EVALUATION OF THE BENEFITS OF SOME FLOOD CONTROL MEASURES IN BANGLADESH

Ferdous Ahmed

In partial fulfilment of the requirements for Degree of Master of Science in Engineering (Water Resources)

Department of Water Resources Engineering,
Bangladesh University of Engineering and Technology, Dhaka.

March, 1987.

EVALUATION OF THE BENEFITS OF SOME FLOOD CONTROL MEASURES IN BANGLADESH

Ferdous Ahmed

In partial fulfilment of the requirements for Degree of
Master of Science in Engineering (Water Resources)

Department of Water Resources Engineering,
Bangladesh University of Engineering and Technology, Dhaka.

March, 1987.

Certificate

This is to certify that this work has been done by me and neither this thesis nor part thereof has been submitted elsewhere for the award of any degree or diploma.

(Professor Ainun Nishat)
Countersigned by Supervisor

(Ferdous Ahmed)
Signature of Candidate

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF WATER RESOURCES ENGINEERING

We hereby recommend that the thesis presented by

Ferdous Ahmed

entitled

"Evaluation of the Benefits of Some Flood Control Measures in Bangladesh"

be accepted as fulfilling this part of the requirements for the degree of Master of Science in Engineering (Water Resources).

Ainun Nishat — Chairman of the Committee (Supervisor)

Abdul Hannan — Member

M.K.Alam — Member

M.H.Siddiqi — Member

Ainun Nishat — Head of the Department

March 24, 1987.

ABSTRACT

The major objectives of the study were to critically review the methods of quantification of benefits from flood control measures at the project formulation stage in Bangladesh and to find out the extent of their realization after project completion. Six representative projects were studied to establish the general pattern of the method of quantification and one of the completed projects, i.e., Chandpur Irrigation Project (CIP), was studied indepth to assess the impacts of the project and to throw some light on the variation of projected and achieved benefits.

It was established that, in Bangladesh, the benefit in agricultural sector is given the sole importance and that, in almost every case, other benefits were excluded from the economic analysis although, as it came out of the indepth study of CIP, benefits other than that in agricultural sector as a result of the projects may be substantial and are of appreciable importance. It was recommended that these other tangible benefits - both direct and indirect - be taken into the economic analysis in order to improve its reliability.

Another important finding was that the feasibility studies employed mostly the 'pre- and post-project' comparison to determine the benefits of flood control projects which alone is not sufficient and, it was recommended, should be used in parallel of the 'with and without project' comparison to give more realistic insight into the economic suitability of the projects.

ACKNOWLEDGEMENTS

The author considers it a matter of great honour and rare opportunity to work under Professor Ainun Nishat whose able guidance, encouragement and cooperation made this study a success. Profound gratitude is acknowledged to him.

The author is also greatly indebted to Dr. A. Hannan and Dr. M. K. Alam of BUET and Mr. M H. Siddiqi of MPO for they kindly agreed to act as examiners and for the constructive criticism and valuable suggestions they made.

Special thanks go to Dr. J. U. Choudhury for his encouragement and cooperation during the study. The help Mr. M. A. Gazi and Mr. Paul Thompson did by providing valuable references is thankfully acknowledged. Also the nice company of Mr. Thompson during the field trips is recollected.

The contribution of many others who helped spontaneously and who helped without knowing that they helped the author is greatfully remembered.

Ferdous Ahmed

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

1.1 Introduction

Flood is a common natural hazard that Bangladesh, like many other countries around the globe, has to face frequently and it has been recognized as one of the major constraints to the development of the country. No doubt, in spite of the acute shortage of of resources, a good number of efforts has been undertaken to mitigate and minimize the impacts of flood hazards over the last several decades. But the area that has been brought under such programmes is still small and new flood control projects are being undertaken to bring in more areas under protection from flood.

Flood control projects, in general, bring in benefits in the form of protection of crops,property and lives, bring in a changed social setting that allows for planning and development of economic as well as agricultural activities. In fact the life pattern in a flood free area is totally different from that of a flood prone zone. But many of the projects do not always attain the goals that are set before them. Moreover, some programmes result in social, economic or environmental effects that are different from the projections made during project preparation. Some adverse effects, i.e., waterlogging, disruption to navigation, etc., are also seen after the projects are completed.

All project approval authorities require a statement of the benefits to be obtained from the project and the estimated benefits are compared with the tentative cost of the project to obtain benefit cost ratio or internal rate of return which serves as basis or criterion for project approval. Hence it is important that benefits and costs of the project are calculated on rational basis. The evaluation of benefits from a flood control project is based on a forecast of the anticipated improvements as there is no other way of predicting the changes that may occur due to the project accurately. Therefore, though the cost element of the project may be estimated reasonably correctly, the estimation of benefits remains a hypothetical exercise and is dependent on projections and forecasts.

With many projects already completed and many to be planned and implemented in the near future with flood control as the main objective, it would be an useful exercise to evaluate the achievements of completed projects and to incorporate the learning gathered from them in the planning process of the future projects. In order to recommend changes in project planning and appraisal procedure, the actual benefits that emerge on the completion of flood control would have to be evaluated carefully and compared with the anticipated projections made in the planning phase. With this aim this study has been undertaken.

1.2 Importance of Flood Control in Bangladesh

Flood is a recurring hazard in Bangladesh. The area that undergoes inundation every year is about 26,000 sq km or nearly 18% of the total area of the country. In some years, the figure increases to double itself. But about 3/4 of the country is vulnerable to flood (see Figure 2.9). Up til now, only as little as 8% (net benefited area is 1.3 Mha) of the total area of the country has been brought under the protection against flood (MPO, 1985a).

The damage to life and property in Bangladesh associated with floods is tremendous. Though the documentation of floods are available for the last thirty years, it is difficult to obtain a clear picture of the extent and magnitude of damage which is comparable from year to year (Nilufer,1985). However, that the flood causes severe economic breakdown of the country is obvious.

In Bangladesh the national economy as well as the majority of the population is overwhelmingly dependent on agriculture. The food supply-population imbalance is a major constraint in the development strategies of Bangladesh. Some 2 million tons of food grains have to be imported annually. In order to feed her huge population, Bangladesh must increase its food production which is only possible by effective flood control, improved irrigation and drainage programme along with the provision of adequate agricultural inputs.

1.3 Methods of flood control

Strictly speaking, total and complete control over flood is sometimes physically very difficult to attain and in most cases may prove to be economically infeasible. That is why, what we actually seek to do is to adapt some methods, involving structures and or non-structures, to combat the adverse effects of the flood water with the aim of mitigating the sufferings. Though the term 'flood control' is common in use in our country and the USA, still in some countries like Australia, engineers prefer the phrase 'flood-damage mitigation' or simply 'flood mitigation' which is technically more meaningful (Wisler and Brater). Considering the fact that complete flood control, in its literal sense, was never adopted anywhere and is unlikely to be adopted in the future, it does not seem to arise any confusion to the use of these two terms interchangeably.

There is a number of methods of flood control with the minimization of flood damage as the primary goal. Some of them require hydraulic structures to store enough water into an area or to store or regulate the discharge of the flowing water while others, instead of structures, employ better control over the environment or the people of the concerned area through administrative measures in order to curtail the amount of damage and human suffering to a minimum. The former methods are known as structural and the others as non-structural methods of flood control.

1.3.1 Structural methods

The methods that require hydraulic structures or any other sort of channel modification to alleviate the flood damage are known as structural (or engineering) methods. Their primary objective is to reduce or regulate the discharge or stage of the rivers and if not so, to protect the area by putting up a physical barrier to protect the land from being inundated. The different structural methods have been discussed below in brief.

1) Reservoirs: The purpose of a flood control reservoir is to store excess flood water during high flow and to release it in a regulated manner. In effect, the reservoir is used to 'cut off' the flood peak above safe level. This is accomplished by conserving all inflow in the resrervoir until the released flow matches the safe capacity of the channel downstream of the reservoir. All flow above this rate is stored until inflow falls and then the stored water is released to recover storage capacity for the next flood.

The dam of a detention basin is usually equiped with a controlled conduit called penstock through which water is taken through turbines for hydropower generation and with a spillway which acts as a safety valve, in case the designed volume of storage is likely to be exceeded. Very often the objective of a reservoir is not only to achieve flood control but also hydropower generation, water supply, pisciculture, recreation, navigation etc. This makes the project more attractive from economic considerations. And this type of reservoirs intended for more than a single purpose is known as multi-purpose reservoirs. Sometimes, instead of of a large reservoir, a number of small reservoirs are used for more flexibility in operation and effectiveness.

2) Embankments and floodwalls: The oldest and most common means of flood protection is the construction of embankments or floodwalls. Embankments are also known as dikes and levees. The functional aspects of both embankment and floodwall are same. The difference is that the embankments are usually massive earthen structures while the floodwalls are generally compact concrete structures.

Embankments and floodwalls are essentialy longitudinal dams erected roughly parallel to the river. The embankments only prevent the water from spreading over into the flood plain. A special case of embankment, when it encircles an area completely, is known as a polder. This is generally done when the concerned area is vulnerable to flooding from all directions.

3) Channel Improvements: Generally they are for reducing the stage of the rivers by improving the hydraulic capacity of the rivers. This may be accomplished by decreasing the roughness of the channel, steepening the hydraulic gradient, control of the sediment load or any combination of these. Clearing of the river banks of the bush, trees and other vegetations may reduce the roughness. Meander loop cut-offs have the effect of increasing the slope, thus increasing the velocity of water and consequently reducing the flood stage. Reduction of sediment load upstream can help the river to be widened and deepened by erosion.

4) Flood diversions: The purpose of flood diversions is to divert the flood water from one river to another river or other water body in order to reduce the discharge and stage in the affected area. They are known as by-passes or floodways. They serve in two ways - firstly they store a portion of flood water and secondly they provide an additional outlet for the upstream water.

The flow of water into the diversion channel may be regulated or may be left uncontrolled. Undoubtedly the regulated one is more attractive but its additional cost must be weighed against the benefits of this additional flexibility.

1.3.2 Non-structural methods

Non-structural methods are administrative measures aimed at the alleviation of flood losses. Indeed, they allow the floods to occur physically and regulate the distribution and characteristics of life and property in such a way as to minimize the damages. The different non-structural methods have been discussed here briefly.

1) Flood proofing: Flood proofing means making properties less vulnerable to floods. It includes use of construction materials that suffers less by inundation, change in the building structure to keep water away from entering and causing internal damage, etc. Any isolated establishment of high value may be sometimes be individually flood proofed by a small ring of flood wall. The buildings may be made to meet some requirements such as sealing off the holes at the lower portion completely or raising the plinth level by several feet so that during flood water cannot enter inside.

2) Flood warning & forecasting: If the people can be informed of a possible flood in proper time, they can be prepared for it. This can reduce the damage to acceptable magnitude. Sometimes, when the predicted flood is very great, evacuation of the area may be required. This method may be relatively inexpensive and given good communication, can provide ample time for flood fighting preparations.

Under emergency, the promptness of evacuation and temporary flood fighting often determines the extent of damage and avoidance of it. Also it depends much on the hydrological characteristics of the river concerned. Generally the larger the catchment area of the river, the better is the chance of successful forecasting.

3) Land management: Arguments are often made that the deforestation is a major cause of flood. The vegetations help reduce the peak of runoff by more transpiration, and high interception during and after rain, making the flow more difficult and as well as by promoting the generation of loose organic soil which is favourable for infiltration of rainfall.

So it is possible to reduce the severity of flood considerably by land management which can promote sufficient vegetation. However, while this method is quite satisfactory with small floods, its effectiveness diminishes in case of larger floods.

4) Flood Plain zoning: The different portions of the flood plain are subject to different degrees of threat from flood. So according to the vulnerability of different sorts of occupance, the zones of different flood risk can be distributed among them in such a way that the damage during the floods is kept at a minimum.

Generally the risky zones are used for agricultural purpose or recreational parks, etc. On the other hand, the safer zones are used for industries and other urban activities. This mainly comes from the economic considerations during floods. By adopting this method costs of the initial development, flood protection, residual flood damage and relief and rehabilitation during flood periods are kept at a minimum. No doubt, with no pressure on land area in a country, it is an attractive and feasible way of flood alleviation.

1.3.3 Discussion on different methods of flood control

All the different methods of flood control have their own advantages and shortcomings. Although they depend heavily on the characteristics of the particular situation, they have some effects that are common in every situation.

Embankments are fully effective in protection as long as they are not overtopped or the stream flow attacks it directly. After that embankments are of no use as a flood protection measure and the damage would be as great or even greater than when no embankments had existed at all due to the false sense of security (see Figure 1.1). But in case of diversions, with the increase of discharge, their capacity also increases and as a result, they become more effective and benefitial. Diversions, therefore, serve more when the design flood is exceeded.

The effect of channel improvement is essentialy the same as that of diversions but also depends much on the type of improvement. For instance, the removal of a local sand bar may be effective at low stages and have an imperceptible effect at higher stages. Again, the widening of a channel may have a small effect at low stages and a much higher effect at a high stage. As it can be seen from the same figure, the beneficial effect of the reservoirs is gradually reduced when the design flood is exceeded.

It is, therefore, clear from the above discussion that the effects of different flood control structural measures are different. The same is true for non-structural measures. What is good for one place may prove infeasible at another place. Of course, in the case of non-structural methods the efficiency of the project will depend more on the administritive and socio-economic factors than on physical aspects of the flood.

So, as one might expect, every method is not effective in combating flood in a particular place. It will depend on the topography of land, hydraulic and hydrological characteristics of the rivers, land use pattern and economic status of the country.

1.3.4 Methods used in Bangladesh

Bangladesh, which is mostly a flat deltaic basin has no suitable site for reservoir construction except the south-eastern hilly areas. This advantage of this area has already been exploited and the only reservoir of the country is in Kaptai which is used for hydropower generation in addition to flood control. Channel improvement has been used in a limited number of rivers such as the Kushiara and the Lakhya rivers. The high cost of dredging, etc. makes the scope of channel improvement limited to the navigation and protection of small towns.

The extent of diversion works so far done in Bangladesh is also small. This technique has been applied to only a very few rivers such as the Manu and the Muhuri. That in monsoon almost every river has high discharge leaves little room for the additional discharge from other rivers.

It is obvious, therefore, that most of the structural methods, except embankments of course, have limited scope for either physical or economic reasons. So we are left only with dikes, polders and other embankments as the only useful instrument in fighting floods in Bangladesh. And frequently they are quite suitable for this country.

In Bangladesh much effort has already been made for flood forecasting and warning but so far with little practical results. Of course, in case of early warning, it helps to reduce valuable human life and some of their movable belongings but due to the poor communication facilities, in all areas of the country and the rural areas in particular, the reduction of damage is likely to remain unsatisfactoy. Moreover, warning cannot help agriculture which is the main victim of flood in rural areas. Also, as the flood usually spreads over a vast area, there hardly remains any suitable place for the people to move to for shelter.

The other non-structural methods which are possible to be implemented only by exercising strict administritive and legal control do not seem to suit the environment of our country. It can be assumed, not erroneously, that people would be reluctant to take the extra trouble of flood proofing. For the same reason and for the shortage of forest areas, land management also does not have any potential. Further with the enormous pressure of population, the possibility of flood zoning is almost zero.

Therefore, the only method suitable for this deltaic plain seems to be the embankments and exactly that has been adapted in Bangladesh. All major studies, i. e., IECO(1964), Krug (1957), Hardin(1963) and Thijsse(1964) have shown that embankment or levee is a good measure for regulation and control of flood in this country.

The suitability of embankments in Bangladesh as the principal flood protecting method has some strong arguments behind it, such as:

1) Construction of embankments is a labour intensive work and labour is always available in any part of the country at a comparatively low cost.

2) It does not require skilled labour.

3) Soils in Bangladesh in general can be used for embankment contruction.

4) It can not only prevent flood damage but at the same time encourage higher cropping intensity which is extremely benefitial to poor farmers as well as to the weak national economy.

