°
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°
Dinājpur
Rangpur
Bogra
Rajshāhi
Mymensingh
Sylhet
Tangail
Pābna
Kushtia
Dacca
Comilla
Jessore
Farīdpur
Noākhāli
Chittagong (hill tracts)
Barisāl
Chittagong
Khulna
Patuākhāli
Char Jabbar
Bay of Bengal

The choice for a variety of crop cultivation in Char Jabbar is practically limited. The frequent flooding of areas by saline water is a major handicap. Only after the monsoon rain in June, when the salt content is somewhat washed out from the soil is it possible to cultivate transplant aman paddy. Thus, in the absence of a widespread cultivation of cash crops, major income is derived from the cultivation of a subsistence crop, namely aman paddy which occupies almost 95 per cent of the total cultivated area. In addition, cultivation on uneconomic holdings which are being subdivided and gradually fragmented owing to 'Laws of Inheritance', reduces the income of the peasants to a bare minimum. The variation with regard to income level between farmers is thus small.

Although the population density of Char Jabbar is much lower than that of the mainland, the area has not always been a self-supporting unit. Recent data on the area and population are not available. One estimation puts it around 18,000 population with a corresponding density of about 400 persons per square mile, by the end of June 1970. On the whole, the rate of increase of population in Char Jabbar is higher than the rate of increase for the province of East Pakistan as a whole.

A key to the process of adjustment is the general educational level. Approximately 11 per cent of the total population according to 1961 census were classified as literates.[1] With an estimated total population of 18,000 (1969-70), there are only 6 primary schools (up to Class V) and of them only one is being upgraded. The total number of students is estimated to be 1200. There are a number of College students who are not resident in the area. Though the last census was taken in 1961, there can be little doubt that the general economic pattern of life in the area has changed considerably during the past 9 years.

It has been estimated that over 15 per cent of the population are in the age group of 40 or over; 25 per cent in the age group between 25 to 40; 30 per cent between 15 to 25 and another 30 per cent below 15 years. In the above estimate about one thousand persons who are working elsewhere have not been included. Thus the working age group is large by any standard. But there has been a large number of people in-migrating from the adjoining islands, particularly Sandwip and Ramgati causing a further pressure on the land in Char Jabbar. On an average the number of in-migrants has been around 500 per year. Such rapid inflow of population from adjoining islands may create a higher damage potential in the area under study which, as stated here, has witnessed some of the most destructive cyclones in the past. The element of hazard has also been increased recently by a combination of natural and cultural processes. That is why an attempt has been made to study some of the morphological changes that have taken place in the study area.

Morphological Changes. A former island, Char Jabbar which was formed by the annual flooding of the Ganges-Brahmaputra-Meghna rivers is now linked with the Noakhali mainland through the Meghna Cross Dam No.2 built by the East Pakistan Water and Power Development Authority (EPWAPDA) in 1964. Relatively rapid changes in land forms due to erosion and sedimentation have occurred in nearby areas including the island of Char Jabbar. Physical evidence of changing conditions is apparent in eroding river banks; areas of new deposition and consequent changes in land forms are also present.

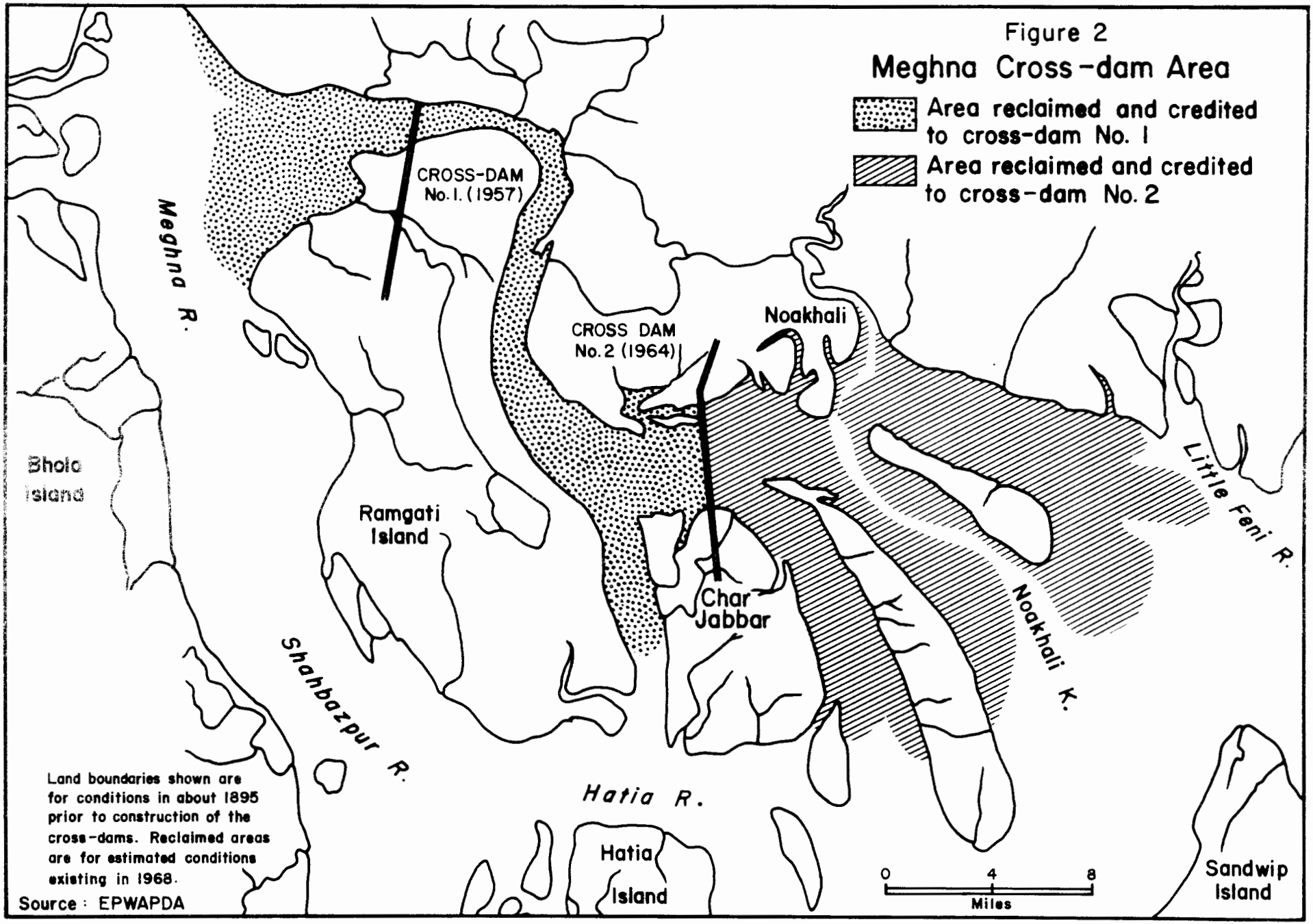


Figure 2
Meghna Cross-dam Area
Area reclaimed and credited to cross-dam No. 1
Area reclaimed and credited to cross-dam No. 2
CROSS-DAM No. 1. (1957)
CROSS DAM No. 2 (1964)
Meghna R.
Noakhali
Bhola Island
Ramgati Island
Char Jabbar
Little Feni R.
Noakhali K.
Shahbazpur R.
Hatia R.
Hatia Island
Sandwip Island
0 4 8
Miles
Land boundaries shown are for conditions in about 1895 prior to construction of the cross-dams. Reclaimed areas are for estimated conditions existing in 1968.
Source : EPWAPDA