While the above reasonings tend to justify embankments for flood control, however it is not totally free from drawbacks. For example, embankment blocks the entry of fertile fine silt and fish population into the flood plain. It also causes the river bed to rise gradually. But considering everything and also that we have got to minimize the damage caused by frequent floods by one means or by another, the construction of embankments, the most commonly adopted flood control method, seems to be logical. To be more straight forward, we are left with no other better alternative.

1.4 Objectives of the present study

The major objectives of the present study are to review the methods of quatification of benefits from flood control projects in Bangladesh at project formulation stage and to find out the extent of realization of.projected benefits. Representative projects would be chosen to study the quantification methods adopted in Bangladesh and one project would be studied indepth to throw some light on the variation between the projected and acheived benefits. Then, after a comprehensive and critical study of the different components of flood control benefits and their importance, an effort would be made to recommend on benefit assessment of flood control projects at the planning or feasibility study stage.

In fact, a number of specific points that would be investigated as described below, would, when integrated together, constitute the main objective of the present study.

1) Critical review of the quantification of different components of benefits from flood control projects in Bangladesh and determination of the relative importance attached to them.

2) Indepth study of the impacts of the selected project (Chandpur Irrigation Project) - both direct and indirect, tangible and intangible.

3) Recommendation towards an improvement in method for quantification of benefits from flood control measures at the time of planning or feasibility study stage.

Chapter 2

LITERATURE REVIEW

2.1 Losses Due to Flood

Floods always bring many unwanted consequences along with them. These may be broadly identified as damage to crops and properties, loss of human life, loss of cattles and domestic birds, environmental degradation creating among others, harzards to health, etc. These damages are very much diversive in nature and impact. Some consequences of flood, such as damage to crops, destruction of different structures including buildings, interruptions to transportation etc., are direct and are felt by the general people as the flood occurs; some other consequences are indirect and are felt even after a considerable time after the flood has passed. Among them are the health hazards, retarded economic and commercial activities, damage to the submerged structures and machineries that exposes itself only after long time. The nature and extend of flood losses are determined by the type of land use of the flood plain. Besides this, the depth of water, duration of flood, etc. are also important features that contributes towards damage.

At this point it might be useful to seek for a definition of valid flood losses. Foster (1942) defined flood losses as those arising from the following exigencies:

a) Any destruction or damage caused by a flood to the exsisting real or personal properties of a community.

b) Loss of earning or loss of services.

c) Increased expenses of usual operations.

d) Diminution of capital value of real state.

e) Expenditures caused by the flood emergency or a threat of flood.

This definition of flood losses seems to cover almost every loss except the health hazards and environmental problems, loss of pond fishes etc.

2.1.1 Different Categories of Flood Losses

Because of the diversity of the different types of flood losses, they are discussed under seperate headings.

1. Loss in Agriculture: Most of the crops (except a variety of rice that rises with water and some long-stem crops like jute which can withstand shallower flood water) suffer severely by flood. The damage may even range upto the complete destruction of the crops. Of course, the extent of damage depends on the type and stage of growth of the crops and hence on the time of occurrence of the flood. Presence of flood water retards the rise of soil temperature in the spring, reducing the flowering season, aggravates the nitrogen deficiency in crops, damages seeds and seedlings and finally reduces the crops resitance to summer drought by restricting root growth (Penning Rowsell & Chatterton, 1984). Some crops like potato may be completely destroyed, if flooded for more than 24 hours, due to the lack of oxygen and light. Cereal crops are affected differently at different seasons. Also the soil itself may suffer progressive deterioration and permanent damage with prolonged saturation caused by floods.

The flood may wash out the fertilizer that has been applied in the land. It may also wash out or inactivate by diluting the insecticides and pesticides that have already been applied. The flood water may even erode the topsoil and replacement may be necessary. To restore the fertility of the affected land it may take a few years.

Floods, if carrying too much eroded materials and sediment, can bury the seedlings or even the grown-up plants because the hairy leaves of crops catch the silt and finer eroded materials. The leaves become heavier and lodge down the plants which can not surface up for photosynthesis. This causes early destruction of different plants, especially rice (Zaman 1981b).

In case of prolonged flooding, when flood water increases rapidly, the rice varieties with slow elongation ability are partially or completely damaged due to rapid submergence. The extent of damage may vary from slight to extreme depending on the variety, depending on the variety. Thus under prolonged flood conditions rice of rapid elongation ability can escape damage (Gomosta 1981). In case of intermittent floods, the sitration is completely different. High elongation ability is undesirable because, when the flood water subsides, the elongated plant lodges and ultimately, the whole crop is damaged.

The deep water rice plant can survive total submergence for 72 hours. This ability then gradually decreases and may be zero after 7 days of submergence. Whereas, seedlings, at least 4 weeks old, do not exhibit adequate flood tolerance. Plants older than 40 days show greater tolerance and fight flood well if the water level does not rise very much (Zaman 1981a). The damage to rice in terms of yield also varies with the time of flooding with respect to the stage of plant growth (Pande, Mittra and Ghosh 1978). Figure 2.1 illustrates this fact.

2. Urban Areas: The damage caused by flood in urban areas has two main components one being the physical damage or destruction of the properties and other being the interruption to the economic and social life. The damage of the rural areas, except the croplands, can be looked upon in the same way as that of urban areas. Residential and commercial buildings, when inundated by flood water, undergo, damages the extent of which depends on the type, use, internal decoration, material and location of them. The immediate damage includes the destruction or loss of life of the building fabrics,electric and gas fittings, domestic appliances, furniture etc. After some time the damages to plaster resulting from dampness, softening or erosion of sand lime mortar etc. become evident. Still later, dampness in brickwork, spilling and efflorescence come into notice. Some municipal facilities such as swerage system, water supply system, cleaning the garbage, etc, pose special problems.

3. Communication: The transport system of flood-affected area undergoes serious problems. Firstly the road, high way and railway networks may go under water at different places keeping them out of use until the water-level subsides. And secondly, there may be physical damage to the road and railway embankments and top surface. They may be washed away if the flood water is forceful enough. Bridges are also susceptable to this danger. All these make communication difficult, sometimes even impossible, during the flood and demands, replacing and repairing after the flood which are also expensive. Streets and roads suffer heavy damage in flood from washing and erosion, and heavy deposits of debris has to be removed after the water recedes.

4. Business and Commerce: All the establishments engaged in trade - in one way or the other - suffer during the floods. In the markets, the stored commodities encounter two-fold problem. One is that, due to lower mobility during floods, some goods like food stuff, groceries etc. may lose their utility, fully or partially, because they cannot reach the consumers in time.

There is a possibility that they get rotten inside the store in contact with water or simply because of being stored too long. Another damage comes from the fact that the inventory cannot be controlled properly due to interruption in communication.

Banks and other financial institutions, professional and consultancy establishments and other offices may have to be kept closed until the water goes down. It may so happen that valuable documents and papers gets spoiled in contact with water, let alone the loss of furniture and decoration. Service concerns such as laundrics, plumbers, barbers, bearty shops, restaurants and hotels, cinema and theater halls, etc. are barred from rendering their service in full swing.

5. Industries: Apart from the losses arising from the damage to factories and offices, the industries suffer heavy loss due to the interruption of work and lack of transporting facilities. A industry may be cut off from the raw materials or it may be forced to store its finished product, which may be used as raw material in other industries.

The damage that occure to the machineries, when in contact of flood water, varies widely from industry to industry. Engines, pumps and similar heavy machines do not suffer any great damage from simple immersion but require dismantling and through cleansing. Even then, they cannot escape more rapid deterioration and earlier replacement. Many types of raw material and finished products, such as textiles and clothing, are liable to total destruction. Others may be damaged in quality so that their value is reduced.

6. Public Health: Floods are often followed by health hazards. Certain waterborne diseases like cholera, hepatitis, giardiasis and campylobacter are favoured by the wide-spread flood water and can unveil themselves in the form of epidemic. Cholera and gastorenetridimies are common features of flood prone areas. During flood, every community, specially the rural ones, faces unhealthy and unhygienic environment around them which may cause typhoid fever, scabies etc. In the urban areas, control of garbage and sewer system becomes difficult and the public health condition is threatened.

7. Social Aspects: Flood also makes the social life miserable. First of all, the flooded area suffers economic breakdown for all the reasons discussed above. Secondly, the flooded area may be cut off from rest of the country as a result of disrupted communication. Sometime the relief works are hampered in those areas. The interruption of different municipal and service facilities

cause immense trouble for the urban people. Besides all these immediate effects, there are also some long term effects of flood on the society. It is a well-known fact in our country that the people of river bank areas, which undergoes flooding almost every year, are generally more rough and desperate in nature. Their own life, which is one of perpetual struggle against the natural calamities, has made them so.

Virtually, the effect of flood propagates deep into the social and economic life of the affected area. And the more indirect and delayed the effect, the more is the possibility to confuse its connection with the flood. However, they can be identified by a close and careful look, though most of the time they, being intermingled with other dynamic social factors, often become distorted and evasive.

8. Loss to Closed Fisheries: During the flood the fishes of the pond may escape into the rivers and the river fishes may find a way into the ponds. The net loss under the situation is dependent upon the types of fishes involved and investments made in closed fish culture.

2.1.2 Direct & Indirect Losses

When a flood destroys the jute of a certain area, the farmers concerned suffer a loss. But this is not an end in itself. The jute mills that depend on the jute of this area, will also suffer, because they may be out of the raw material for their production. Here, the loss of the farmers is a direct loss and the loss of the jute industries is an indirect loss.

Direct loss may be defined as the damage that results from the flood itself while the indirect loss results from some impacts of flood elsewhere, not from the flood itself. It can be noted that direct losses can be prevented by controlling flood while indirect losses can be made up in ways other than flood control. For instance, the loss of jute industry can be eliminated if some other sources of jute is available but the loss of farmers cannot be minimized without flood control.

It may be mentioned that the indirect losses also, in turn, may inflict damage to other places which is not related to the flood at all. In this way the loss propagates far away, though its magnitude becomes smaller or can be compensated for. At this point, we must think of the point which we shall consider the limit in calculating the loss from a flood. This point is, as one might expect, arbitrary to some extent and is viewed differently by those involved in water resources planning. Wherever may be the point, knowledge about what is happenning beyond that, is always valuable in planning projects.

2.1.3 Tangible and Intangible losses

Among the flood losses, some can be measured in terms of money. For example, the loss of crop yield can be quantified and can be converted into an taka equivalent. The damage to a building can be calculated from the cost of repairing and replacement. But there are some losses that cannot be given any monetary value.Loss of human life is one obvious example. Loss of domestic and farm animals can be quantified fairly bu using some marked values. On the other hand, no monetary value serves to measure the loss of historical monument or natural beauty. The losses that can be measured in terms of money are known as tangible and the losses that defy this monetary quantification are called intangible or irreducible.

Floods cause many intangible losses. Among them are ill health or anxiety consequent to flooding, lack of security, loss of national prestige or personal integrity, reduced economic stability etc. All physical damage to the buildings, roads, railways, and all agricultural loss fall in the category of tangible losses.

Though the intangible losses are kept outside the economic study, they nevertheless, play important role in decision making process in flood control planning.

2.2 Benefits From Flood Control Measures

Flood control measures result in a two-fold benificial effect. First, it prevents eliminates or minimizes the flood losses. Second,it stimulates productive activities in the protected area. In most cases, flood control benefits fall primarily in the first category, with thd increased production benefits being of a secondary nature.

The flood losses have already been discussed in details in a previous section and their elimination, which forms a component of flood control benefits, will not be repeated here. Rather the benefits those are in addition to them will be described.

2.2.1 Different Categories of Benefits

Since the benefits are of the same diverse nature as the flood losses, they must also be described under different headings:

1. Agriculture: Flood control measures can make it possible to bring more land, specially lowlying lands kept fallow earlier, into cultivation. Also the absence of seasonal flood motivates the farmers to grow additional crops in a year. These factors make the farmers more well-off and they can afford new agricultural inputs like fertilizers, improved seed and even modern technology. Thus high cropping intensity and high yield can be acheived by flood control.

2. Urban Area: In urban areas, once they are free from the threat of flood, can stimulate increased settlement, industries and other commercial activities. As the flood no longer occurs, the buildings and streets can be constructed in comparatively lower land with less cost which was not possible either. The price of land also increases. And the cost of flood-fighting can be eliminated or minimized considerably.

3. Communication: Flood protection reduces the maintenance cost of highways and railways considerably. Once flood control measures are completed, the height of the new highways and railways can be reduced and thus their cost becomes less. Same can be said about the size of bridges and culverts.

4. Business and Commerce: The protection from flood initiates different kind of commercial and business activities in the protected area. New markets and shopping centers come into being in order to deal with the increased agricultural products. The business of the agricultural inputs also increase remarkably as the intensity of agriculture increases and as the condition of farmers improves enabling them to afford chemical fertilizers, insecticides, pesticides, improved seeds etc. As the investment in the protected area becomes more profitable new banks and financial institutions find avenue of activities like giving credit to the farmers and other businessmen.

5. Industries: New industries are likely to develop in the flood protected area because of the absence of flood threat and the general overall improvement of the area. The industries that provide agricultural inputs or use agricultural output as their raw material have greater opportunity in the flood protected area. As communication facilities play important role in the site selection for industires, the improvement of communication from flood control introduces additional scope for different kinds of industries.

6. Public Health: Since flood control measures prevent many health hazards and the people, specially rural people, enjoy more income as a result of flood control and can afford sufficient food, the overall condition of public health improves. Better communication also provides easy accessibility to distant medical centers and hospitals.

7. Social Aspects: The society gains in many ways from flood control. During the period of the construction of flood control structures, new employment opportunity is created. After completion, it provides lot of people in maintenance and operation. The increased industrial, commercial and agricultural activity provide employment to unemployed and better works to the underemployed. As a direct result of flood control, economic stability and income distribution improve. Regional development is another acheivement.In short, a flood control measure is expected to enhance the overall welfare to the soeciety although it may sometimes be hard to put them together.

2.2.2 Primary & Secondary Benefits

The benefits of flood control measures can be classified into two groups, namely primary and secondary. Primary benefits are the immediate result of the flood protection measures such as prevention of the flood damage, increased agricultural production etc. They denote the value obtained from project-produced condition and services. These benefits accrue from physical effects of the project on the user as constrasted with effects transmitted through other impacts of the project. On the other, hand secondary benefits represent the value added to activities influenced by the project through economic rather than technology linkage. Stimulation of industries and commercial activities falls in this category. Secondary benefits, as their very name implies, are the results of the project of subsequent nature.

As is the case of indirect flood losses, the secondary benefits from flood control are hard to identify properly and are even harder to quantify correctly. However, they should be paid proper attention and should be taken into account as much as possible when comparing benefits to losses.

2.2.3 Tangible and Intangible Benefits

The concept of tangible and intangible of benefits is just the same as that for flood losses. Tangible benefits are those measureable in monetary unit and intangible benefits are those that do not lend themselves to such quantification. The increase in agricultural production, increased industrial production, prevention of damage to building and other structures etc. are all tangible benefits because the value added by them can be calculated and be put in monetary units. But benefits like greater security against loss of life or enhancement of the environmental quality, cannot be given any monetary equivalence. So they are intangible.

So far the goal of any water resources project is to maximize the well-being of the society and since much of this well-being comes from the intangible benefits, the importance of intangible benefits should not be underestimated in the planning of a flood control project. However, it is often difficult to weigh their relative importance because they are much qualitative rather than quantitative in nature.

2.2.4 Negative Impacts of Flood Control

Even though the aim of the water resources project is to benefit the people, some of their impacts are found to be rather harmful. It is true that these harmful impacts are not the intended ones and they can be called the side-effects or by-products of the project.

Negative impacts are found with almost every water resources projects and flood control measures are no exception. Generally, most of the negative impacts are environmental and ecololgical problems. These will be discussed here and since embankments and polders are mostly used in Bangladesh, greater emphasis will given to the problems arising from them.

Any flood control measure will eliminate or reduce the deposition of fertile fine silt carried by the flood water in the flood plain. Consequently, the land, being deprived from this natural fertilizer, becomes progressively less fertile and dependent on more artificial fertilizers to keep pace with the more intensive agricultural activities. The value of water borne silt as a beneficial agricultural factor is recognized in Egypt, Australia, India and USSR, where sluices have been provided in the levees to admit flood water to the nearby agricultural areas (Framji & Garg, 1976).

Fisheries in the flood plain may also suffer adverse effects after flood control measures are taken. During the floods, some fishes are trapped in the ponds, ditches and canals of the main land and subsequently are caught by villegers. The control of flood obviously blocks this migration of fish and fish catch reduces after that. The flood control measures also tend to change the ecology of the area which may be detrimental to fish life.

In the post flood control period, drainage congestion has been a great problem in flat valleys, such as the Gangetic plan. Waterlogging is another problem, generally associated with embankments, where drainage is absent or poor. As the polders detatches the protected area from the rivers, heavy rainfall may cause internal drainage problems and waterlogging which, in turn, is reflected in reduced agricultural production.Waterlogging may also cause outbreak of vector pests such as mosquitoes and snails (de Jong 1982).

Flood protection makes possible and encourages pernnial irrigation but at the same time introduces more moist ecosystem. This moist ecosystem attracts new species of pests, worms and insects many of which are highly undesirable. Of course, it also attracts some species like earthworms which are beneficial to agriculture.Changed ecological situation can also cause harm to birds. This happened in some of the polders in Netherlands where the number of migrating birds fell sharply after their construction (Polman, 1983).

In Bangladesh, empoldering has led to containment of silt deposition within the channels and many of them have badly silted up. In the coastal areas many drainage sluices have became in-operative, creating serious drainage problems in polders (Ullah & Islam 1982).

2.3 Quantification of Flood Losses and Flood Control Benefits

Needless to say that the flood losses and benefits from flood control measures can be accounted under many headings which are diverse in nature. So while selecting a project among a number of alternatives or while simply evaluating the merits of a single project, the planners are faced with the problem of weighing the benefits of the project against the cost or comparing the benefit cost relationship of different alternatives. The first step in solving this problem is to find the equivalence of one sort of benefit or cost to another within one alternative and then to compare different alternatives. This is because each alternaive (or variation) of one project is associated with a unique set of costs and benefits which are different from those of another alternative both in number, quantity and quality. In order to compare the outcomes of different project variations, the costs and benefits must be expressed in a common unit, or in other words, be quantified. And money is obviously the most convenient unit. It should be noted, however, that, to quote James and Lee (1971), "the use of monetary units in economy studies is based solely on convenience and does not imply a materialistic approach of considering only monetary profits while ignoring the many values of life, health and happiness which can not be expressed in money units". The simple reason behind it is that diverse values are understood by more people when expressed in monetary terms than when any other kind of unit is used.

Besides, although it is true that in great catascrophic floods the loss of life is appalling and the prevention of this loss is also a justification, the costs of flood control are necessarily measured in economic terms and, to make adequate comparison of cost against benefit, the latter must be gauged on the same basis. Moreover, aside from the loss of life, flood control or protection is entirely an economic matter (Foster,1942).

However, the appraisal of any public work including water resources projects, should not be necessarily restricted to financial and economic analysis alone. The social aspects should also be taken into account. After all, the aim of the planners should be to use the available resources of brain-power, man-power and materials in the most efficient manner, in order to create the physical living condition that are needed for the spiritual, intellectual and moral development of mankind (Kuiper,1965).

2.3.1 Determination of Benefits

In this section, the determination of the benefits from flood control measures will be discussed. It is worth noting that water resources projects are usually aimed at several targets such as flood protection, irrigation, drainage etc. at the same time and the same ideas in the determination of flood control benefits can be generalized with little effort to such extent as to cover the other types of water resources development projects.

In most of the cases, flood control benefits accrue primarily from prevention of losses with the increased production benefits being of a secondary nature (Kuiper,1965). It is conceivable that the computation of flood damages from past records is comparatively easier but the computation of increased production, which is a result of the response of the all people concerned in a future time, is at best an intelligent guess.

If flood damage can be defined simply as a cost of flood risk, then the intermittent and sometimes heavy cost of floods may be reduced to an annual basis in accordance with the mathematical expectancy, as expressed by the formula

$$A = pD \qquad \ldots \qquad (2.1)$$

in which A is the annual flood loss, p the probable number of floods per annum and D the total damage caused by the floods (Foster, 1942). But things are not so simple because the magnitude of flood varies and the frequency and extent of damage also varies.

An improved method that takes into account these variations starts with three basic curves, the discharge-frequency curve, rating curve and the stage-damage curve as shown in figures 2.2,2.3 and 2.4. The first two curves can be prepared from past records of stage and discharge of the river concerned. The third curve, i.e., the stage-damage curve may be prepared based on the previous flood damage records with necessary interpolation and extrapolation. Even with utmost care, the stage-damage curve would always be only an approximation as well as an emperical relationship.

However, once these curves are available, the determination of benefit is fairly simple. It is possible to draw a damage-frequency curve(Figure 2.5) from the above mentioned curves. The area under this curve will give the annual flood damage.

The different type of flood control measures will affect the frequency curve and the rating curve differently and this effect would be reflected in the damage-frequency curve. For instance, in Figure 2.6, it is assumed that the embankments are designed for a flow of 150,000 cusec, corresponding to a frequency of exceedence of 7 percent per year. It is obvious that benefits are only obtained as long as the flow is less than this. When this flow is exceeded, the damage is as large as if there had been no embankments at all. So the damage caused by the floods greater than 150,000 cusecs will now be equal to the benefit of embankment construction. This benefit is shown in Figure 2.6. The probable case with the same design flood for diversion channel or reservoir is shown is Figure 2.7. In this case no damage will occur when the flood does not exceed 150,000 cusec. And when it is exceeded, damage would occur but would be reduced. Depending on the local circumstances (shape of rating curve, shape of stage-damage curve) the reduction may further increase, remain the same or decrease, with the increasing magnitude of flood flow (Kuiper,1965).

Instead of using graphs, the annual flood damage at natural conditions or the benefits of a project can be computed in a tabular form, as shown is table 2.1. The annual damage under natural condition is the maximum limit of the benefit that can be expected from a flood control measure.

An essentially same method was dvocated by Foster (1942) but he added an important observation for agricultural lands. In contrast with urban and other rural damages, potential crop losses resulting from floods vary greatly from season to season and they vary with the area flooded in a manner distinct from other damages. Beyond a relatively shallow depth, they do not increase with added inundation, for, if a crop is flooded sufficiently to be a total loss it suffers no further damage by deeper water.

These factors necessitate different treatment and entail the use of two other curves instead of the stage damage curve. The first curve is the 'area flooded' curve which represents the area of land flooded at various stages. The second is the 'crop loss' curve, which shows the potential loss of crops for various seasons of the year. The two curves can be constructed based on the following data:

a) Total area in which crop losses are to be computed,

b) The average proportion of the total area that is cultivated,

c) The average acreage devoted to various crops,

d) The average cost of preparation of land and crop at various seasons,

e) The average prices of the harvested crops,

f) The dates or seasons of various farm processes performed in the raising of crops (that is, planting, cultivation, harvesting and ploughing), and

g) Latest date on which a crop may be replanted so as to produce a harvest.

The first 3 items are used in the construction of the stage versus area-flooded curve, and the rest are required for the crop-loss curve. As an example, a potential crop loss curve is shown in Figure 2.8 and the computations to find the annual crop damage has been presented in Table 2.2. It may be noted that the losses in the period May to October has been taken and their average ordinate ($ 12.62) has been used in the Table 2.2. This has been done so just for convenience.The crop loss can also be calculated considering every month of the year and using different ordinates for different months.

Table 2.1

Computation of Average Annual Damage

Peak flow (cusec)	Frequency %	Damage ($1,000)	Frequency of Interval	Av.Damage of Interval	Av.Annual Damage ($ 1,000)
100,000	30.0	0			
			16.0	20,000	3,200
125,000	14.0	40,000			
			6.0	70,000	4,200
150,000	8.0	100,000			
			5.0	150,000	7,500
175,000	3.0	200,000			
			2.0	250,000	5,000
200,000	1.0	300,000			
			0.6	350,000	2,100
225,000	0.4	400,000			
			0.3	450,000	1,400
250,000	0.1	500,000			
Total Average Annual Damage					$ 23,400,000

Source: Kuiper (1965).

Table 2.2

Crop Loss for the Period May to October

Stage (ft)	Flood frequency per year: For Stage	Flood frequency per year: For Interval	Land flooded in acre: For Stage	Land flooded in acre: For Interval	Crop loss: Per acre	Crop loss: Total ($)	Annual loss ($)
26	0.608		0				
		0.257		270	12.62	3407	876
27	0.351		540				
		0.1847		760	12.62	9591	1771
28	0.1663		980				
		0.0992		1155	12.62	14576	1446
29	0.0671		1330				
		0.0431		1465	12.62	18488	797
30	0.0240		1600				
		0.01615		1710	12.62	21580	348
31	0.00785		1820				
		0.00545		1895	12.62	23915	130
32	0.00240		1970				
		0.00220		2055	12.62	25934	57
34	0.00020		2140				
		0.00018		2160	12.62	27259	5
36	0.00020		2180				

Source: Kuiper(1965)

2.3.2 Economic Analysis

Economic analysis is a critical and practical aspect of project planning, evaluation and resource utilization. All projects, as they call for investment, must be proved to be beneficial or profitable before being accepted for such investment. And economic analysis is a tool that is used to determine the feasibility of a project. In simple words economic analysis is the critical review of all the costs and benefits associated with a particular project with a view of finding out to what extent it is worth of the investment which comes from a limited amount of resources. It is helpful in determining the priority and/or position of a particular project from the national economic point of view, among other similar or different projects which may be competing for the same resources available.

For any project, what is considered first is the total return or productivity or profitability to the whole society or economy of all the resources committed to the project regardless of who in the society contributes them and regardless of who in the society receives the benefits. This is the social or ceonomic return of the project and it is determined by applying what is termed as economic analysis (Gittinger,1972).

The economic analysis of water development project may be performed in serveral ways, depending on the nature of the problem. For instance, when water power has to be developed on a certain reach of river with a given head and a given load factor, the technical problem merely becomes one of comparing the cost of alternative designs. However, when the social or economical implications of the project propagates deep through the society, the economic analysis becomes much more complicated. This is the case with flood control projects. The costs may be spread over several years and the return may be coming only after considerable time after the investment is made.

Computation of benefit in in such case may be based on the following functions.

The future value F of an amount P invested now is given by the equation

$$F = P(1+i)^n \quad \ldots \quad (2.2)$$

where i = annual interest rate

n = number of years after which the future value is computed

Similarly the present value of an amount F after n years is given by

$$P = F/(1+i)^n \quad \ldots \quad (2.3)$$

Using these formulae, it can be easily shown that if an annual sum A is invested at the end of every year on a compound interest basis, then its present value is given by

$$P = A\{(1+i)^n-1\}/\{i(1+i)^n\} \quad \ldots.(2.4)$$

and this is equivalent to a future value of

$$F = A\{(1+i)^n-1\}/i \quad \ldots.(2.5)$$

invested at a time at the end of n years.

In economic analysis every component of cost and benefit is reduced down to its corresponding present value for the convenience of manipulating them. Once this is done, all costs are added to find out the total cost and all the benefits for total benefit.

There are several parameters that are used in economic analysis as a measure of return or productivity of a project. The first one is the concept of net benefit. In this parameter the total cost is substracted from the total benefit to give what is called net benefit. Of course, before doing so all components are converted to corresponding values with respect to one particular time, generally the present time. Mathematically it can be expressed as

$$\text{Net benefit} = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1 + i)^t} \quad \ldots\ldots(2.6)$$

where B = benefit
C = cost
t = time in years
n = period of analysis

It can be noted that net benefit depends on the interest rate. The main drawback of this parameter is that it does not give any idea about the relative volume of benefit and cost.

The second parameter, namely Benefit-Cost Ratio (B/C Ratio), is defined as the ratio of total benefit to total cost. Mathematically it is expressed by equation 2.7.

$$\text{B/C ratio} = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} \bigg/ \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} \qquad \ldots(2.7)$$

Again it should be noted that the present values of all cost or benefit components are taken.

The third parameter, the Internal Rate of Return (IRR), may be defined as the interest rate that would make the benefit-cost ratio equal to unity. In other words, it is the interest rate that makes the net benefit equal to zero over a certain period. Hence, it can be found out, by trial and error, either solving equation 2.6 with zero at the left hand side or solving equation 2.7 with unity at the left hand side.

The ultimate goal of economic analysis is to find out these parameters for a project. But what hardly need mentioning is that the outcome of economic analysis is dependent on the assumptions and projections regarding the cost and benefit components which may be subjected to a certain amount of uncertainity.

In economic analysis, the shadow prices of all the commodity or service are used in the computation. This is done because various reasons, such as institutional regidities, price control, government subsidies, imperfect information about prices offered by competing sellers or buyers, monopoly elements etc., markets are imperfect. That is the market price of any commodity or service deviate from its true value for these reasons. Gittinger (1982) defined shadow price as that price which would prevail in the economy if it were in perfect equilibrium under conditions of perfect competetion. The easiest way to find out the shadow price is to use the foreign exchange rate of the item or to use the world market price.

2.3.3 Financial Analysis

It goes without saying that the farmers or other commercial entities working inside the scope of a project would not cooperate in the desired manner from the projects point of view as long as the project does not provide them with substantial benefit. In other words all of them must have some sort of incentive to motivate them towards the desired way. Otherwise any optimism regarding any project would be difficult to attain. Hence, the necessity of another analysis which is known as financial analysis, enters into the project planning.

The computational procedure of financial analysis is the same as that of economic analysis. There are, however, some conceptual differences. The purpose of economic analysis is to find out the contribution of the project to the economy as a whole using shadow prices whereas financial analysis shows the financial or commercial feasibility of the project to the individual farmers or other institutions like banks, cooperatives etc.

Gittinger (1972) discussed three distinctions between economic and financial analysis which he described as follows:

a) In economic analysis, certain prices may be changed to reflect better true social or economic values. The adjusted prices are often termed 'shadow' or 'accounting' prices. In financial analysis, market prices including taxes and subsidies are always used.

b) In economic analysis, taxes and subsidies are treated as transfer payments. The new wealth generated by a project includes any taxes the project can bear during production and any sales taxes the buyers are willing to pay when they purchase the output. Taxes are part of the total project 'benefit' which is transferred to the society as a whole to spend as it sees fit and are not treated as a 'cost' to the society since it is an expenditure of resources which the economy incurs to operate the project. In financial analysis such adjustments are unnecessary; taxes are treated quite simply as a cost and subsidies as a return.

c) In the economic analysis, interest on capital is not seperated out and deducted from our gross returns since it is a part of the total return to capital available to the society as a whole and it is that total return including interest which the economic analysis is designed to estimate. In financial analysis, interest paid to outside suppliers of money is treated as a cost and repayment of money borrowed from outside suppliers is deducted before arriving at a benefit stream. Interest imputed or 'paid' to the entity from whose point of view the financial analysis is being conducted is not treated as a 'cost' because it is a part of the total return to the equity capital contributed by the enitity and, hence, is a part of the financial return which the entity recieves.

2.3.4 Indirect and Intangible Benefits

While the identification and qualitative description of the indirect and intangible benefits of flood control project are comparatively easier, their quantification which is necessary to bring them into economic or financial analysis, is rather complicated. In principle, it is quite logical that the indirect and intangible benefit components should be taken into account as much as possible. But in reality, there are some problems in doing so.

In the first place indirect benefits, which are of secondary or tertiary origin, are very much unpredictable, particularly with respect to quantification. Secondly, they come into existence as a return of project investment only after a considerable time. And it is hard to predict beforehand the social and economic conditions that would prevail in that time and influence the magnitude of indirect benefits. Moreover, where more than one project exist at the same place, it becomes difficult to attribute a particular item of secondary benefit to a project.

All these complexities have led some agencies to estimate indirect benefits as a percentage of direct benefits. For instance, the U.S. Soil Conservation Service uses percentages ranging from 5 to 20 depending on the type of direct benefit for flood control (James & Lee, 1971). However, adaptation of such fixed percentage without any judgement of the magnitude of indirect benefits is difficult to justify.