The process of land building and erosion is very pronounced in the delta area and the speed at which some of these drastic land changes are occurring is extremely fascinating. New lands, or chars as they are called locally, can be formed overnight while some coastlines are estimated to be receding at rates of up to 800 ft. per year.[2] However, delta building which is a continuous natural process as seen in the area has been substantially altered by human interruption. Thus, owing to both natural and cultural processes as mentioned above, further morphological changes are brought about with regard to Char Jabbar which lies in the Meghna Cross Dam Area (Fig. 2). A separate discussion with regard to Meghna Cross Dam Area is needed because of the extensive land form changes and the role played by embankments and other projects there.

Meghna Cross Dam Area. Ramgati, which used to be an island and is shown as such in almost all maps, is presently a part of the Noakhali mainland owing to the construction in 1957 of a 7 mile long earthen embankment across one of the main channels of the Meghna which prior to the construction of the cross dam was showing trends of gradual siltation. Being diverted to the west, the main current of the Meghna now passes through the Shahbazpur River, flowing in between Noakhali and Barisal districts.[3] The Cross Dam permitted the connection of Laksmipur and Ramgati thanas by road and created a new land area of more than 80 square miles (over 500,000 acres). Nearly all of this area is presently under cultivation and new settlements have sprung up (Fig. 3). But the westward flow of the current has caused active erosion on the northeastern coast of Bhola Island, the southern part of Ramgati Island and the northern parts of Hatia and Sandwip Islands (Fig. 4). At the same time, sedimentation has occurred between Bhola and Hatiya Islands. The rivers around these islands, it may be stated here, are practically parts of the sea.

As can be seen from Fig. 3, there was another channel to the east of Ramgati known as 'Baggar Dona' which used to pass to the north of Char Jabbar and separated at one time the island from the mainland. As a result of the completion of the Meghna Cross Dam No.2 which was constructed in 1964 in conjunction with the Coastal Embankment Project, the river Meghna has receded further to the south. As a result of further siltation and the effect of the Cross Dam No.2 throughout the eastern portion, a new land area of about 120 square miles has been reclaimed. In addition, the Noakhali mainland, particularly the Shudharam thana, has now been joined with the Ramgati thana which as mentioned earlier was an island even only a few years back. Thereby, a new damage potential is also being created at an accelerating rate by occupance of coastal areas subject to high winds, wave action and salt water flooding associated with storms.

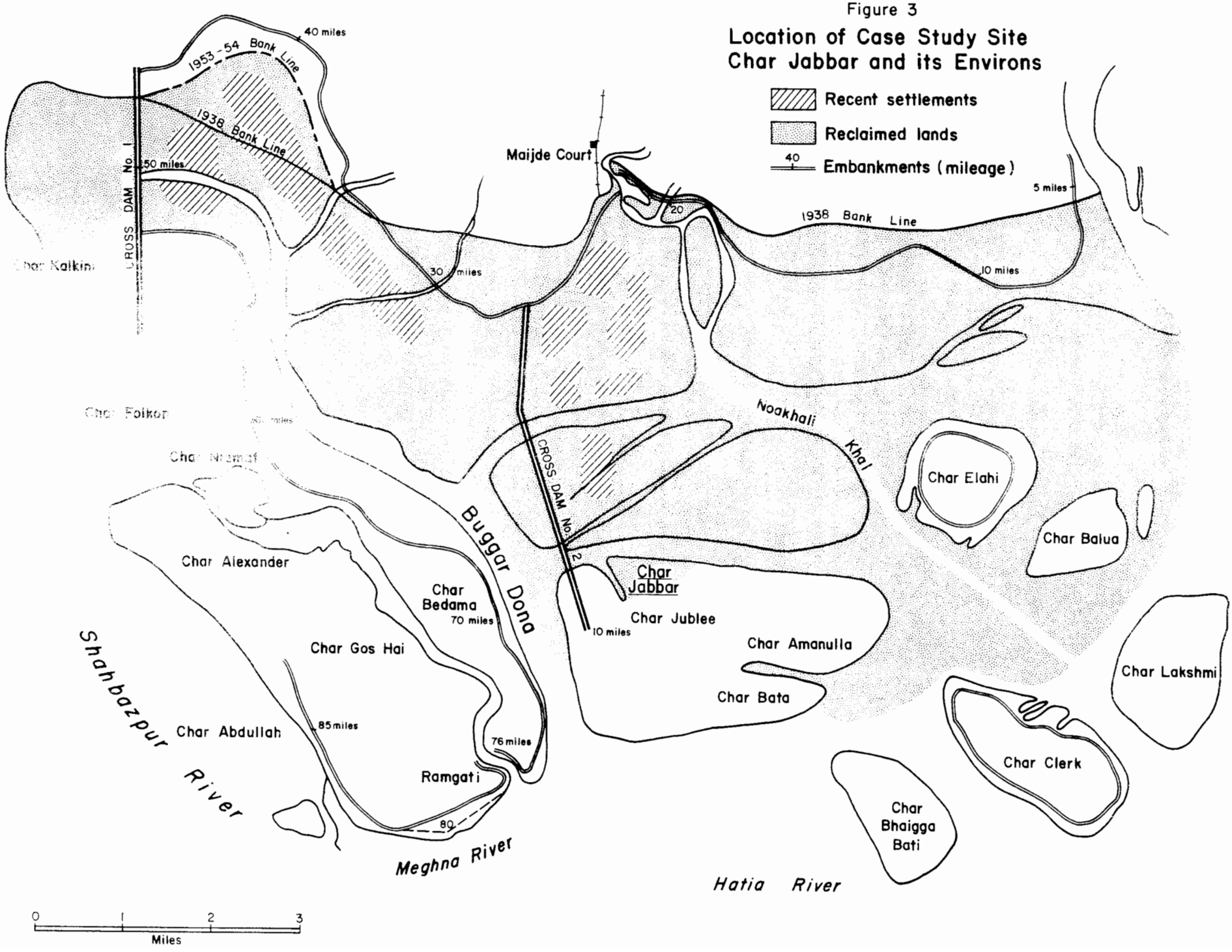
Flood Hazard

CharJabbar has a high degree of hazard from coastal flooding. This stems not only from occurrences of storms but also from tidal bore, a phenomenon quite common in the north-eastern portion of the Bay of Bengal south of the district of Noakhali.

With regard to normal inundation, a record flood of approximately 9 ft. above the ground level has been estimated from field interviews. The high water level elevation has been seen almost reaching the crest level of the Cross Dam No.2 which is at R.L. 22.0 P.W.D. Since no part of the island reaches this height, the area is covered with storm water from time to time. In the cyclone of 1960 practically the whole area was inundated by water and high waves.

Figure 3

Location of Case Study Site Char Jabbar and its Environs



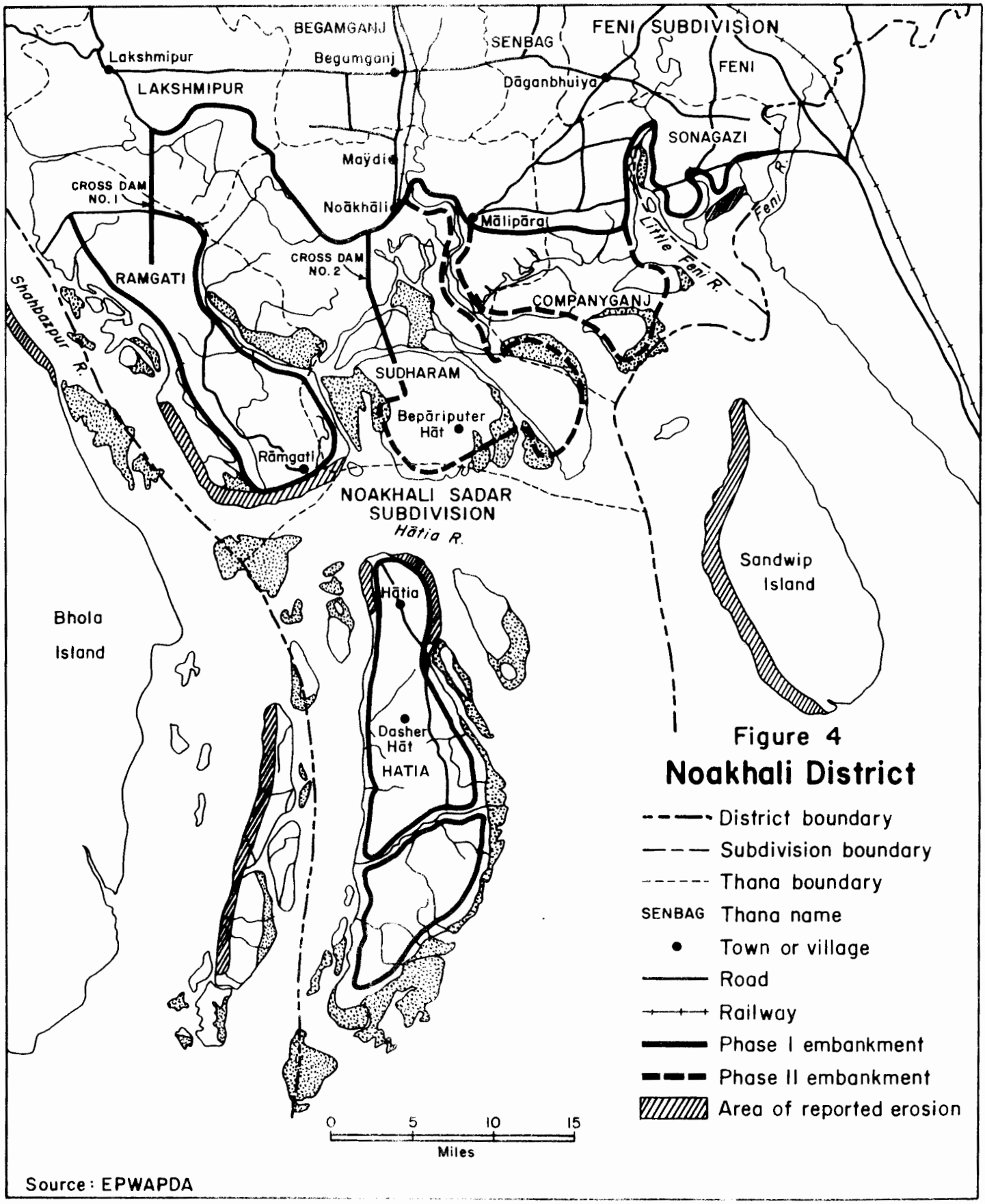


Figure 4

Noakhali District

- District boundary
- Subdivision boundary
- Thana boundary
- SENBAG Thana name
- Town or village
- Road
- Railway
- Phase I embankment
- Phase II embankment
- Area of reported erosion

The actual storm frequency cannot be ascertained for the area under study. However, heavy damage has resulted from severe cyclones in the recent past. Though their intensity is very variable, only the most severe cyclones produce storm surges which have been responsible for widespread loss of life and damage to property.

With the exception of a few cases, most of the damages to this area have been from cyclones in the month of October which happens to coincide with the harvesting season of aman paddy.

It is estimated that about 12 per cent of the severe cyclones produce storm surges.[4] Historical data on surge heights vary considerably. They range between 10 to 45 feet above normal tide level.[5] Storm surges for recent cyclones have been noted to be some 10 to 20 ft. in height. Cyclonic storm surges of 15 to 25 ft. can also be expected.

Tide water levels. Considerable damage is also attributed to the occurrence of tides alone. The normal inundation has been estimated to be about 4 ft. during the months of July, August and September. Normal tide range in the area under study is approximately 11 ft.[6]

The range of tides varies with the season and depends on the prevailing winds. The tide level of the sea is always increased by storm in the sea. The amount of extra rise depends on the intensity (velocity) of the storm and the direction of the wind at a particular place. Moreover, in the Bay of Bengal the cyclonic wind comes from the sea towards the land. The tendency, therefore, is to drive the sea water towards the land.

The highest water level particularly in Char Jabbar occurs in August when there is enormous flood water flow from the land towards the sea, and is about 16 ft., the lowest being about 10 ft.[7] The mean high water level elevation appears to be + 9 ft. PWD Datum.[8] In exceptional cases the water level elevation has been reported to be about 18 to 20 ft. from the m.s.l.

This occurs usually in the month of August-September. The water level was seen to rise almost near the top of Cross Dam No.2 by the field party. However, the mean annual maximum high water level elevation has been estimated to be + 14 ft. PWD Datum.[9]

The lowest level occurs in March when the water level elevation has been found to attain 4 ft., maximum being 8-9 ft.[10] But in exceptional cases, particularly at full and new moon, the water level elevation in March has been reported to be about 13-14 ft. The mean low water level elevation and the mean annual minimum low water level elevation appear to be 0 to -1 and -2 ft. respectively PWD Datum.[11]

It has been found that the tide level which exceeds the monsoon high tide level is generally caused by a wind speed of about 100 m.p.h. This was more or less the speed of the cyclone of 10th October 1960 and 9th May 1961. The result was that tidal surges caused saline flooding of paddy fields and made them unfit for cultivation for several years and contaminated the tanks with saline water. It might be mentioned here that the storm surge on the 31st October 1960 occurred when the sea was at its low tide. The surge height was estimated to be around 23-24 ft.[12] Had the storm surge taken place at high tide, the catastrophe would have been unimaginable. Of course, the point is debatable whether at a high tide condition the storm would have lifted the sea-water to the same height above the tide level; because a greater volume of water would have prevented the lifting capacity of the storm and probably it would have considerably decreased its force.[13]

The phenomenon of tidal bore has also been causing widespread damage in the study area. Tidal bore has been found to be occurring immediately after low water at rising tide, but does not exist under all

tidal conditions. It is most common and of greatest magnitude during spring tides, especially in March, April, September and October. The vertical rise of water like a wall, sometimes as high as 10 ft. moves across the Bay and upstream into the river channels with a roar causing localized erosion and adding further hazard to already inundated coastal area.