It is of interest to note that the Presidential Advisory Committee on Water Resources Policy in the United States has recommended that economic analysis should be made on the basis of direct benefits alone (Kauiper, 1965).

Gittinger (1972) also supported this practice to whom it seemed best not to try to allow for secondary effects specially for developing countries. The practice of the World Bank and that of most other international lending agencies reflect this conclusion.

Almost every water resources development project including flood control measures has a group of benefits which are intangible or in other words, which can not be expressed in monetary term. These may include better income distribution, national integration or just a better living condition for rural people. Such intangibles are real and reflect true values but they do not, however, lend themselves well to economic valuation.

Gittinger (1972) recommended that intangible effects be acknowledged but he opined that attempts should not be made to value them nor to include them in the economic analysis computation.

James and Lee (1971) suggested that, even though it is not possible to assign a monetary value to intangible benefits, but major intangibles should be considered by use of decision matrix as shown in Table 2.3.

Table 2.3

Comapring Altenatives Achieving Multiple Goals

Alternative Goal	Economic benefits	Regional income	Environmental quality*
A	$ 1000	$ 400	50
B	$ 900	$ 400	75
C	$ 900	$ 600	50

*Measured in a unit increasing with higher quality environment.

Source: James & Lee (1971)

Of course this table is incomplete in the sense that there is no way of comparing the environmental quality with economic benefits or with regional income making the way of dicision making difficult. But, nevertheless, it is able to give a somewhat useful picture of the situation.

2.4 Flood Damage in Bangladesh

A large portion of Bangladesh goes under flood water every year and it varied from 1,813 sq. km. to 52,517 sq. km. or 1% to 37% of the country in the period 1954-85 (Table 2.4). In this table is also shown the loss of human lives which is well over a hundred persons in certain years. This figure does not include the human lives lost during cyclones or storm surges such as that of November, 1970 which took a estimate figure of 0.5 million lives.

The flood vulnerability map (Fig. 2.9) gives a clear picture as to what extent the country is vulnerable to inundation. It is estimated that about 68,040 km² of the country is vulnerable to different depths of flood of which 56,295 km² is cultivalble (Nilufer,1985). Hence, it is not surprising that the government policy of gaining self-sufficiency of food-grains is closely related to, among other things, the issue of effective flood alleviation.

The documentation of flood damages in Bangladesh by BWDB are available since early fifties. In the annual flood reports, BWDB has described damages mainly to standing crops, roads, culverts, bridges, railways, highways etc and loss of cattleheads, domestic birds etc. The loss of human lives is also given. A close scrutiny of Table 2.4 would reveal the variability of floods in Bangladesh in respect to areal extent, agricultural damage and loss of human lives.

In order to obtain an idea about the damages to different types of properties, the flood situation in the year of 1973 can be discussed. The 1973 flood may be considered as of normal magnitude since 21% of the country went under water as compared to 1% (minimum, in 1981) and 37% (maximum, in 1974).

The floods in this year claimed 38 human lives. A total area of 29,914 km^2 in the districts of Comilla, Dhaka, Bogra, Chittagong, Faridpur, Kushtia, Mymensingh, Noakhali, Pabna, Rangpur, Rajshahi, Sylhet and Tangail was inudated out of which 18,233 km^2 was crop land. The extent of damage to standing crops was 100% in Comilla, 85% in Pabna, 100% in Chittagong and 50% in Rangpur. Total damage amounted to 989,835 tons of rice, 192,275 bales of jute and 97,017 tons for other cash crops. The loss of livestock was 783 in the districts of Bogra, Comilla, Mymensingh, Noakhali and Rangpur. 48,445 homesteads were completely and 82394 homesteads were partially damaged in the districts of Comilla, Bogra, Faridpur, Mymensingh, Rangpur, Pabna, Rajshahi and Tangail. Four bridges and 24 culverts were destroyed and road and railway communication with the districts of Sylhet, Comilla, Chittagong, Mymensingh, Noakhali, Faridpur, Rajshahi, Pabna and Rangpur was seriously affected due to damages to the roads and railways. Reports of breaches along the embankments were from Comilla by the Gumti at 8 places, Sylhet by the Dhalai at 10 places and other several places. Moreover erosion and loss of land also occured by different rivers (BWDB 1973).

Having discussed the different damages in different sectors, let us turn to the average situation of the country as a whole over a long span. Flooding in this country is on such a wide scale that it is difficult to obtain a clear picture of extent, depth and damage which can be immediately comparable from year to year (Nilufar 1985). However, according to one estimate, the annual flood damage is approximately Tk. 11000 million out of which Tk. 6000 million is for agricultural damage (Khan, 1984). The average annual damage in terms of rice is about 1/4th of the annual food shortage of Bangladesh (Nilufar 1985). All these indicate that the criteria of crop damage by floods needs special attention in Bangladesh.

Damage to crop due to standing flood water depends on, among others, age of the plant, water depth, duration of flood, quality of water etc. as discussed in section 2.1.1. In Bangladesh, during pre-monsoon flood (April through June), aus rice is in its early growing stage in April. At this time it can survive flooding upto 0.3 meter in depth for a period of 3 days with muddy water and 6 days with clear water. In its later growing stage in late June, aus rice survive flooding upto 0.75 meter. Submergence over longer periods or under greater depth will damage the plant. Jute, in its early growing stage in June, can stand about 0.6 meter water for 1 or 2 weeks.

Aus, T. Aman and jute are the three important crops that are vulnerable to flood caused by monsoon storms during July and August. Aus rice, in its mature stage, can withstand flooding upto 0.9 meter for 6 days; T. Aman, in its early growing stage, can survive flooding upto 0.3 meter for 3 days with muddy water or 6 days with clear water; and jute, in its mature stage, can survive upto 0.9-1.2 meter for upto 2 weeks. More depth of flood water or longer period of submergence generally have damaging impact upon them.

Floods due to late monsoon storms during September and October is not generally critical where deep water rice is grown except for southern fringe of Tripura Hills where maximum flood may occur in October and flood water more than 0.75 meter deep may destroy the rice crop completely (Nilufar 1985).

Table 2.4

Flooded area and damage in Bangladesh

year	flood affected area(000 km²)	% of total area of the country	loss of rice (million kg)	no. of human lives lost
1954	36,778	26	450	
1955	50,505	35	482	
1956	35,483	25	813	
1960	28,490	20		
1961	28,749	20		
1962	37,296	26	766	
1963	35,224	25	85	
1964	31,080	22	184	
1965	28,490	20	35	4
1966	33,411	23	467	6
1967	25,641	18	85	
1968	37,296	26	1123	126
1969	41,440	19	221	
1970	42,476	30	1209	37
1971	36,335	25	209	120
1972	20,720	15	249	77
1973	29,914	21	616	38
1974	52,517	37	544	
1975	16,527	12	284	10
1976	28,309	20	693	54
1977	12,499	8	73	10
1978	10,790	9	133	47
1980	34,965	24	288	
1981	1,813	1	161	
1982	2,473	2		
1983	11,070	8		
1984	28,205	13	914	
1985	10,987	8		

Source: Nilufer (1985) and BWDB (1985).

Chapter 4

QUANTIFICATION OF FLOOD CONTROL BENEFITS IN BANGLADESH

4.1 Introduction

The purpose of the present chapter is to critically review the method of quantification of benefits from flood control measures as it is followed in Bangladesh. It would be carried out by examining the selected projects. The basis of selection of these projects has been discussed in Chapter 3. The perspective from which the flood damages are viewed and the assessment of benefits from flood prevention at the planning and feasibility study stage would be studied. Moreover, the different categories of benefits and the relative importance attached to them would be studied and the way intangible and secondary benefits are treated would be closely observed. Lastly the different facets of the quantification method adopted in Bangladesh would be discussed and their limitations would be pointed out.

4.2 Chandpur Irrigation Project(CIP)

4.2.1 History

Chandpur Irrigation Project was first proposed by the then EPWAPDA in 1962 as the initial unit of the Tippera-Chittagong Multipurpose Project (IECO 1964). The aim of the proposal was a project comprising two seperate polders, 135,320 acres in total, one north and the other south of the Dakatia River, covering an area of 135,320 acres. In 1963, IDA provided a credit of US $ 9 million for flood protection and gravity irrigation. Following a IDA review in 1964, it was agreed upon that the south polder should be expanded from 77,300 acres to about 137,000 acres and that work on the north polder (58,000 acres) should be postponded. Again in 1965, because of increased costs, slow execution of the project works and serious doubts about the design concept of the proposed gravity irrigation system, IDA cancelled the amount of the credit (US $ 3,75 million equivalent) earmarked for irrigation works (IDA 1972). In 1966, plans for gravity irrigation of south polder was also abandoned (WB 1981). Difficulties encountered in the process of land acquisition was another major cause. Flood protection works continued unitl 1967 when, due to cost increase, it became clear that even the simplified project could not be completed. As a result IDA suggested to halt construction works and to employ consultants again to redesign the project (WB 1981).

The revised project prepared by LDL(1969) was appraised in 1969-70 and a new credit of US $ 13 millions (which made the total cost US $ 22.7 million) was made in May, 1970. Under the project, flood protection is provided to 140,000 acres of which 75,000 acres is irrigated. The construction work began immediately but was interrupted by the war iof liberation March, 1971 and the credit (184-PAK) was suspended in December. After independence, Bangladesh Government ascribed high priority to this project and reactivated it with some modifications. However, the implementation programme was hampered seriously, particularly before 1976 due to problems relating to the mobilization of consultants, appointment of project staff, timely release of budgetary allocations, approval of contracts, coordination among implementing agencies, procurement of machineries, shortage of cement and land acquisition (WB 1981). Progess improved during 1977 and the project was officially inaugurated in 1978. Benefits in agricultural sector started to flow in immediately but most of the LLPs could not be made available in the field until 1980, three years behind schedule.

4.2.2 Description

The CIP covers an area of about 217 square miles in the Comilla and Noakhali districts. The embanked area is roughly oval in shape, 19 miles long in the north-south direction and 16 miles across it. The Meghna and the Dakatia rivers are flowing on the west and north side of the CIP area. The other two sides are not bounded by rivers.

The project was designed to provide flood protection, drainage and irrigation to the area inside the polder. Before the implementation of the project, the area was subjected to frequent flooding during the summer and rainy seasons when the adjacent rivers, specially the Meghna, attain high flood stages under the influence of heavy runoff. Drainage was also a serious problem as it used to become increasingly more difficult as the monsoon season progressed. On completion of the project, the embankment prevents the flood water intrution while the South Dakatia river, along with the canal system of CIP, drains off the excess water through the regulator at Hazimara.

The project area extends over 5 thanas (Upazillas) in old Comilla and

Noakhali districts. Table 4.1 shows the arable and non-arable areas under different thanas (now upazillas).

Table 4.1

Arable and Non-arable land in CIP area

Upazilla	Arable land (acres)	Non arable land(acres)	Total land (acres)	% of total CIP area
Chandpur	12,755	8,958	21,713	16.5
Faridganj	23,964	25,150	49,144	37.4
Raypur	19,308	13,393	32,701	24.9
Ramganj	8,128	6,602	14,730	11.2
Lakshmipur	6,166	7,139	13,205	10.0
Total*:	70,321	61,242	131,463	100.0

* The total area mentioned in different reports at different times show some variations which may be due to the relocation of embankments at different time.

Source: data collected from BWDB, Chandpur Office.

Bangladesh is mainly a deltaic plain of the Ganges-Brahmaputra-Meghna River system and the project area is no exception in respect of topography from rest of the country. While the Meghna and the Dakatia rivers flow the side of the project area, the South Dakatia river bisects the CIP area in the north-south direction. Besides the existing and old channels of this river, there are numerous khals and canals that dissect the area into tributary basins, the village mounds with their orchards and adjacent tanks and the innumerable small paddy plots. The khals and canals, besides providing drainage to the rivers, form the major transportation network within the project area. The older lands generally have a much denser network of khals than the newer lands (LDL 1969). There is only minor topographic relief within the project area with elevations ranging between about 5 and 15 feet above mean sea level. More than four-fifth of the area has elevation inbetween 9 to 13 feet (Table 4.2).

Table 4.2

Land - Elevation of CIP area

Contour Interval (ft)	Area in acres	% of total
Below 6	5,800	4.1
6 to 7	1,000	0.7
7 to 8	1,500	1.1
8 to 9	6,100	4.4
9 to 10	21,200	15.1
10 to 11	38,400	27.4
11 to 12	39,700	28.3
12 to 13	18,300	13.1
Above 13	8,000	5.8
Total	140,000	100.0

A reconnaissance survey of the important khals in the area was made in 1969. Some 218 miles of these channels were surveyed. The elevation of the bottom of the khals ranged from below 1.0 to above 7.0 feet (Table 4.3).

Table 4.3

Bottom Elevation of Khals in CIP

Bottom Elevation (ft)	Length(miles)	% of total
Below 1	25.0	11.4
1 to 2	22.3	10.2
2 to 3	27.2	12.4
3 to 4	33.0	15.2
4 to 5	36.2	16.6
5 to 6	31.0	14.2
6 to 7	20.0	9.5
Above 7	22.9	10.5
Total	218.4	100.0

Source: EPWAPDA (1969).

The climate of CIP, as in any other part of Bangladesh in general, is a warm tropical climate with seasonally varying heavy rainfall and high humidity. Three distinct seasons can be observed:

1) From March through May is the warm season. About 15% of the annual rainfall occurs during this season, usually in the form of violent, short duration thunder storms.

2) The rainy season, from June through September, is characterized by heavy rainfall, with 75% of the annual total occurring.

3) The cold season is from October through February when rainfall is infrequent.

Unconsolidated sediments underlie the entire project area. In the northern and eastern portion,. these sediments have been deposited by the overflow from the rivers, mainly the Meghna and its tributaries and the Old Brahmaputra. In the western and southern portion, the sediments are more recent and have been deposited by tidal action as well as overflow from the rivers.

The 63 miles long peripheral embankment is the most important physical feature of the project which eliminates flood water flow into the area from adjacent rivers. Local flood caused by heavy rainfall within the polder, should it occur, is taken care of by Hajimara Regulator and 5 other sluices. In addition to this, a pumping plant (capacity 1200 cfs) at Char Baghadi has been set up to provide adequate irrigation water. Also some portion of the South Dakatia river specially in southern region was improved and straightened (with 2 loops cuts) for the smooth drainage of water.

4.2.3 Benefit in Agriculture

In the feasibility study, project benefits were assumed to increase throughout the project development period in a pattern that are directly related to the growth in agricultural production. The majority of benefits from the CIP was expected, of course logically, to be derived from the increased agricultural production made possible by the prevention of flood as well as supply of irrigation water supported by agricultural extension services.

Extensive efforts must accompany project implemntation to ensure that the farmers adopt the use of fertilizers, improved seeds and modern techniques for better farming. This idea was realized and thus the provision for agricultural extension services was looked upon as an integral part of the project.

It was assumed that flood protection in the wet season would allow a shift from low-yielding deep water aman paddy to transplanted high yielding varietis and winter irrigation would increase cultivated area permetting cultivation of HYV boro and of horticultural crops. These developments, together with strengthening of agricultural support services, were expected to increase average cropping intensity from 170% to 240% and paddy yields by almost 100%. Projected benefits were to include incremental paddy production of about 99,000 tons and some increase in the production of oilseeds and high value crops such as vegetables and potatoes.

It was expected that the yields of different crops would increase as a result of protection from flood, supplementary irrigation and agricultural supporting services. The summary of these are given in Table 4.4. The food grain production from different crops were also estimated which is shown in Table 4.5.

Table 4.4

Present and anitcipated future yields of crops in CIP area (mds/acre).

Crop	Present		Future	
	Rainfed	Irrigated	Rainfed	Irrigated
Pasture	0.0	0.0	0.0	120.0
Sugar cane	330.0	0.0	330.0	650.0
Boro Paddy,Local	20.0	0.0	20.0	0.0
Boro Paddy, HYV	0.0	45.0	0.0	60.0
B. Aus	17.4	0.0	17.7	0.0
T. Aus	0.0	0.0	0.0	50.0
B. Aus/Aman	12.0	0.0	12.6	0.0
B. Aman	11.1	0.0	20.0	25.0
T. Aman	11.6	0.0	24.0	50.0
Chilies	7.4	0.0	7.4	15.0
Oil Seeds	4.7	0.0	4.7	12.0
Grains	4.2	0.0	4.2	12.0
Fodder	65.0	0.0	65.0	140.0
Fodder Kharif	0.0	0.0	0.0	100.0
Millet	10.0	0.0	10.0	0.0
Wheat	0.0	0.0	0.0	40.0
Potatos	76.0	0.0	76.0	175.0
Misc.vegetable Kharif	0.0	0.0	0.0	100.0
Misc.vegetable-Rabi	36.0	0.0	36.0	120.0
Jute	15.7	0.0	18.0	26.0

Source: LDL (1969).

Table 4.4a

Estimated food grain production available under present and future conditions with and without project.

Condition	production in 1000 mds		
	Cleaned rice	Wheat & Millet	Total Edible Production
<u>Present</u>	1,128	74	1,202
<u>Initial year of project implementation</u>			
Project	1,299	74	1,373
Non project	1,162	74	1,236
<u>1/3 of project implementation</u>			
Project	1,841	135	1,976
Non project	1,254	74	1,328
<u>2/3 of project implementation</u>			
Project	2,041	259	2,300
Non-Project	1,347	71	1,418
<u>Full development</u>			
Project	3,536	409	3,945
Non-Project	1,445	71	1,516

Source: EPWAPDA(1969).

4.2.3 Benefit in Transportation and Navigation

The two main means of transport in the CIP area were and still are roads and small country boats. No special measure was taken to improve road transport. But the fact that the polder would be used as a road and that the prevention of floods would make the construction of roads inside the polder easier and cheaper was realized and was viewed as a direct benefit of the project. But it was not possible to quantify it due to lack of data (World Bank, 1972).

On the other hand, the navigation benefits were reviewed more critically and an attempt was also made to quantify them. It was stated in the feasibility study that navigation benefits would result principally from the increased and more uniform water level that would be maintained within the project area during the winter months. Substantial benefits would also arise from the improved capacity to transfer goods and people by boats. But the data available on these were limited making the quantification difficult. However, an analysis was made for the navigation benefits and it was found out that the project would save a total of 881.4 ton-miles and 1360.0 passenger-miles annually. The annual navigation benefits in the years of full development was estimated to be US $ 0.4 million (EPWAPDA,1969).

4.2.5 Benefit in Employment

According to unofficial estimates of the then Pakistan Planning Commission, about one-third of the available man-hours of the agricultural labour force in the then East Pakistan (now Bangladesh) were unoccupied in 1961. The situation, it was expected, might be worsening due to the rapid population growth. But it was expected that the increased agricultural activities of the project area would reduce the greater unemployment and underemployment than in the country as a whole.

The primary cause of the high unemployment rate in the project area was the seasonal nature of the agriculture at that time which is largely limited to raising the aman rice crop. The proposed project was expectd to provide, through flood protection and irrigation, year-round growing of crops with higher yield and cropping intensity, thus consuming more labour with a more even seasonal distribution. However, none of these was quantified in the feasibility study. But World Bank (1972) estimated that the project would provide agricultural employment equivalent of 20,000 year round jobs. The increase in production would enhance, according to the feasibility study, the income and employment of industrial and commercial business in the project and adjacent areas.

4.2.6 Flood Control and Other Primary Benefits

In the feasibility report, this was one of the major categories of quantified benefits which included:

1) reducing flood damages to homesteads, business establishments, roads

and other public and private facilities;

2) improving the quality of and providing a more dependable source of domestic water supply and

3) providing improved surface movement of goods and services on the roadway of the encircling embankment.

The amount of these benefits was estimated to be US $ 0.4 million annually at the full development stage of implementation, the basis of calculation of which was not given in the feasibility report.

4.2.7 Other Benefits

Besides the benefits discussed earlier, the project was expected to generate other minor benefits but no attempt was made to quantify them. Among them are a 33 KV transmission line, built for the Char Baghadi pump house, having the capacity to supply a future extension southwards into the project area thus paving the way for rural electrification; intensive agricultural extension work, copperative credits and other services requred to support agricultural development etc. The education and infrastructure accompanying improvements in agriculture, it was expected, would facilitate development of cottage industries and the non-agricultural sector of local economy (LDL, 1969). The project was also expected to increase the value of the annual agricultural production by about 235% over the non-project conditions when full project development is achieved. Benefits would arise because of economies of scale involved in supply, processing and distribution of them. Other benefits were envisaged as generally improved living conditions of farmers in the project area.

4.2.8 Economic Justification of the Project

The CIP was designed to exploit the high development potential of part of the Meghna flood plain in the eastern region of Bangladesh. The principal source of benefit is agriculture as discussed earlier. The economic evaluation of the project was based on an internal rate of return analysis using quantifiable direct benefits only in the feasibility study. It was found out that the project was economically attractive and the quantifiable primary benefits could be expected to provide an internal rate of return (IRR) in excess of 17% for an assumed slow rate of development. It was estimated that actually IRR would be between 19% to 20% (BWDB 1969). At the same time several optimistic and pessimistic conditions of costs and benefits were analyzed. The most pessimistic being that of a 20-year buildup period with all costs being 125% of those used for the analysis and benefits being reduced to 75% of the estimates. The IRR under these assumptions was about 13%.

It was estimated by IDA (1972a) that the quantifiable benefits from the project would be an annual increase in the value of farm production the years after completion of major polder works, to about US $ 21 million or 2.5 times present levels, and more than double the level that could be achieved with expected improvements in farm inputs but without irrigation and flood control. Most of the additional production would be food for local consumption which would otherwise have to be imported. Therefore, compared to inputs only conditions, the project would yield a saving of foreign exchange of about US $ 12 million annually after the tenth year, rising to about US $ 15 million annually with the project at full development after the thirteenth year (IDA 1972a). The economic rate of return was expected to be over 15%.

4.3 Meghna-Dhonogoda Irrigation Project (MDIP)

4.3.1 History

The Meghna-Dhonogoda Irrigation Project was identified as a potential investment-worthy water resources project in early sixties by the then East Pakistan Water and Power Development Authority. One of the local consulting firms was commissioned for the preparation of the fasibility of the project potentials in 1963 and they submitted their report in early 1967. The studies and investigations made by them identified the concerned project as highly feasible and recommended that the project should be realized as soon as possible. But the actual work could not be started due to, among other constraints, the lack of fund, particularly the foreign exchange component of the cost. The Bangladesh Water Development Board took up the project with fresh enthusiasm in 1972 and ADB took interest in the project. A Japanese consulting firm in collaboration with a local firm, prepared a fresh feasibility study. In 1977 when their report was completed, the initial steps for implementation of the project had already been started. Corrently the project is under construction and is expected to be completed by 1989-90.

4.3.2 Description

The central aim of the project is to boost agricultural production, create employment opportunities and improve the general well-being of the people through the provision of irrigation and drainage facilities along with the protection from flood by a ring embankment. This project forms a part of the lower Ganges River Basin Development Programme and has been given high priority by the Government as one of the most important projects which is characterized by the protection from annual flood and by security and stability of inhabitants life (BWDB 1977).

The project covers a gross area of about 44,000 acres (13,760 hectares). After the completion of the project works, some 43,400 acres will be protected from annual inundation of which about 34,500 acres will recieve year-round irrigation water. For flood protection, the area is encircled by a 37 miles long embankment. There are two main pumping plants at Kalipur and Uddhamdi that can be used both for irrigation and drainage. There are also three other pump stations inside the project area to act as secondary pumping units so that the whole area gets irrigation water which is otherwise impossible due to the undulation of the area. The total length of the main and secondary irrigation canals is about 48 miles and that of the main drainage channels is 100 miles. Navigation locks are provided at the two main pumping stations for the easy passage of the country boats. Provisions heve been kept for the development of an agricultural demonstration farm and for fisheries development. The agricultural development of the project area will be greatly facilitated by the demonstration farm the purpose of which is to transfer appropriate knowledge to the farmers. For fish culture in the canal system a pilot project has been suggested which will be implemented jointly by BWDB and Fisheries Department. As the fish farmers will require initially financial support, the consultant has recommended a credit scheme on reasonable term.

4.3.3 Agriculture

In the feasibility study, radical changes have been proposed in agriculture and the benefit prediction has agriculture at the focus. The present major crops in the project area is B.Aman and B.Aman mixed with Aus which occupy respectively 45% and 30% of the cultivable land. It can be noted that this mixed type of paddy is generally followed by Rabi crops. The cropping percentage of jute is 12%. Boro is cultivated only in the low lying areas and accounts for only 12% of the available land. The detail present cropping pattern is shown in Table 4.5.

Table 4.5

Major present cropping pattern in MDIP area.

Crop	Acreage	% of total
B.Aman fllowed by Rabi	1,810	4.96
Aus & Aman mixed followed by Rabi	11,067	30.29
Jute followed by Rabi	2,400	6.57
Jute	2,019	5.51
B.Aman	14,547	39.81
HYV Boro	2,790	7.64
Local Boro	1,750	4.79
Aus followed by Rabi	135	0.37
Total:	36,542	100.00

Under the proposed plan, with the flood protection and irrigation facilities, the acreage of B.Aus, Boro and Rabi vegetables will increase while that of B.Aman (Single) will decrease. Projected yield and production of Paddy, the main crop, has been shown in Table 4.6. It shows that the unit yield of different types of paddy would increase gradually and total annual paddy production would also increase from 56,356 tons in 1978 to 83,633 tons in 1989.

Table 4.6

Projected yield and production development for paddy in MDIP

year	Unit yield (ton/hectre) Boro (HYV)	T.Aman (HYV)	T.Aus (HYV)	T.Aman (Local)	annual production (000 tons)
1978	3.2	2.7	2.9	2.0	58.4
1979	3.2	2.7	2.9	2.0	58.4
1980	3.4	2.9	3.2	2.1	63.0
1981	3.6	3.1	3.4	2.2	67.0
1982	3.7	3.2	3.5	2.3	69.0
1983	3.9	3.4	3.6	2.4	72.3
1984	4.0	3.5	3.7	2.5	74.0
1985	4.1	3.5	3.8	2.6	75.6
1986	4.2	3.6	3.9	2.6	77.6
1987	4.3	3.7	4.0	2.7	79.6
1988	4.4.	3.8	4.1	2.7	81.6
1989	4.5	3.9	4.2	2.8	83.6

It has also been noted in the feasibility report that the farmers would be exposed to the facilities like demonstration farm, agricultural extension services, input required for farming, marketing, credit, cooperative societies etc. Proposal is also made to change the land tenure, from small fragmented plots into larger plots, in order to acheive the full benefits from the project.

Based on the recommended cropping pattern, the cropping intensities were calculated (Table 4.7). It is obvious from the table that rice would continue to be the dominant crop after completion of the project although there would be considerable change in the relative importance of various types of rice. The reliable water supply would enable cultivation of HYV Boro in most areas in the dry season. It is worthnoting that the irrigated HYV Boro produces much higher and more stable yields than Aus and B.Aman and since their growing seasons overlaps, the increase in HYV Boro area would be accompanied by a decrease in the area under Aus and B.Aman.

Table 4.7

Comparison of present and projected cropping intensities in MDIP

Crops	Present (ha)	Future without project (ha)	future with project (ha)
Paddy			
Boro(HYV)	0.15	0.15	0.60
Boro(local)	0.05	0.05	0.00
T. Aman(HYV)	0.05	0.15	0.80
T. Aus(HYV)	0.01	0.05	0.20
T. Aman(local)	0.20	0.20	0.10
T. Aus(local)	0.40	0.30	0.10
B. Aman	0.40	0.40	0.00
Sub-total	1.26	1.30	1.80
Other crops			
Wheat	0.05	0.10	0.10
Rabi	0.05	0.10	0.30
Jute	0.10	0.10	0.05
Summer veg.	0.01	0.05	0.04
Sugarcane	0.01	0.01	0.01
Sub-total	0.22	0.36	0.50
Total	1.48	1.66	2.30

The agricultural production to be realized from the project in the fifth year after completion of the construction is estimated at 83,633 tons of paddy and about 35,000 tons of vegetables including potato, sweet potato etc. which at 1977 prices can be valued at about US $ 13 million (BWDB 1977).

4.3.4 Fisheries

Realizing that the empolderment may result in adverse ecology for the natural fisheries as happened in CIP, due attention is given to culture fisheries development. The khals and canals that would maintain more or less a constant water level after the completion of the project, have been proposed to be utilized for harvesting and catching fish in a scientific manner. However, the responsibility of this will be of another institution, Department of Fisheries, demanding intimate inter-institutional cooperation.

As the flood hazards will be controlled, the ponds and the marshy areas may be reclaimed and utilized. The pilot scale fisheries programme is intended to provide the fish farmers with the knowledge and materials for fertilization, feeding and harvesting of fish. Also there is provision for credit for the fish farmers. In the fifth year of the pilot programme, the expected yields would be 121 tons in the managed canals and 645 tons in the ponds and beels. The total yield during the pilot project period is estimated at 2,424 tons with a value of US $ 13.5 million (BWDB, 1977).

4.3.5 Transportation and navigation

The feasibility report says that 14.8 miles of new roads would be constructed and 27.7 miles of existing roads would be improved as a part of the project. Also 10 bridges and 16 foot bridges are to be constructed along with the roads. As the completion of the polder will relieve the area from inundation, the roads can be lower in crest and therefore cheaper.

At present nevigation is the main means of transportation and also after the completion of the project it would continue to be the dominating one. Two navigation locks will be provided at Katipur and Uddandi to facilitate the movement of small country boats to and from the empoldered area. The new and improved khals within the area would be able to provide a good navigational network inside the project area.

4.3.6 Employment

The project is expected to generate positive impact on the abundant manpower of the project area. It has been estimated that while the without project condition requires only 3.0 million man-days annually, the with project condition requires 5.2 million man-days. Besides, the construction phase of the project will require an additional 6.3 million man-days which would help considerably to relieve the intense unemployment, although for a limited time. It is also expected that the enhanched commercial, industrial and agricultural activities associated with the project would create a lot of employment for the people.

4.3.7 Other benefits

Besides the direct benefits mentioned above, the project would also generate some indirect benefits such as flood control, expansion in agro-based industries like rice milling, oil extraction etc. Improved availability of farm by-products such as bran, broken rice, straw, and jute rejects would also encourage farmers, especially the underemployed small holders, to rear livestock on a small scale as a subsidiary year-round occupation.

4.3.8 Economic justification

The project is expected to generate many benefits, both tangible and intangible and both direct and indirect. However, the intangible and indirect benefits are not taken into account for economic analysis of the project due to the complications encountered in quantifying them. It is envisaged that on full agricultural development, some 83,633 tons of paddy and about 35,000 tons of vegetables would be produced.

The main beneficiaries, i.e., the farmers are expected to harvest about 6 tons of paddy per hectare of land as against 2.5 tons per year at present (BWDB 1977). A farmer would also be able to increase his net return from agriculture to US $ 592 including payable water charge, living expenses etc. as compared to US $ 180 at present and US $ 250 in future without the project.

On the basis of the direct tangible economic benefits and economic cost only, the economic internal rate of return (EIRR) for the project is estimated at 16.1% on the following assumptions:

1), a project economic life of 50 years,

2) a projected reference rice price, of 188.48 US dollars per ton (c.i.f. of 20 percent broken),

3) an average paddy yield of 6 tons per hectare per year,

4) an agricultural development period of 5 years after the completion of

the project works, and

5) a 5-year construction period.

In general, these assumptions are considered, according to the planners, to be on the conservative side. However, sensitivity tests conducted for a variety of circumstances show that the project would be still economically justifiable. The results are:

CASE	EIRR(%)
1. Reduction in the rice price from 188.48 to 170 US dollars per tone.	14.2
2. Reduction in yield by 10%	13.6
3. Two years delay in construction period	13.2
4. Cost increase by 20%	14.1

4.4 Karnafuli Irrigation Project (Halda Unit) (KIPH)

4.4.1 History

The Karnafuli Irrigation Project consists of four separate units, all of which are located contiguous to the lower reaches of the Karnafuli River below the Kaptai dam. These four units are:

1) The Halda unit, the largest of the four, lying north of the Karnafuli in the Halda River valley.