The figures referred to above bring out the exposed nature of the coast and vulnerability to salt flooding even during the dry months. This is a major factor which considerably hampers agricultural production.

Losses and Damages

In the absence of published data on Union level, estimates of the extent and value of damages caused so far in Char Jabbar are extremely difficult to make. Nor is it possible to estimate the average annual damages due to tidal flooding. Likewise, it is not possible to estimate the damage on a Union level with reference to the recurrence of a single large storm like that of 1960 cyclone, when the entire island was subjected to severe inundation and property damage in addition to loss of human lives was very high. A rough measure of the houses damaged in Char Jabbar by the cyclones of 10 October 1960 and 31 October 1960 can be had from the Census Reports of Pakistan 1951 and 1961. The number of houses listed in 1951 Census Report was 4,610; while in 1961 Census Report the number of houses shown was 2,338.[14] The reduced number of houses in 1961 is yet another example of the damage caused in 1960 cyclones. Though accurate estimates with regard to damages to various sectors of the economy are lacking, some statistics are available in the published District-wide data.[15]

III. PERCEPTION OF STORM HAZARD

Before attempting to look into the processes of choice employed by both public and private sectors, it is necessary to examine people's perception of storm hazard. The choices stem necessarily from a perception of danger as well as a knowledge of available means to reduce the hazard.

Respondents' Perception of Storm Hazard

Respondents interviewed revealed an extremely high awareness of past experience. As a matter of fact, all of the adults in the area had experienced major storms like the two cyclones of October 1960. Despite the fact that most of the respondents experienced storms more than once, only about 47 per cent of them expect storms in future. About 82 per cent of the respondents who experienced damage in the last two storms expect damage in the future. Apparently the link between awareness of the past and expectation of future events is complex.

It is interesting to note here that although 47 per cent of the respondents expect storms in future, 49 per cent were uncertain with regard to possibilities of future storms and damages. Of these nearly all attribute control of natural phenomena to 'God's will'. Only a few respondents were willing to acknowledge a repetitive pattern of storms. A small per cent described storms as either increasing or decreasing in frequency or in intensity. In short, a large number of respondents view storms as 'God's will'.

These interpretations do not answer the question as to why people continue to live in areas subject to natural hazards. Nearly 85 per cent of the respondents have no plans to leave the area despite their past experience with hazards. Not only was the area the birth place of most respondents, but owing to scarcity of land and inadequate employment opportunities elsewhere they have no freedom of movement from the area.

IV. HUMAN ADJUSTMENTS TO COASTAL FLOODING

In the course of long habitation in the island many adjustments to the hazards of coastal flooding have evolved. The way of life and adjustment to the coastal hazard is influenced by tradition, orthodox ideas, beliefs and attitudes. The fact that nearly three-fourths of the respondents did not show willingness to go somewhere else for subsistence is enough to explain their indifference to hazard despite their recognition of it. Even when a violent storm seems to be approaching the area, many follow a 'wait and see' policy. This is a major reason for suggesting a set of adjustments which are primitive and rudimentary in nature. The idea that man has nothing to do with nature reveals the attitude of the majority of the people with regard to decision making. Besides, optimism is another factor which plays a great role in decision making. The entire range of adjustments against coastal hazards should be viewed with this general background in mind.

The adjustments could be divided in general into two broad categories, namely (a) a variety of adjustments requiring prior preparation, and (b) emergency adjustments without prior preparation.

Adjustments Requiring Prior Preparation

This comprises measures taken by the people which are somewhat permanent in nature and sometimes are incorporated into original construction or in the course of replacement of damaged structures. The somewhat permanent nature of these adjustments, which sometimes involve minor construction, also demands that they should be done prior to the occurrence of the hazards. However, approximately one-fifth of the respondents surveyed in the study area undertook one or more of the following adjustments.

A. Construction of 'machan' or raised platforms. The construction of 'machan' is the most common type of adjustment found to be prevalent in the area. These are of bamboo or bamboo matted raised platforms of various sizes constructed in the house and supported by four to six bamboo poles. The platforms lie generally three to four feet above the floor and are erected roughly parallel to the ground. Although bamboo is the chief material for building 'machan', sometimes pieces of wood are also used. 'Machans' serve a dual purpose, affording a shelter to persons and domestic animals, and protecting the property from destruction. Not many people can afford to have 'machans' in their houses because of the construction cost involved and the lack of materials available locally. However, 'machans' appear to be somewhat useful during the abnormal tidal inundation although they generally cannot withstand storm surges. They serve to store the useful household belongings when the water level rises high enough to inundate the room. On the other hand during the time of exceptional flooding the people themselves, children in particular, are forced to take shelter on them. Poultry birds and other domestic animals are given shelter on the 'machans' occasionally when flooding affects the area.

B. Hay-loft or attic. Besides the 'machans' sometimes overhead platforms similar to hayloft or attic are also erected. Such structures that lie just below the roof and hang overhead like ceilings are also made of bamboo. They serve more or less the same purpose as the 'machans' but are useful for storing various types of articles including specially prepared bamboo poles to be used for providing a necessary support to the house and roof during the cyclones

C. Supporting the house with bamboo poles. This is one of the common types of adjustment adopted particularly after a cyclone warning is given. Bamboo poles as mentioned above which are usually kept ready by some individuals in the house are placed on the ground diagonally with the upper end touching

the sidewalls of the house. Such poles are generally placed all around the house or on the side opposite to the direction from which the cyclone is expected. This measure is adopted with the hope that the supporting poles would prevent the house from being blown away or washed out by storm surges.

D. Planting trees around the homestead. Everyone interviewed practised this type of adjustment. The planting is done so densely that in most cases they completely conceal the houses. From outside they look like scattered growth of vegetation and it can hardly be assumed that there are houses inside the thickets. These trees contribute regularly to the increase of the family income as well. Besides, the privacy of the house is also afforded including the womenfolk who observe 'purdah'.

During the cyclones these trees afford very good protection except, of course, when in rare cases trees are knocked down by the storm, causing damage to the houses. Even then the first onslaught of the storm is faced by these trees, thereby protecting the houses and preventing their damage to a great extent. This type of adjustment can only be found in the 'chars' of the oldest formation which present much the same appearance as the main land. But in the new 'char' areas the recurring intrusion of saline water during the growing period of the trees, makes this form of adjustment difficult. If the trees survive at all, they take a considerable amount of time to reach maturity. Houses, therefore, lay bare and exposed to the hazard.

E. Structural change. One of the most important permanent adjustments to flood hazard is the design and construction of the structure to minimize damage or the elevation of the site above the tide water elevation.
The interview data reveal that about one-fourth of the respondents adopt this kind of adjustment. These fall mainly into the following categories.

i) Elevation of the plinth or the courtyard. The striking feature of the household unit is its elevation a few feet above the normal tide level or at least built over a high plinth which is higher than the surrounding area. Elevation of houses has necessitated digging up of earth from nearby places adjacent to the houses and these in turn have been converted into ponds or tanks, mostly rainfed, which are used for a variety of purposes including washing and drinking as well. The height of the platforms is usually decided by the person's past experience and his means. The raising of the house as an adjustment to common tidal flooding is, thus, very widespread.

ii) Anchorage devices. Anchorage devices, the support of the very deep wooden frame from the ground to the roof, usually provide a strong foundation to the house. Invariably, the wooden frames go much deeper in the ground, a practice which is very common in this area.

iii) Construction of special type of roofs. The construction of a special type of roof for the house is also a way of providing protection against storms. In order that the wind cannot have severe effect on the house, many people build the roofs in a particular way. The roofs, usually made of thatch and sometimes of tin (C.I. sheets), are very low and remain only about 3 or 4 feet above the ground on the side from which the wind is most likely to hit the house. The thatched roof is generally considered to be economic and is preferable to tin (C.I. sheets). Not many people can afford to have tin roofs. At any rate, thatch being not very costly, the cost of rebuilding the roof can be kept within economic means.

F. Keeping ready made materials at hand. Other peculiar measures which the coastal dwellers adopt in times of emergency consist of simple life buoys of banana trees or bamboo and banana and rope which are kept ready within their tree-surrounded compounds. The purpose behind this is

that if the storm surge takes menacing proportions and washes away the house, the people at least will be in a position to save their lives with the help of the raft either made of bamboo or banana. This kind of emergency action requires cutting nearby banana trees even at the eleventh hour.

Some people also keep big pitchers in their house and when the water level rises they take the important utensils and other valuable materials inside the pitcher and try to remain afloat. Normally with an earthen pot one can remain afloat for a long time. Although some prior preparation is required for them, both of these are in fact emergency measures and adopted only when other adjustments fail.

G. Tying the house with ropes. This is a device for preventing the house from being blown away or washed away by storm surges. When warning is received about the occurrence of the cyclone or they themselves can realize that a cyclone may strike soon, many people, as an emergency measure, tie their houses, particularly the roofs, to some nearby trees or poles with strong ropes which are previously kept ready for this purpose. In many cases the practice of tying the sidewalls along the roof with strong ropes as a kind of land anchor also exists.

H. Construction of 'Killa". 'Killas' are a kind or raised structure which are built for providing shelter to the domestic animals, particularly cattle, goats, sheep and buffaloes during tidal inundation. This kind of structure involves the raising of land in an area varying on average from 500 to 800 square feet or more to a considerable height of 10 to 15 feet from the ground (usually a few feet above the high tide level) and then over it, the erection of a bamboo shed with thatched roofing. There is also a bamboo fence around the sides of a 'Killa' and on one side there is an entrance which allows the animals to come up. An interesting

characteristic of the 'Killas' is that they are generally made higher and steeper in the south and lower in the north. A second characteristic is that the bamboo sheds are erected in the higher or the southern end.

The 'Killas' are usually located in the new 'Char' areas where there is no mature vegetation though there is sufficient growth for grazing. Just before the normal high tides when the grazing lands go under water, animals are brought inside the 'Killa' where they are kept confined until the tidal water subsides. With the receding of the tidal water animals are brought down and allowed to graze freely once again. Though 'Killas' are meant for housing and protection of animals, one or two attendants usually live in these structures temporarily. 'Killas' have also been found to be used by people during the storms, but for human adjustment against storm surges they are not ideal as they remain in the hazard zone on the one hand and away from the village on the other.

Unlike 'Killas' another type of structure for keeping animals known as 'Tong' - not very common in the study site - is supported by bamboo structures, sometimes by wooden pieces as well which help the water run through. Since the construction of both the structures is expensive, their distribution is scattered and found mostly in isolation.

Emergency Adjustments Without Prior Preparation.

Adjustments of this type consist of measures which are adopted only during the time of emergency when the wind or surge of water become unusually threatening. These do not involve any new construction and thereby any expenditure as such, and they are resorted to only when the first set of adjustments fail, or when no other alternative remains. Most emergency actions that may have been taken in response to a great danger signal involve little or no prior preparation. These include the

removal of life and property from the path of the water or taking protective action to minimize damages from actual inundation. It was not surprising to find that some of the common actions cited by the respondents consisted of getting out from the path of the danger and doing nothing with regard to damage reduction measures. This is due to lack of both time and helping hands, and transport in addition to communication system[a] to plan for the evacuation, elevation or removal of their furnishings. Thus emergency measures undertaken then are rudimentary, improvised and primitive - at times.

A. Safety of household materials. When it is felt that it is no longer safe to remain inside the house, hectic activity follows with regard to taking care of the household materials: (a) Household articles considered to be useful are either placed upon the elevated platform just below the roof or are bound together and thrown into the shallow pond with the hope of retrieving them later if they survive at all. (b) More valuable goods including jewellery are wrapped either with a paper or pieces of cloth and put inside the earthen kitchen oven. (c) A great majority of the respondents put valuable materials under the floor of the house or other places at a depth of 3 or 4 ft. and hope that they would be safe from inundation and also would be easy to get back.

B. Personal safety. When the water rises to an unusually high level people climb on top of their thatched roof and at other times cut its binding, thereby converting it into a raft on which they can remain afloat.
In the past many were actually saved from drowning when they were washed away but saved by the surrounding trees of the homestead. Another measure is to climb a high tree and stay there clinging to the branches until the menace is over. In such cases they have to bind themselves to the tree with a rope or cloth lest they are washed away by the onrush of water. The date palm tree is preferred since it is strong and affords a good support.

For safety of the women folk and children a peculiar measure is adopted which includes tying up of available wooden cots and other floating materials to a nearby tree with a strong rope and placing women and children on the raft-like structure. The measure is considered safe because they expect that with the rise of the water level the raft also will continue to rise. In rare cases, people make a kind of ladder with locally available materials and tie it to the tree strongly for a possible means of remaining above the water level.

Other uncommon measures which deserve attention are keeping windows and doors open to permit the water to pass through. The most common concern which has been reported by the respondents is with the safe preservation of match boxes. Many would wrap them with paper or put them inside a container which is then wrapped in many layers of cloth. At times people have been found carrying them on top of their heads.

C. Safety of the animals. At such times when it appears impossible to provide safe shelters for the cattle and other animals, many people set their cattle free so that they may flee the calamity and find their own shelter. In most cases the cattle die, but if fortunately they do survive, their owners try to find them and bring them back.

V. CHOICE OF ADJUSTMENT FOR THE PUBLIC SECTOR

The public choice in the context of recurring storm damages consists of improved warning systems, emergency actions which include evacuation of affected people to safer places, administration of relief to victims, protective works and possible direction to future land use.