2) The Ichamati unit in the lower valley of Ichamati khal, also lying north of the Karnafuli, and east of the Halda unit.

3) The Boalkhali unit, an alluvial plain lying south of the Karnafuli and opposite to the Halda.

4) The Sylok unit, the smallest of the group, in the lower valley of Sylok khal, lying opposite to Ichamati, south of the Karnafuli.

The first unit, namely the Halda unit, has been taken for the present study. The project was conceived in the early sixties by the then East Pakistan Water and Power Development Authority and an international consulting firm, was entrusted with the responsibility of primary investigations. They came up with their reports in 1968. Then the details of the Karnafuli Irrigation Project were carried out. This began in 1970 under an IDA credit but, unfortunately it was interrupted by the liberation war. However after independence, the basic data was updated and the final reports were published in 1974.

After that the works of the project began but the construction of the embankments could not be achieved due to opposition of local people regarding land acquisition. Now, the possibilities of constructing embankments along the existing roads are being explored which would involve minimum amount of land to come under acquisition.

4.4.2 Description

The proposed project would provide irrigation, flood control, drainage and improved agricultural supporting services to the farmers. The project comprises a gross area of 48,000 acres of which 38,300 acres are agricultural land. About 36 miles long embankments along with 16 gated regulators, 27 re-lift pumping stations and 710 LLP'S are there for protection against flood and for irrigation water supply. At some regulator sites, there are facilities for cargo transfer. About 41 miles of existing khals has been improved and 6.5 miles of new khals has been excavated.

The flood control features of the project comtemplate a dike along the north bank of the Karnafuli of sufficient height to contain the highest expected flood in that river. This dike would tie onto the railroad fill west of the Halda on the southeast side of the project. Dikes would be constructed on both sides of the Halda to the Diversion dam near Fatikchari of sufficient height to contain 10 year frequency flood and alleviate the annual inundations which now occur (EPWPDA,1968).

According the feasibility study, there would also be provisions for supporting services to agriculture. These include 6 agricultural demonstration areas, extension services, supply of improved seeds and fertilizer, etc. The development of fisheries has also been given due importance.

4.4.3 Agriculture

Almost every water resources project in Bangladesh has as its main objective, the boost of agricultural production. And the Halda unit of Karnafuli Irrigation Project is no exception. The economy of the project area was essentially agricultural and nothing has been proposed to change it with the project's completion. At full development stage, the annual paddy production to be about 141,000 tons compared to the 93,000 tons in the past and 115,000 tons without project in the future. It was also expected that the average farm income from agriculture would increase from about 90 US dollars to about 120 US dollars per capita per year.

Before project the cropping intensity was about 203% and about 95% of the area was double cropped and 4% was tripple cropped. The remaining land was devoted to year round sugercane cultivation. There is no remarkable change in cropping intensity in the feasibility study but it was planned that most local varieties of paddy would be replaced by HYV's thus increasing total output. It was expected that total paddy production would be 118,000 tons as against 80,000 tons before project. While the boro acreage is expected to increase from 20,000 to 2800, the HYV T. Aman and HYV T. Aus would be introduced as new rice varieties (respectively 30,000 and 4,000 acres) in the project area. After the completion of the project, it was expected, the yields would be increased as shown in Table 4.8.

The crops selected for the proposed agriculture are adapted to the land and soil conditions, local climate and to irrigated agriculture. Before the project, the dominant crop was T.Aman as single crop but it frequently suffered damage by flood. Next crop was T.Aus and the third important crop was rabi crops. It was noted from the past history that the farmers of the area did not receive any cash benefits from jute of sugarcane. Therefore no jute production and only a small amount of sugarcane for local consumption were recommended in the feasibility reports. Moreover, for a prosperous agriculture kin the area, cetain cash crops such as vegetables, chillies and quick growing fruits have been recommended.

Table 4.8

Present and future yield in KIFH area

Crop	Present yeield (mds/acre)	Future yield (mds/acre)
Aus(local)	14	17
Aus(HYV), rainfed	28	32
Aus(HYV), irrigated		47
t. Aman(local)	21	24
T. Aman(HYV),rainfed	32	36
T Aman(HYV), irrigated		45
Boro(local)	25	
Boro(HYV)		46
52		
Pulses and Oilseeds	6	7
Vegetables	75	120

4.4.4 Fisheries and Environment

The carp spawn fishery is an unique and important fishery on the Halda river. The project concept, of regulating khal flows with regulation of the Halda river itself, was designed to have mimimal effect on the fishery. Moreover, as the knowledge of fishery is limited, the World Bank appraisal of the project recommended specialist study in the Halda river area. Accordingly, a credit was sanctioned for fisheries Development Programme to assess the impact of irrigation and flood control project on fisheris and to design fisheries development projects.

Regarding public health, the project, it was expected, should improve conditions because of the increased avaibility of fresh water on a year-round basis. Schistosomiasis is not present in Bangladesh. Consequently no adverse environmental effects were expected from the project (World Bank,1975).

4.4.5 Transportation and Nevigation

Except for the metalled highways, the roads in the project area become impassable during the monsoon season. Consequently, all the traffic is dependent upon river transport. But with the control of flood provided, it is hoped that, these roads would be usable without further improvement.

The proposed reduction in discharge of the Karnafuli River due to the irrigation water withdrawal would have no adverse effect on the nevigation in the Chittagong port area (BWDB 1968).

At the mouths of five principal Khals, facilities will be built to carry small country boats around the regulator structures and over the embankments. Thus the project would produce no direct effect, beneficial or adverse, on the nevigation and transportation in the project area and the neighbourhood. However, it was expected that the overall condition in these regards would improve due to the expansion of agricultural activities and subsequent expanded marketting.

4.4.6 Employment

As the increased production would result in this project from the cultivation of HYV paddy and shifts in the cropping calendar, rather than more intensive land use, the labour requirement in the area at full development would increase only by 15%. But over the same period of time, the predicted increase in labour force will be 21%. Annual field labour requirement in the area in 1975 was 6.8 million man-days and would reach 7.8 million man-days in the full development stage (World Bank 1975). However, it is expected that the employment opportunities for landless labourers in marketting and transportation would increase substantially as a result of the increased agricultural production.

4.4.7 Other Benefits

Apart from the benefit components described above, the project will also some generate minor benefit components. Among them, comes first the extension programme for agriculture. There is provision in the project to educate the general farmers in the field of scheduling of land preparation and planning dates, crop culture under irrigation and other relavent basic techniques. The Ministry of Agriculture would be responsible for agricultural research and extension, and, through BADC, for procurement and distribution of agricultural inputs in the project area, while the Ministry of Local Government, Rural Development and Cooperatives would be responsible for the Integrated Rural Development Programme (IRDP), cooperatives and the Thana Irrigation Programme

(TIP) (World Bank 1975). BADC would be responsible for multiplying and distributing HYV seeds. It would also monitor the supply of fertilizers and other agrochemicals.

Income redistribution is another benefit that the project area would enjoy after the completion of the project. In 1975, due to the unbalanced income distribution about 70% of the families had a per capita income below US $ 90 which was the average per capita income for the project area. It is expected that the project would increase the net farm incomes of the submarginal farmers (1.0 acres), who in the past did not have irrigation, by about 80% and the incomes of small (3.0 acres) and large (5.0 acres) farmers by about 90%. However, the demand for hired labour would increase and create additional employment for landless labourers and submarginal farmers (World Bank 1975).

4.4.8 Economic Justification

The direct benefits of the project includes increased agricultural production, reduced transport costs through improved nevigation possibilities on khals and increased fish yields. The project would have also substantial secondary employment effects in trade and transport.

The project would provide reliable irrigation to an area of 38,000 acres. This would cause a major shift in the cropping pattern and increase the production of milled rice by some 17,000 tons over the projected production without the project. This represents annual gross foreign exchange savings of about US dollar 4.3 $ (1975 price). And after deducting the foreign exchange costs of spares and replacements, fuel, fertilizers and pesticides, the net annual foreign exchange savings attribulable to the project would be about US $ 3.3 million (World Bank, 1975).

Taking only the increased agricultural production into account, the Economic Rate of Return was calculated to be 15% on the following assumptions:

1) a 3 year construction period,

2) full agricultural development is reached 5 years after the completion of the project,

3) projected 1985 world market prices in terms of 1975 dollars for rice, fuel and fertilizers,

4) all farm labour is valued at about 50% of the peak market wage and construction wage at the market wage,

5) allowance is made for the protection provided by import restrictions and duties by using a shadow rate of US Dollar,

US $ 1.00 = Tk. 16.

6) costs and benefits of fisheries development programme, along with other benefits such as higher employment and income in trade and industry based on agricultural productions in the project area, were excluded from the analysis,

7) taxes, duties and subsidies are omitted, and

8) a 40 year project life.

Moreover, the sensivity of the Economic Rate of Return to changes in costs, prices and other assumptions were made and it was found that the project would still be economically justifiable in all those cases.

CASE	ERR(%)
1) completion delayed 2 years	13%
2) 15% increase in construction costs	13%
3) 15% decrease in rice price	12%
4) (1) + (2)	12%
5) (1) + (2) + (3)	10%
6) 15% increase in cost of inputs	14%
7) 25% increase in full and operating cost	14%
8) all farm labour valued at full market wage	14%
9) Taka valued at the official exchange rate of Tk. 13 = US dollar 1	13%
10) Taka valued at a shadow exchange rate of Tk. 19 = US dollar 1	17%

4.5 Barnal-Salimpur-Kolabashukhali Project (BSKP)

4.5.1 History

This project is one of the many small scale water development projects that have been undertaken by BWDB. In recent years, BWDB has been undertaking small projects that were envisaged to be, where possible, labour-intensive and would utilize, as for as possible, local indigenous materials consistent with sound engineering practice. The objectives behind this idea was to reduce crop damage by floods, increase crop yields and raise cropping intensities by means of low flood protection embankments, water control structures, drainage channel improvement, together with supplementary irrigation, provision of agricultural supporting services and strenthening of operation and maintenance activities.

The project was already under implementation with local resources. The history of development of the area dates back to 1961 when the Hatiar khal was partly excavated with a view of removing drainage congestion. In 1971, the Faridpur Flood Control Division prepared a feasibility study of the project and construction of the Hatiar khal regulator was started in 1975.

4.5.2 Description

BSKP is primarily a flood control and drainage project. Of the 63,000 acres of gross area, about 45,000 acres are low lands which used to be flooded by high tide and rainfall to a depth of 6 ft. from June to October every normal year in the pre-project times. Waters entering the area during high tides in the low flow season bring in salinity causing damage to crops.

The main two components of the project are:

-an embankment with sluices encircling the project area

-institutions guaranteeing adequate operation and maintenance of the constructed works and enabling farmers to acheive an increase in production, justifying investments and extra efforts.

The embankment is to prevent floods and the sluices are to drain out excess water from the project area. In the project area, water control has been improved by making bunds, small embankments, drains and water reservoirs (also for fish cultivation).

In order to acheive sufficient benefits from the physical components of the project, agricultural extension service in the project area was strengthened. It includes facilities like advice towards better farm management, cooperatives, supply of pumps, fetilizers, seeds etc.

There is in total 52.2 miles of embankment with the Nabaganga River at north-west, the Atai River in the west and the Atharabanki and the Bhairab rivers at the south of it. After poldering the area, only rainwater would accumulate during monsson and it is possible to drain it off through sluice gates into the adjacent rivers. However, for some low lands, effeicient drainage would require some additional channels to be exavated. The total area has been divided into 5 drainage basins with individual outlets (regulators).

4.5.3 Agriculture

The dominant source of benefits of the project is increased agricultural production. Before project, only 24,000 acres out of 56,000 acres were suitable for proper cultivation of crops. Out of these land about 16,000 acres was devoted to B. Aman partly followed by a rabi crop and the rest was used for Aus, mixed Aus and Aman or limited amount of T. Aman followed by a rabi crop.

The land use has been planned according to the height of the land and the vurnalability of land to inundation. Table 4.9 summerizes the agricultural development plan. And the next table (Table 4.10) shows the breakdown of land deveoted to different crops in different seasons. It was also expected that the yield of the crops, especially paddy, would increase considerably as a result of the project. For example. B. Aman and T. Aman were both expected to increase in yield from 18 to 24 mds/acre, wheat from 6 to 26, pulses from 6 to 10, oilseeds from 7 to 10 etc.

It was estimated that the present paddy production (732,000 mds) would increase to a value inbetween 1,128,000 to 1,227,000 mds. Other crops would also show increase in production but not as much as paddy. Also it would contribute most to the project benefits.

Table 4.9

Agriculture development plan of BSKP

Elevation (ft. PWD)	area (acres)	duration of inundation without	with	cropping pattern without	with
<0.5	2,000	12	12		
0.5-2.0	9,300	12	8-9		B. Aman
2.0-4.0	24,200	11-12	6-9	B. Aman (partly)	B. Aman
4.0-6.0	8,800	5-7	3-5	B. Aman/ Mixtures	B/T Aman +Oilseeds/wheat
6.0-8.0	4,700	2-4	0-2	T. Aman/ Mixture+ Pulses/ Oilseeds	T. Aman + Sorghum/ Oilseeds

Table 4.10

Present and projected areage of BSKP

	(acreages in 100 acres)			
Crops	P	WO	W1	W2
B. Aus	35			
B. Aman	335	158	388	388
Aus-Aman	5	57		
T. Aman	3	25	82	35
Boro	43			47
Sub-total, paddy:	421	240	470	470
Sesame	7	25	25	5
Sorghum			22	22
Wheat	2	35	35	55
Pulses	7	53	242	242
Oilseeds	7	22	53	53
Jute	16			
Sub-total:	49	135	377	397
Grand total	470	375	847	867
Cropping intensity(%)	100	80	180	184

Note: P for present, WO for future without project, W1 and W2 are for two alternative future conditions with projecrt

4.5.4 Other Benefits

The only two benefits other than increased agricultural production mentioned in the feasibility report were: (1) creation of employment opportunities during construction period for 5 to 7% of the labour force and a slight improvement of the long term employment in the project area, and (2) improvement in internal communication as a result of upgrading and pavement of 35 miles of roads. But, however, these were not taken into consideration in economic or financial analysis which was based solely on the increased agricultural production.

storage and milling of rice and wheat along with oil extraction etc. But no forecast was made as to what shape they would take after the project completion except merely speculating their spread in the changed circumstances with increased agricultural production (BWDB,1979).

4.6.6 Economic Justification

The economic analysis of the project was made only on the basis of an increased agricultural production due to better water control. Other benefits, such as improved employment opportunities, increases in farm income, better diel etc., are believed to be too difficult to quantity (BWDB,1979).

The benefits and economic rate of return of the project are summarized in the Table 4.14. A senstivity test was also made and the results are given in the Table 4.15. It can be noted that the figures are quite impressive.

Table 4.14

Project benefits of CBP (in 1000 Taka)

Condition	Financial	Economic
Without		
Gross production value	320,180	409,770
Production cost	219,126	104,191
Net production value	101,054	305,579
Phase-I		
Gross production value	495,650	641,975
Production cost	302,192	136,328
Net production value	193,458	505,647
Project benefits	92,404	200,068
Phase-II		
Gross production value	718,350	960,600
Production cost	375,582	178,929
Net production value	342,767	781,671
Project benefits	241,713	476,092

Source: BWDB (1979).

Table 4.15

Summary of IRR(%)

Condition	Phase-I		Phase-II	
	Financial	Economic	Financial	Economic
1. Proposed project	11.4	26.5	15.8	30.8
2. Proposed project minus fisheries losses	10.2	24.2	14.3	29.0
3. Proposed project with increased investment [1]	10.4	24.6	14.9	29.3
4. Proposed Project with reduced yields [2]	8.2	22.6	13.4	28.1

Note: (1) Increased investment for phase-I include 10% higher investment and maintenance costs on embankment and drainage works. An additional 20% for irrigation works has been assumed for phase-II.