Just after the cyclone which ravaged the study site twice in the same month in the year 1960 the Government of East Pakistan adopted a very elaborate and extensive plan for remedial as well as preventive measures. This is embodied in "Long Term Rehabilitation Programme for the Cyclone Affected Areas in East Pakistan." Detailed instructions for dealing with the cases of distress caused by natural calamities are contained in the Famine Code and the Famine Manual. Further instructions for dealing with situations arising out of cyclones have been laid down in the "Emergency Standing Orders for Cyclones" and "Emergency Standing Orders for Relief", published respectively in 1961 and 1962. Suggestions with regard to the reconstruction of the cyclone affected areas in the form of "Special Programme of Action and Basic Reconstruction Programme" are also contained in the report of the "East Pakistan Housing Programme: Preliminary Suggestions for the Reconstruction of the Cyclone Affected Area".

In all these reports lengthy discussions are provided on damage-reduction adjustments such as warning and emergency actions, zoning and building codes, afforestation, protective embankments, shore protection and the reconstruction of the cyclone affected areas. Below is a discussion on each of these actions as they relate to Char Jabbar.

Warnings and Emergency Actions. Though a spectacular improvement has been made with regard to meteorological network and dissemination of meteorological warnings as such, there still remains the problem of the warning reaching each village in time, not to speak of each house in a village, after it has reached its destination by radio, W/T, R/T or telegrams.

The interview data suggest that two-fifths of the respondents did not get timely warning; about 17 per cent got warning through indirect sources.

Because many of the addresses are located miles from the nearest Telegraph Office or Telecommunication centre and messengers, either 'chowkiders' or 'ansars' have to cover the distance on foot to get to the destination, the dissemination of the message is understandably delayed. It may be mentioned here that in Char Jabbar there is no Telegraph Office and the area is about 16 miles away from the nearest Telegraph Office. It is, however, possible from the interview data to derive a rough measure of aggregate responsiveness to the warning network and participation in emergency actions.

From the respondents at Char Jabbar it was found that more than two-fifths adopted some form of minimal emergency actions involving temporary removal, elevation and securing of property. Emergency actions that require the advance stock piling of special materials, such as bamboo poles, ropes of considerable strength, pieces of wood and trunks of banana trees, were not very widespread despite the fact that everybody interviewed had prior knowledge of the possible extent and magnitude of the hazard from storms and storm surges.

About two-thirds of the respondents indicated that loss bearing could be substantially reduced should a warning be available at least seven to eight hours ahead. Within this time period a variety of emergency adjustments could be evolved depending on the respondents' place of work and location of his home.

Discussions with local inhabitants revealed that, thanks to transistors which are to be found in some rural villages these days, the problems of getting warning has, to a limited extent, been solved. Cooperation among the local inhabitants helps spread the warning as far as possible. But the critical time is the period between 11.30 P.M. to 6.30 A.M. when the radio transmission remains off.

Evacuation. For cyclones of lesser intensity, for example for a wind velocity less than 75 m.p.h., there is very little to do except stay indoors and take emergency actions relating to elevation, removal and securing of property as far as possible. The removal of people to safer places like community shelters or other enlisted buildings, particularly after the danger warning signal, has been the major public concern. The community shelters, built in each Union, are two storied buildings which stand at least six feet above the ground level. Designed to withstand the wind velocity of approximately 100 m.p.h. the community shelters have been provided with necessary space to accommodate nearly 500 people. The large tank nearby which has been specially dug for drinking purposes stores mainly the rain water.

Though removal of people to safer places is a major public concern, this form of adjustment has not been very widespread despite the fact that a great majority of the respondents' main concern was to 'get out' as far as practicable. It was found from the interview data that nearly 10 per cent of the respondents take minimum emergency action involving personal safety. Another 4 per cent indicated their choice to 'get out' of the hazard zone but were not sure about their destination. The majority of the respondents was of the opinion that there is a practical limitation for accommodating a large number of persons in the community shelter with arrangements for food and sanitation.

Other reasons for respondents' indifference to community shelter stem from the very attitude and tradition of the local people. For women folk to walk in public a long distance is not regarded as desirable under any circumstances. In addition, people prefer to take shelter with known persons or relatives. Finally, serious limitations to the

development of a large-scale evacuation programme in the hazard zones are imposed by the lack of an adequate communication system.

Besides, preparation prior to evacuation to enlisted buildings without panic would require several hours. Considering local difficulties, a conservative estimate puts the time required for preparations and evacuation at about 5 to 10 hours.

Emergency Action - Relief. Available evidence suggests that it is the after-effects of storms that take more menacing proportions in causing more deaths and damages to property as compared to the period of storm occurrence. Some of the public actions designed to improve the hazard situation need to be reviewed.

Tubewells and Reservoirs. The most urgent problem to be attended to after the storm subsides is the supply of fresh drinking water. Since drinking water from ponds is no longer available due to flow of salt water, the 'Special Programme of Action' envisages sinking of a large number of tubewells and the provision of a few storage reservoirs for drinking water in the affected area. The action contemplated is to have tubewells at least several hundred feet deep.[16] It was seen that most of the tubewells sunk after the cyclones of 1960 and 1962 to a depth of 100 ft. had become saline.[17] The sample interview data revealed that instead of sinking tubewells several hundred feet deep, hundreds of tubewells were sunk without due regard to the recommended depth, merely to increase the number. While about 75 per cent of the tubewells are out of order in Hatia Island, all are out of order in Char Jabbar where the study team, including the author, had to drink impure pond water.

As regards the reservoirs which are under construction now in many places, their design has been such as to prevent them from being covered by eventual tidal flood. The storage reservoirs, which are rectangular concrete structures with provision for filling and emptying when necessary, will be at least 10 ft. above the ground. Though there will be a problem of storing fresh water, approximately 3,000 to 5,000 gallons of water - an amount much too inadequate for the actual need of the locality - can be stored in each reservoir for several days before fresh water is made available.

Emergency Relief. As a part of the emergency action, the Government policy envisages necessary relief and help to the affected people in all classes. It may be mentioned here that related to the alternative of bearing loss are the relief activities of the community, for these activities may make bearing the loss a more attractive alternative. However, with the creation of Union Councils under the Basic Democracies Order, the responsibilities in this field have greatly devolved on the Union Councils. The Union Councils are the main agency in the actual administration of relief as well as in supplying correct data about the damages on which the entire plan of relief and rehabilitation is to be based. Success of relief operations, it may be stated, depends entirely upon the timely supply of correct data as well as the amount received from different sources.

About three-fourths of the respondents in the study site did not receive sufficient funds or loans to repair and rebuild damaged structures. A general apprehension is that emergency relief materials are not distributed on consideration of the need of each individual.

Ninety per cent of the respondents hold the view that emergency relief materials are distributed to some favoured individuals much to the distress of others. In spite of this, no respondent indicated that the prospect of obtaining relief consciously entered his decision making.

Although the effect of the storm surge cannot be wholly ascertained, it is the view of the respondents based on their experience that in an abnormal salt inundation, crop damage recovery time has been about 3 to 4 years, household reconstruction 2 to 3 years, and planting of trees at least 8 to 10 years, irrespective of relief or loan obtained from various sources. These statistics argue strongly for some form of protective works.

Protective Works. Protective works of any kind are non-existent in Char Jabbar, the one exception being the Meghna Cross Dam No. 2. For the prevention of tidal flooding in Char Jabbar major emphasis is placed on the necessity of building protective works similar to the type of embankment which has been constructed in the adjoining islands of Hatia, Sandwip and the former Ramgati island. For the area as a whole both private and public interests stress the need for construction of protective works to shield them from the Bay.

Through the construction of the Cross Dam, as previously mentioned, an estimated area of about 120 square miles which was once the bed of the river Meghna has been reclaimed. Of this about 10 per cent has been designated for rehabilitation programmes and in the remainder, about 62,000 acres, a variety of crops is being grown. The Cross Dam, though its main purpose was to reclain a vast extent of land, is devoid of any sluice arrangements. Perhaps the construction of the sluice gates was not considered feasible owing to the nature of the former river bed sediments. However, this seemed to have some adverse effects on the economy of the area.

The present problem is such that due to construction of the Dam the vast extent of cultivated land in Char Jabbar and adjoining areas like Char Jubilee, Char Bhata has become particularly vulnerable to high tides in the months of June, July, August and September. Tidal water and heavy rainfall, normal in these months, are not able to drain out, and frequent abnormal inundation results. Annual crop damage has been estimated to be about 25 per cent during the fresh water inundation (Kharif season). On the other hand, due to absence of protective embankments all around the study area, salt inundation has been particularly severe during the months of March, April and May.

With a view to affording protection against tidal flooding the future plan envisages a protective embankment all around the area. A closure, five miles long, between the Ramgati embankment and the southern end of the Meghna Cross Dam No.2 has also been planned. The Bogger Don channel would be closed and a large drainage sluice regulator installed.[18] The plan was deferred from the phase I programme of the East Pakistan Water and Power Development Authority (EPWAPDA) but included in phase II because much of the area is still being built up by siltation. Accretion has been rapid since the construction of the two Cross Dams. Most of the study area is at or above elevation + 10.00 PWD Datum at the present time and low areas are rapidly being built up by sedimentation.[19]

The project envisages reduction as well as prevention of damage from cyclone wave surges largely at the margins of the storm. The embankments are not designed to prevent over topping or to resist the storm surges in the main path of the cyclone. The protection afforded has been shown to be effective in recent storms but is incidental and may not be guaranteed.[20] However, in view of the recurring heavy losses and damages to property, public choice has largely been in favour of the construction of embankments.

The construction cost per running mile of an embankment has been estimated to be approximately Rs.120,000, sluices included. On the other hand, if embankments were to be built to afford full protection against a violent storm surge the cost per unit of length would be more than ten fold the figure mentioned above.[21] The public choice also seems to have favoured the costly programme of building embankments on account of the fact that "even as they are now designed, the EPWAPDA embankments will provide a much needed shield to the areas exposed to cyclones; in extreme cases they may not impede the tidal waves from flooding the coastal belts but they will certainly substantially mitigate their violence and considerably reduce the extent of the affected areas."[22]

It is evident from the discussions above that in certain coastal situations engineering works can be constructed to protect vulnerable areas. However, there are great technical unknowns in coastal engineering related in some fundamental way to the magnitudes of energy that can be dissipated on the coasts. Thus it might be safe to forecast that increased coastal protection will develop a greater sense of confidence, without a corresponding increase in security. Where protection in coastal areas is not accompanied by new zoning laws or building codes, this increase in confidence may stimulate inmigration and thus increase flood loss potential.

Land-Use Change and Control. The final set of adjustments employs a variety of devices like land use regulation, zoning ordinances and building codes that will reduce damage from tidal flooding. These are actually devices which dictate land use and settlement pattern within the hazardous

zone and reduce the intensity of damage to a considerable extent. Imposition of building code or land use regulations in particular brings about changes not only in house structure and change in various other details of construction but also a change in the existing land use pattern, for example, a shift from the existing crop land use to a belt of afforestation along the river banks. All these involve a policy requiring the local administrative body to have absolute control over the land through zoning ordinances and other regulations.

It may be noted here that a policy of land-use change and control is yet to be undertaken in the study area. Secondly, an afforestation programme along the embankment for its protection has had a limited success, and elsewhere the programme as a whole has suffered from a variety of local difficulties, such as (a) problem of protecting the young plants from cattle grazing, (b) land acquirement in an area where agriculture is basic to the economy, and (c) regeneration of natural forest over a long period of time.

Finally, it may be mentioned here that several public reports have envisaged an overall change in house structures. But in these reports more attention has been given to building structures, designs and possible costs of construction than to the existing economy of the area. The costs of construction as envisaged in these reports are such that neither the individual nor the public agency can afford to undertake the programme. Further, the programme as a whole is likely to suffer from a lack of locally available construction materials and a host of other difficulties including the communication system.

From the foregoing discussion it is evident that among the variety of possible adjustments in coastal flood management, only a few have been considered in terms of the local factors and prevailing conditions.

The brief review with regard to choice of adjustment suggests that public policies relating to the reduction of damages have not worked fruitfully. The reason for such failure could be attributed not only to the attitude, tradition, and culture of the coastal dwellers, but also the lack of provision of basic facilities as envisaged in the framework of public policy.

VI. CONCLUSIONS

As shown in the above sections, there has been little innovation in policies regarding coastal flood management in Char Jabbar over the years. The general tendency has been to rely on a narrow range of public adjustments, such as warning and emergency action and flood relief. Further, not enough thought has been given to organizing a community programme which takes into consideration the cultural background of the area. The factor which considerably influences the increase of damage potential in the area under study is the lack of general education. Also, absence of telegraph office, dispensaries and good communication system lead to the increase of flood-loss potential.

Private Measures. Private perception of storm hazards results from the tradition, belief and orthodox ideas prevailing in the area. People understand that they are running a risk by occupying the coastal area. In the face of this realization the cultural traits of the area have been largely responsible for the adoption of primitive measures against future losses. Moreover, a simple realization of the expected loss in future is not a sufficient incentive for taking a wide range of preventative measures. This is because resources are limited and also because of the belief that the government help will be forthcoming if severe losses are

experienced. Given the fact that more families have been moving into this area the flood loss potential has, to say the least, been increasing.

Public Measures. Even more important is the absence of an integrated public scheme to deal with flood loss. Some public agencies are involved with coastal flood protection schemes while others are engaged in agricultural and resettlement programmes to develop the area. Thus, developing the area materially without providing corresponding protection against tidal flooding further increases the potential of loss.

Other possible public adjustments such as building codes, change in land use and zoning of the coastal land have only been given cursory attention. This is because of the resulting difficulties in relocating those residents who would be displaced by such ordinances. As a result there has been a bias towards adjustments which involve public engineering constructions such as protective embankments.