(2) The Projected annual increase in yields have been reduced by 20%.

4.7 Dhalai River Project

4.7.1 History and Description

The Dhalai River Project (DRP) of BWDB is of recent origin. The feasibility studies of the project has only been completed in May 1986. Flood in the Manu and Dhalai basin is a regular feature which destroys crops almost every year. In 1984, flood destroyed crops, damaged properties, cut off communication links both by railway and highway and washed away domestic animals.

In this circumstances, Dhalai River Project which is a flood control measure by embankments, was conceived. The project area comprises a gross area of 23,320 hectares in Moulavibazar district out of which 3,095 hectares undergo annual flood damage of crops. The total length of proposed embankment is 142 km with 9 drainage structures. Manu and the Dhalai are flashy and have many peaks in the rainy season because of nearness of the foot hills of the Tripura high land. During any intense rainfall there is rapid rise of water level in these rivers and the flood water spills over and inundates the project area. This occurs a number of times every year. Rice, namely Boro, Aus and Aman, is the main crop in this area. Intensity of rainfall determine the success or failure to get a good harvest of crop planted in the flood plain. The objective of DRP is to control these floods and the damages resulting therefrom. It may be noted that, at present there is no provision for irrigation facilities in the project proposal.

4.7.2 Agriculture

The proposed project is designed to improve the agricultural aspect of the area and the economic analysis is based solely on the benefits accruing from increased agricultural production.

As a result of flood protection, the project area in the future is expected to be free of crop damage caused by floods. Table 4.16 shows the estimated damage for different crops in the project area under the prevailing situation. The immediate benefit of the project, it can be said, would result from the prevention of flood losses of different crops. 50% of the area under rice (about 97% of the total cropped area) is already under HYV varieties.

Table 4.16

Damaged crop area of DRP area

Crop	Area down (he)	area fully damaged(he)	% of damaged area	Loss in Tons
T. Aus (local)	6,621	1,371	21	2,523
T.Aus (HYV)	6,438	1,030	16	2,945
T.Aman (local)	10,375	293	3	595
T.Aman (HYV)	7,421	380	5	1,033
Boro (local)	400	17	4	39
Boro (HYV)	361	34	9	97

However, more stress would be put to bring in more areas under HYV cultivation by properly motivating farmers. Apart from this, no major change is anticipated in the cropping pattern. The present and proposed cropping pattern are presented in Table 4.17. The cropping intensity which is now 176% would remain same under the proposed condition. However, application of optimum dose of inputs, in place of small quantity used at present, is recommeded and it is expected that the yield and production of different crops (mainly rice) would result from it (see Table 4.18).

Table 4.17

Present and Post-Project cropping pattern of DRP area

Crops	area in hectare	
	Present	Post-Project
Single Cropping		
1. T.Aman (local)	3,754	1,182
2. T. Aman (HYV)	983	3,553
3. Boro (local)	400	197
4. Boro (HYV)	361	558
5. Sugar cane	33	33
6. Orchard	66	74
Sub- total	5,594	5,597
Double cropping		
1. T. Aus (local) followed by T. Aman (local)	5,934	2,931
2. T. Aus (HYV) followed by T. Aman (HYV)	6,006	9,009
Sub-total	11,940	11,940
Tripple cropping		
1. T. Aus (local) followed by T. Aman (local & rabi	687	746
2. T. Aus (HYV) followed by T. Aman (HYV) & rabi	432	373
Sub-total	1,119	1,119
Total	18,656	18,656
Compared area	32,834	32,834
Cropping intensity	176%	176%

Table 4.18

Present and future acreage and yield of diffierent crops

Crops	Area(ha)	yield(ton/ha)	Total production
T. Aus. (local)	5,250	1.84	9,660
	(3,677)	(2.03)	
T. Aus (HYV)	5,408	2.86	15,467
	(9,382)	(4.15)	
T. Aman (local)	10,082	2.03	20,466
T. Aman (HYV)	(4,859)	(2.3)	
T. Aman (HYV)	7,071	2.95	20,859
	(12,935)	(4.15)	
Boro (local)	383	2.30	881
	(197)	(2.76)	
Boro (HYV)	327	2.86	935
	(558)	(4.61)	
Potato	495	9.12	4,514
	(495)	(13.83)	
Chillies	197	0.55	108
	(197)	(0.74)	
winter vegetables	394	10.97	4,322
	(394)	(13.83)	
Oilseeds	33	0.65	21
	(33)	(0.74)	
Sugarcane	33	42.31	1,396
	(33)	(55.3)	
Orchard	66	1.75	1,155
	(74)		

Note: Figures in brackets are future values.

Source: Adopted from BWDB (1976).

The presently used inputs and recommended quantity of inputs are shown in Table 4.19. At present, measures are also used along with chemical fertilizers and no pesticide is used. The feasibility report recommended to replace the use of manure by chemical fertilizers and to introduce the use of pesticides.

Table 4.19

Inputs presently used and recommend for future

crops	human labour days		animal labour days		fertilizer(lbs)	
	present	fut.	present.	fut.	present	fut.
Aus(local)	164	172	52	54	124	152
Aus(HYV)	178	190	52	69	160	159
T.Aman(local)	164	172	52	60	107	152
T.Aman(HYV)	178	196	52	60	173	181
Boro(local)	172	196	52	54	96	152
Boro (HYV)	192	212	52	60	146	318
Potato	140	216	52	64	203	234
Chillies	126	148	40	44	140	157
Vegetables	176	290	44	54	238	225
Oilseeds	70	108	38	44	158	212
Sugarcane	210	300	44	60	209	460
Orchard	160		30		335	

4.7.3 Other Benefits

The feasibility report of Dhalai River Project is unique in that it did not mention any other benefits apart from flood loss prevention and increase in agricultural activities.

However, the farm budget analysis for an ideal farm of 1.95 hectares for a family size of 7.3 persons points out that the net crop income would increase from a present value of Tk. 3,399 to Tk. 9,679 after project implementation. The living standard is also expected to increase with it.

4.7.4 Economic Justification

The net value of the expected additional annual crop production with the project amounts to Tk. 185.16 million per year in financial term and Tk. 318.80 million year in economic term. The internal rate of return of the project is 36% (financial) and 51% (economic). The ratio of benefits to cost, using an interest rate of 15% and 20% for discounting future benefits and cost to their project worth is 3.15 and 2.25 in the financial terms and 5.42 and 3.87 in the economic terms. It can be noted the economic analysis is solely based on agricultural benefits.

A sensitivity test was performed on the result of both financial and economic rate of return, the objective of which was to evaluate how sensitive the economic criteria are to changes in the major assumptions underlying the basic evaluation. The results are summarized in Table 4.20 from which it can be seen that the project is still fairly feasible even considering worse conditions than the assumptions for the basic evaluation.

Table 4.20

Sensivity analysis of benefit-cost ratio for DRP

Assumption	B/c ratio (fin).		B/c ratio (eco)	
	(15%)	(20%)	(15%)	(20%)
1, Normal implementation	3.15	2.25	5.42	3.87
2. 10% cost increase	2.86	2.04	4.92	3.52
3. 20 cost increase	2.62	1.87	4.51	3.22
4. 30% cost increase	2.42	1.73	4.17	2.98
5. 10% benefit decrease	2.83	2.02	4.88	3.48
6. 20% benefit decrease	2.52	1.80	4.33	3.09
7. 30% benefit decrease	2.20	1.57	3.79	2.71

4.8 Discussion

The review of the six projects leads to the conclusion that the increased agricultural output has been taken as the primary benefits in every flood control project in Bangladesh and that the secondary benefit components are not taken account of although in some cases their mention has been made. The economic analysis of these projects has largely ignored the indirect and secondary benefits except in the case of Meghna Dhonogoda irrigation Project where the reduction in the cost of transportation and navigation was taken into consideration although neither the basis of calculation nor the contribution of it was spelled out in the feasibility study reports. The feasibility study report of Dhalai River Project in unique in the sense that it even did not mention any benefits other than increased agricultural production. In other cases, however, the other benefits came into discussion, although not into economic analysis. The complexity in the quantification of indirect and secondary benefits has led some agencies such as US Soil Conservation Service to estimate indirect benefits from direct benefits based on percentages originally derived from case studies (James & Lee 1971).This organization uses percentages ranging from 5 to 20 depending on the type of direct benefits from flood control. Besides, the US Bureau of Reclamation has estimated the secondary benefits associated with the production of agricultural crops as a percentage of direct benefits. Typical values for rice and vegetables are 18% and 29% and a uniform percentage of 18 is recommended for induced-by benefits. Very high values have been suggested by Marts(1956) who developed a methodology for estimating local secondary benefits which gives values ranging from 112 to 174 percent of direct benefits. Nothing of that kind is practiced in Bangladesh, leading the planners/engineers to abandon the indirect benefits all together from the economic analysis. While MPO (1985d) has shown some concern about the importance of indirect and secondary benefits, it did not recommend any method to incorporate them into the economic analysis.

The sensitivity analysis of internal rate of return of the projects has been done in most cases but, while they include the variation of IRR with cost increase, reduced yield, delay in construction and reduction of price, they overlook the sensitivity of IRR to the inefficiency in agricultural input distribution or farmers inability to afford these inputs. Considering the fact that the economic analysis is solely (or nearly so) based on increased agricultural production and that this production is largely dependent on proper input utilization, the sensitivity test of IRR with respect to input utilization seems logical and necessary in order to obtain a clear picture of the projects' possible viability.

In case of almost every project (except Dhalai River Project) it was expected in the feasibility study reports that the increased agricultural production would induce the development of small industries, particularly agro-based ones. But no particular program or direction is mentioned so that the improved infrastructure as aresult of agricultural output and associated higher living standard can be exploited to acheive this goal.

The impact of flood control projects on fisheries, which may have adverse ecological effects, was identified as negative benefit in some of the cases. In case of Meghna-Dhonogoda Irrigation Project and Karnafuli Irrigation Project(Halda Unit), special studies was called for in this regard.In case of Chalan Beel Project, the adverse impact on fisheries was found substantial and use of fertilizers and artificial feeds was recommended in the feasibility report to overcome it. It may be noted that, in case of Chandpur Irrigation Project, nothing more than guessing a probable reduction of fish catches was mentioned in the feasibility reports. MPO (1985) also observed that, in Bangladesh, flood control, drainage and irrigation projects have been executed ignoring largely their negative impacts. For example, flood control embankments and drainage improvements raise production of monsoon crops but drastically reduce fishery potential and decrease groundwater recharge vitally needed to irrigate dry season crops.

Chapter 5

EVALUATION OF CHANDPUR IRRIGATION PROJECT

5.1 Introduction

It has already been said that most water development projects in Bangladesh have more than one component like flood control, drainage, irrigation, agricultural extension service and other rural development programmes. The project chosen for the present study, i.e., Chandpur Irrigation Project, is no exception, presenting special difficulties in separating the benefits and impacts that can be attributed to the prevention of flood alone because increase in agricultural production which is the primary index to estimate the impact of the project, does not lend itself to be identified with any single improvement such as flood prevention or irrigation water supply. Moreover, the motivation by agricultural extension officials for adopting improved techniques, institutional credit supply, cooperative activities etc. continues throughout the year and also varies from year to year and time to time within a year. Besides there are other development programmes such as the hatchery for fisheries development at Raipur within the project area. The impact of all these must be reflected on agricultural performance of the project area as well as on the living standard of the people. All these indicate that every change in the project is dependent on several factors and any attempt to isolate their impacts completely is rather difficult.

However, if we neglect the influence of everything other than flood control and irrigation water supply, the problem becomes much simpler. And as these two factors contributes to the project at two distinctly separable time-spans, it is possible, at least to an appreciable extent, to separate the benefits of them and thus evaluate the impacts of flood control in this project.

Considering that agriculture is by far the most important activity in the project area and that the lack of data on other minor sides makes their admission into any quantitative analysis difficult, it is quite logical to use agricultural performance as the major index to evaluate the project impacts.

Figure 5.1 shows a typical cropping pattern for Bangladesh along with the time and duration of occurrence of floods and need for irrigation water. It may be noted that any improvement of kharif-I and Kharif-II crops can be attributed to the flood alleviation of the project area. For boro rice and rabi crops, irrigation water supply is mainly responsible for any enhanchment in crop yield and intensity and to certain extent, flood prevention is helpful where there is early monsoon flood during the harvesting time for boro and some of the rabi crops. But in case of CIP there was no problem of pre-monsoon flood which is a problem generally found in hilly areas. Therefore, the change in boro or rabi crops in CIP cannot be attributed to flood prevention. In other words, flood prevention contributes to Kharif-I and Kharif-II crops while irrigation facilities to boro and rabi crops. This principle would be employed in separating out the benefits of flood control from that of irrigation facilities in CIP area.

5.2 Impact on Agricultural Sector

5.2.1 Cropping Pattern

Improvement in the cropping pattern was among the most direct, tangible as well as immediate benefits expected from the project. No doubt, radical changes have taken place in cropping pattern, but the target that all areas would be brought under HYV aman during monsoon and HYV boro during the dry season, could not be realized until 80-81 after which more than what was expected was achieved (Table 5.1).

Table 5.1

Replacement of traditional crops by HYV's

Area under HYV's as % of cultivated area	Expectd as in 1972 World Bank Appraisal	Actual Acheivement		Actual Achievement as % of expected	
		80-81[1]	83-84[2]	80-81[1]	83-84[2]
-Aus/Boro season	71	55	86	77.5	121
-Aman season	55	11	60	20.0	109
-Aman season (including LIV)	55	41	69.5	74.5	126

Source: [1]BUP (1982) and [2]based on data collected during field trips.

The pre-project cropping in the project area consisted mainly of low-yielding traditional deep-water aman mixed with aus or jute and usually followed by fallow or low-yielding cash crops in the winter season (see Table 5.2). It was expected that winter irrigation would allow cultivation of high-yielding IRRI boro or early T. Aus and with flood protection and drainage, cultivation of IRRI T. Aman would be possible (IDA 1972a). Changes have taken place towards this direction but in a slow manner. A glance at Figure 5.15 will help visualize the gradual replacement of traditional varieties by HYV's while Figure 5.5, 5.7 and 5.9 show how the land devoted to HYV's paddy increased from almost zero to dominating values during last ten years. All of these figures indicate that tremendous change took place in the use of land for different types of paddy. The farmers, being poor and eager for immediate benefits out of their labour, are turning to HYV's whenever possible. But sometimes it is not possible. For instance, in low-lying part of the project and high lands, due to high flood level during heavy monsoon rainfall and shortage of water respectively, HYV's cannot be grown satisfactorily (BUP 1982).

Most obvious of the changes that has taken place after the project completion, are the introduction of HYV's and crop being grown one after another without any fallow period. This is in harmony, at least qualitatively, with the projections made during the appraisal.

Table 5.2

Cropping pattern of CIP before and after project.

Pre-project	Post-project
1. Mixed aus and aman paddy either with or without rabi crops.	1. T. Aman (HYV/LIV) followed by Boro (HYV) followed by Aman (next year).
2. B. Aman followed by rabi crops.	2. T. Aman (local) followed by rabi crops followed by T. Aus (HYV/LIV) or B. Aus followed by aman (next year).
3. Aus and T. Aman with or without rabi crops.	3. B.Aman followed by Boro (HYV) followed by Aman (next year).
4. Jute followed by rabi crops.	4. B. Aman followed by rabi crops followed by T. Aus (HYV/LIV) or B.Aus followed by Aman (next year).
5. T. Aman or IRRI followed by rabi crops without irrigation.	5. T. Aman (HYV/LIV) followed by rabi crops followed by jute or T. Aus (HYV/LIV) or B.Aus followed by Aman (next year).
	6. T. Aman (HYV/LIV) followed by rabi crops followed by Boro followed by Aman (next year).

It was found in BUP(1982) study that in villages inside CIP during Kharif-II season, about 81% of the land was under cultivation while that in control villages (outside CIP) was found 67%. This indicates that the project objective of brining all land under cultivation was not fully achieved. A significant portion of the land in the project villages was still single cropped at that time. In Charbasanta, for instance, about a third of the land was single cropped with HYV boro. There are low lands which remain highly flooded during the monsoon season making cultivation impossible. On the other hand, in Charkrishnapur, the high land village, about one fifth of the land was single cropped with rabi crops (BUP 1982).