As seen in this case study site, the coastal features have been subject to morphological changes owing to both natural and cultural processes. Therefore, emphasis on a particular type of protective measure like embankments may not actually reduce future losses. In many situations adverse results have occurred in other off-shore islands where embankments have been constructed. In other words, a damage reduction programme should not have a particular bias. While there is no denying the effectiveness of a device like protective embankment against tidal flooding, what should be of particular concern is the cost, including long term costs not initially foreseen. A more meaningful benefit-cost analysis of protective embankments should be undertaken before a final decision is reached.

The experience of Hatia and other off-shore islands with respect to embankment is instructive for Char Jabbar. In the adjoining Hatia Island in addition to inundation mainly by rainfall, embankments have also been threatened by river erosion. A portion of the embankment in the north has been washed away and has been replaced by an interior dyke (Fig. 5). The river erosion is continuing at such a rate as to make the EPWAPDA officials fear that in course of time the entire northern tip of Hatia island will be washed away, not to speak of the embankment itself. Moreover, a vast area both in Ramgati and Sandwip island has also been washed away by river erosion (Fig. 4). Embankments in these islands as well as in other areas have also been breached causing further destruction to property.

Another problem, inundation mainly by rainfall, in Hatia island needs careful attention. The drainage sluices in general have been designed to drain out normal rainfall within certain desirable time limits. But over the past few years it has been found that in the month of June-July there is concentrated heavy rainfall which requires much more efficient sluices to drain the area to a desired level within certain optimum time. The month of June is the period for growing the seedlings for transplanted aman - the main subsistence crop of the area - and if there is standing water even on the highest land for more than 2-3 days, the seeds for seedlings cannot be sown. Thus, considerable losses to crops have been attributed to the ill designing of the drainage sluices.

All protective works, to be sure, interfere with natural shore processes and their impact and effectiveness vary. Of course, such protective works against tidal flooding which are in harmony with natural processes have greater chances of success and are likely to be lower cost solutions to problems in the long run.

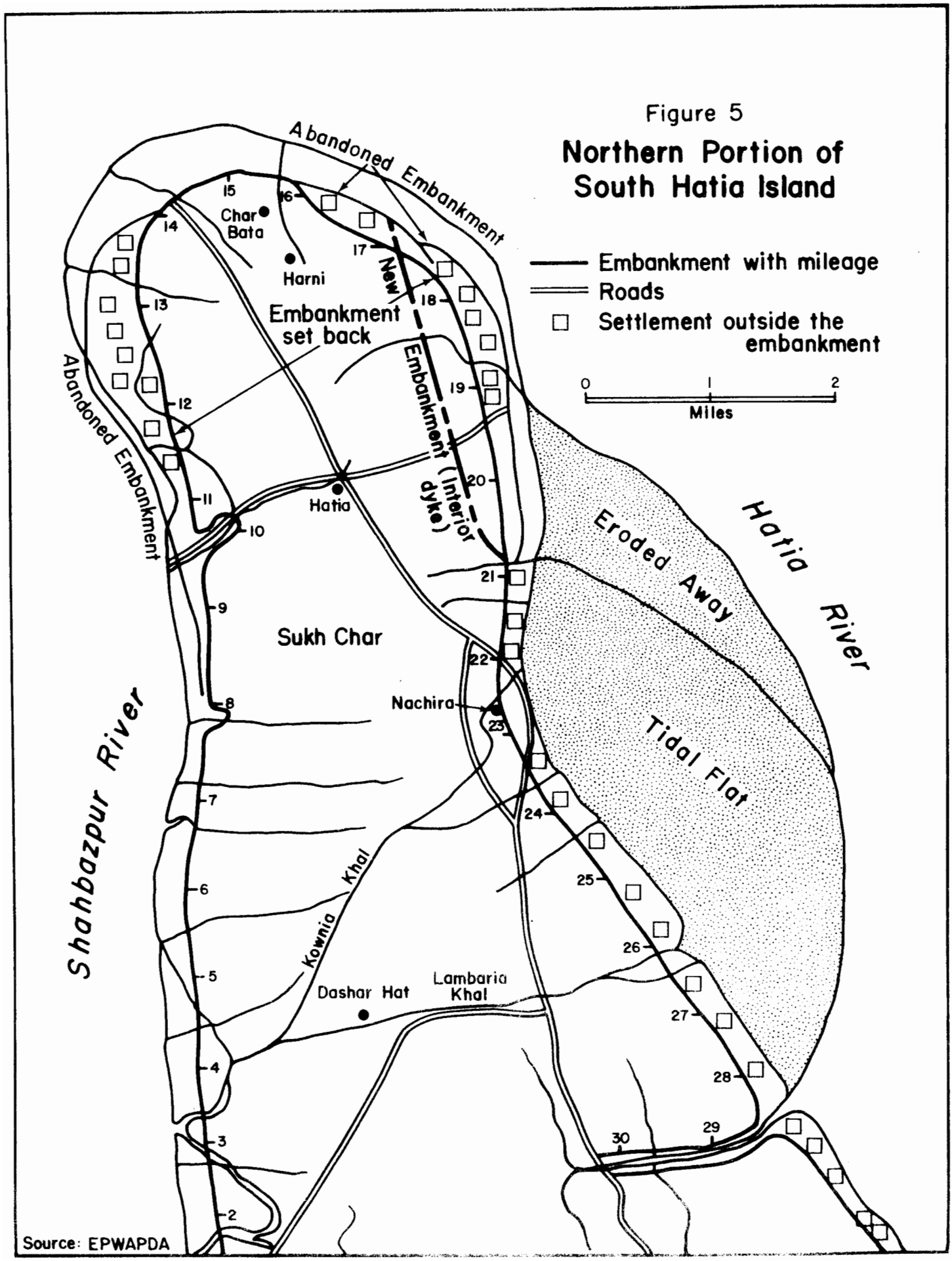


Figure 5
Northern Portion of South Hatia Island
Abandoned Embankment
Char Bata
Harni
New Embankment set back
Embankment (interior dyke)
Abandoned Embankment
Hatia
Eroded Away
Hatia River
Sukh Char
Nachira
Tidal Flat
Shahbazpur River
Kownia Khal
Dashar Hat
Lambaria Khal
Embankment with mileage
Roads
Settlement outside the embankment
0
1
2
Miles
Source: EPWAPDA

The access to the area provided by the construction of the Cross Dam No.2 is an incentive to attract people here from other areas, particularly the adjoining off-shore islands creating additional burden on the economy as well as further increases in the flood loss potential. Any adjustment thought to be suitable for the area has to be viewed with caution considering the socio-economic background of the people. Secondly policies will have to be evolved so that it is possible for them to move towards a wider consideration of adjustments.

In conclusion, this study has indicated the need for better coordination between private and public actions with respect to natural hazards. For example for an improved warning system to produce desired effect it must be integrated with other private and public adjustments to the cyclone problem. Unless this positive approach is taken the future cost of hazards will be increasing at an unnecessarily high rate.

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