In Kharif-I season, B. Aus and Aman (mixed) and B. Aus (local) were the two prominent crops that occupied about 60% and 23% of the total land cultivated respectively in 75-76. Jute and sugarcane was cultivated on 14.5% and 1.5% of total land respectively at that time. The corresponding figures in 76-77 in MDIP were 29% for B. Aman and Aus (mixed), 3% for B. Aus and 16% for jute (Thompson 1986). But soon after the project completion, B. Aus (local) emerged as the dominating crop accounting for 25% of the cultivated land along with T. Aus (HYV) occupying about 17% of land in 80-81. This situation did not prevail for long as high-yielding began to replace traditional varieties. The important ones among them are T. Aus (LIV), B. Aus (HYV), T. Aus (HYV) and B.Aus (LIV) which were cultivated on about 19.5%, 18%, 14% and 13.5% of the total land available for kharif-I crops in 85-86. At the same time, jute and B. Aus (local) occupied about 14.2% and 13.8% of land. The land devoted to kharif vegetables has increased from about 1% in 75-76 to about 3.5% in 85-86. The corresponding figures for sugarcane are 1.6% in 75-76 and 3% in 85-86. These changes are not as significant as the changed in rice varieties which is the main characteristic of the impact of flood prevention on kharif-I crops.

Before project implementation, low -yielding rice varieties were dominating in kharif-II season. For instance, in 75-76, B. Aman and Aus (mixed), B. Aman (local) and T. Aman (local) were the only three crops cultivated in CIP area and accounted for 45%, 32% and 23% of total land available in kharif-II season. It may be compared with the situation in MDIP in 76-77 where B. Aman was the only crop occupying 34% of the total cultivable land. However, from that time, high-yielding varieties were being introduced gradually but traditional varieties dominated the cropping pattern until 78-79, the year of completion of embankments, when T. Aman (LIV) accounted for about 37% of the cultivated land in kharif-II season followed by local T. Aman (23%). The trend of replacement of low-yielding varieties by high yielding varieties continued uptil latest available data(85-86) wherer about 90% of the land available was under high-yielding varieties. In this crop year T. Aman (HYV) and T. Aman (LIV) occupied about 57% and 33% of total land followed by local T. Aman (10%), the only traditional variety of any siginifcance. Thus, the impact of the project in kharif-II season is one of introducing HYV's and replacement of broadcast varieties by transplanted varieties for surviving traditional rice varieties. However, in some of the low lying areas such as Charbasanta, the percentage of land for HYV aman was found to be as low as 1.26% in 1981 compared to 10.64% for the whole CIP area (BUP 1982). This indicates that these low-lying areas are still vurnerable to flooding due to heavy monsoon rain and poor drainage.

Changes have also taken place in cropping pattern in boro and rabi crops but unlike kharif-I and kharif-II, these are not the result of flood prevention. Rather changes in these crops are dependent on irrigation facilities. The land devoted for HYV boro started increasing gradually from before the project and after project its rate enhanched (Figure 5.9). On the other hand, land for other boro varieties decreased almost to nil after project implementation. The land under wheat increased from negligible amount of 12.5% of total area under rabi crops. The area under potato and sweet potato varied widely over last ten years with apparently no distinct trend. The areas under rabi vegetables and oil seeds have increased after project while that under pulses, chillies and spices show no orderly trends.

There has also been drastic change in the utilization of land for different crop seasons (Figure 5.14). After embankment construction in 1978, the land under kharif-II has increased slightly and has assumed a more or less stabilized value which is nearly 70,000 acres. But for kharif-I, the land cultivated has decreased almost 3 times and is now more or less at equilibrium (nearly 25,000 acres). For rabi area, the situation is similar except that it is showing a slight increasing tendency after 82-83. Land under boro rice has increased almost 3 times and is now stable around a value of 50,000 acres. This change is obviously due to, among other things, high yield per acre of HYV boro which is obviously farmers' preference if irrigation is available. The total amount of land cultivated round the year, i.e., the sum of lands used for crop seasons, decreased from 189,514 acres in 76-77 to 157,141 acres in 79-80 due to land aquisition for embankment and other facilities of the project. However, this total land utilization is increasing gradually since then and is equal to 175,804 acres in 85-86. It also reflects the increase in cropping intensity.

5.2.2 Cropping intensity

Cropping intensity in the project area has also shown distinct trends as illustrated in Figure 5.18. It was between 160% to 170% in the pre-project days and in 1981, according to the BUP survey in some villages inside CIP, it became 206% while it was found 188% in some adjacent villages outside CIP. The trend of cropping intensity of Matlab Upazilla (MDIP is a part of it), which is adjacent and be considered nearly identical to CIP ara, is also shown in Figure 5.18. In the year 83-84, the cropping intensity of CIP area was reported to be 225%. But, considering the trend of cropping intensity of Matlab Upazilla, it would be incorrect to attribute all the increase in cropping intensity to the flood control or irrigation water ensured by the project. A part of the improvement must have been due to other factors such as the farmers acquintance with new cultivating techniques, availability of different inputs (improved seed varieties, fertilizer etc.) and efforts of agricultural extension services. While it is easy to mention these factors, it is very difficult to separate out their individual role in the increase of cropping intensity.

It was due to the introduction of HYV boro and kharif-II crops that this increase in cropping intensity has been acheived. The cropping intensity of kharif-II has increased tremendously while that of kharif-I (trditional varieties) has decreased considerably. With cultivation possible round the year, farmers selected Aman and Boro combinations. This explains the decline in cropping intensity of kharif-I and the rise of boro. Had the irrigation facilities not been there to make the cultivation of HYV boro possible, the performance of kharif-I could have been much better in terms of cropping intensity. So it can be concluded that a part of the potential benefit of flood prevention has been masked by irrigation facilities in this project. Large variation in crooping intensity from village to village is observed which is mainly due to the variation in land elevation.

In 1981 the lower lands, cropping intensity was found 170%, indicating only marginal improvement and in the higher lands, it was found as high as

252% (BUP 1982) and similar trends are still present. The reason is possibly that in low-lying areas, considerable land is still unutilized because of drainage congestion problem. In this connection, it may not be irrelavent to mention that the Chandpur BWDB office has identified the lands lower than 7 ft PWD (1898 acres) as non-arable land.

5.2.3 Crop yield and production

Before the project, the area had two problems - one was the excess water during floods and the other was the lack of water during the winter season for agricultural use. That is why it is not surprising that the crop yield was low due to these natural hazards in the pre-project days. However, the situation has changed after the completion of the project. The yields per acre of different types of paddy as well as other crops have gone up as may be seen in Table 5.3.

As paddy is the major crop grown in the CIP area as well as in other parts of the country, its yield and production deserves special attention. Different paddies in the kharif-I and kharif-II seasons have been benefited substantially which indicates the positive impact of flood protection component of the project. Increases in winter crops is also there indicating benefits from irrigation. The average of all paddy yields is shown in Figure 5.2.

The kharif-II crops have been benefited most from the project. It may be noted from Figure 5.11 that every crop of this season has increased in terms of yield. For example, yields of B. Aman (local), T. Aman (local), T. Aman (HYV) and mixed Aus and Aman have increased 64.5%, 46.2%, 35.6% and 50.4% respectively. The yield of T. Aman (LIV) which was introduced just before the project was commenced is about 30 mds/acre an average and this figure is greater than those for other local varieties (20-22 mds/acre). The yield of T. Aman (HYV) is at the top (48.8 mds/acre). This explain why farmers are shifting towards HYV cultivation.

The yield increase in kharif-I season, though has improved slightly, (Figures 5.6 and 5.10), is not satisfactory compared to the achievement in kharif-II season. The increases in terms of yield of B. Aus (local), mixed Aus & Aman and T. Aus (HYV) are 15.1%, 19.8% and 17.6%. There has been small changes in HYV aus yield. The increases in case of sugarcane, jute and kharif vegetables are quite good (66.8% , 40.1% and 43.7% respectivel). The yield of kharif vegetables is increasing gradually (Figure 5.13) while that of jute fluctuates with apperently no recognizable trend (Figure 5.12).

Positive impacts of irrigation water supply is quite evident in the yields of boro and rabi crops (Table 5.3, Figures 5.8, 5.12 and 5.13). The performance of rabi crops is comparable with kharif crops while that of boro is, considering increase in yield only, comparatively poor.

Table 5.3

Pre and post-project crop yields in CIP.

Crop	Pre-project average	Post project average	% incre- increase	Post-project highest with
Kharif-II				
B.Aman(local)	12.7	20.9	64.6	25.0 (80-81)
T. Aman(local)	15.6	22.8	46.2	30.0 (80-81)
T.Aman(HYV)	36.0	48.8	35.6	59.0 (80-81)
B. Aus & Aman	12.5	18.8	50.4	23.2 (83-84)
Rabi				
Wheat	20.5	23.5	14.5	24.8 (84-85)
Potato	112.0	158.5	41.5	196.1 (83-84)
Rabi vege- tables	113.3	178.4	57.5	198.6 (82-83)
Oilseeds	4.9	9.9	102.3	19.0 (79-80)
Pulses	5.4	10.	86.0	14.8 (83-84)
Chillies	5.8	7.2	24.9	9.9 (82-83)
Boro				
Boro(HYV)	49.7	60.4	21.5	70.0 (79-80)
Boro(LIV/local)	31.7	35.6	12.3	47.0 (79-80)
Kharif-I				
B.Aus(local)	15.2	17.5	15.1	21.6 (81-82)
B.Aus & Aman	12.6	15.1	19.8	18.0 (79-80)
T. Aus(HYV)	36.9	43.4	17.6	53.0 (79-80)
Jute	15.1	21.2	40.1	33.0 (80-81)
kharigf veg.	76.7	110.2	43.7	125.0 (83-84)
Sugarcane	384.7	641.7	66.8	800.0 (83-84)

One important feature that should not escape our attention is that most of paddy varieties had their peak yield in the immediately following years after project completion, i.e., in 79-80 and 80-81 (Table 5.3). This observavation has led some farmers and officials as well that natural soil fertility of the empoldered area is declining. Though this view is clear and straight forward, the contribution of declining fertility to the above-mentioned observation is not clear.

At this stage the comparison of CIP and MDIP may be helpful to evaluate the impacts of the project. Table 5.4 shows the yields of some selected crops in CIP and MDIP for the years 76-77 (pre-project) and 83-84 (post-project). The performance of CIP is good in case of B. Aman, Boro (HYV) and pulses. The yields of local boro and sweet potato which have undergone marginal changes in CIP, are well above their corresponding figures in MDIP. The 58% increase in the yield of mixed Aman & Aus has just enabled CIP performance to reach MDIP performance which was static during this period. This indicates that this crop was vulnerable in pre-project CIP area which is not the case in MDIP.

Though the positive impact of the project on crop yields cannot be denied, but one point is worth noting. The post-project highest yields of most of the crops are notably higher than the post-project average values. For instance, this figure for T. Aman (local) is 30.0 mds/acre and 22.8 mds/ acre respectively, for T. Aman (HYV) 59 and 35.6, for Boro (HYV) 70.0 and 60.4, for T. Aus (HYV) 53 and 17.6 and for jute 33 and 21.2.

Table 5.4

Comparison of yields of CIP and MDIP.

Crop	CIP[1]			MDIP[2]		
	76-77	83-84	% increase	76-77	83-84	% increase
M.Aman & Aus	10.7	16.9	58.0	19.9	19.8	-0.5
B. Aman	12.2	23.0	88.5	14.5	13.1	-9.6
Boro(HYV)	39.0	65.2	67.2	31.0	21.6	-30.3
Boro (local)	35.0	31.5	10.0	16.5	13.6	-17.6
Wheat	16.0	24.4	52.5	11.9	22.0	84.9
Jute	9.2	19.0	106.5	15.7	20.0	27.4
Potato	100.0	196.1	96.1	71.0	148.1	108.6
Sweet potato	200.0	188.0	-6.0	52.9	120.0	126.8
Pulses	6.0	14.8	146.6	6.0	8.0	33.3

Note: (1) based on unpublished data of CIP authority

(2) BWDB (1985) MDIP: Agn. Dev. Prg.

All these indicate that there is still ample scope to furthen the yields of diffierent crops possibly by using better inputs and efficient management.

The change in crop production is dependent upon the changes in cropping pattern and cropping intensity brought in by the project. Table 5.5 gives an overall picture of the changes in production of some selected crops in CIP from pre-project time till 84-85. The most remarkable change has taken place in case high-yielding paddy varieties which contributed almost nothing in kharif-I and kharif-II season in 75-76 but now contribute almost 96% and 89% respectively of the total paddy production in this two seasons.The change of in the production of different paddies over the last ten years is presented in Figure 5.16.

Apart from paddies, other kharif-I crops have also shown satisfactory rise in production. In case of some rabi crops, such as wheat, potato, oil seeds and rabi vegetables, the production has gone up gradually after the project. On the other hand, productions of millets, melons and sweet potato have decreased. Pulses, chillies and other spices reached their peak production around 79-80 and after that time are decreasing gradually.

Table 5.5

Total production of selected crops in CIP

Crop	75-76	78-79	84-85
Kharif-II			
Aman (HYV/LIV)		39,200	96,926
Aman (local)	38,348	18,991	4,308
Rabi			
Wheat	NA	2,645	3,245
Potato & S.Potato	6,421	25,765	25,516
Oil seeds	276	643	3,184
Pulses	879	4,041	1,042
Chillies	2,093	3,403	1,011
Rabi vegetables	22,812	5,785	24,506
Boro			
Boro (HYV)	3,802	37,580	94,024
Boro (local/LIV)	294	547	308
Kharif -I			
Aus (HYV/LIV)	218	24,861	11,992
Aus (local)	27,223	15,908	1,444
Jute	5,548	8,596	6,846
kharif vegetables	1,259	3,306	3,557
Sugarcane	12,062	30,857	21,131

Note: Based on data supplied by BWDB, Chandpur

Aman (HYV/LIV) = T. Aman (HYV) + T. Aman (LIV)

Aman (local) = B. Aman (local) + T. Aman (local) + T.Aman (Pajam) + mixed Aus and Aman

Aus (local) = B.Aus(local) + mixed Aus and Aman + B. Aus (Pajam) + T. Aus (local)

Aus(HYV/LIV) = B. Aus(LIV) + T. Aus(LIV) + T. Aus(HYV)

5.2.4 Agricultural Inputs use

The information regarding the use of different inputs to agriculture are not collected by any agency. So the detailed quantitative analysis could not be furnished. However, some facts emerged on the trend during the field investigation.

The Agricultural Extension Division of CIP assesses the demand of field requirement of seeds and BADC distributes seeds among the farmers. The farmers also retain seeds from their own harvest. Alamgir (1983) reported that there is no scarcity of seeds in the project area but the survey indicated that the HYV seeds are costly and farmers have difficulties in obtaining them.

Before 1981, TCCA under BRDB was the sole distributor of BADC fertilizers. Since then, dealership of fertilizer has been given to the private sector. The distribution and marketing of insecticides and pesticides were in the hands of private enterprises from much earlier time. The farmers complain that the prices of these three inputs are too high for them to afford (see Appendix B) and on the other hand, the extension officials say that had the farmers used these in proper quantity, the crop yields could have been increased far more.

After extensive survey work, BUP (1982) came to the conclusion that three main inputs labour, draft power and chemical fertilizer show substantial variation with the type of crop (see Table 5.6). The HYV paddies are highly labour intensive - both HYV aus and HYV boro involving more than 110 man-days, while pulses and mustard are the least labour intensive crops employing loss than 30 man - days per acre. Other relatively more labour-intensive crops include jute, potato and LIV aman.

The labour and fertilizer use is substantially higher in HYV varieties than traditional varieties indicating that the use of these inputs has substantially increased as a result of the project. It can be observed from Table 5.6 that the crops on which heavy dose of fertilizers have been applied are potato, HYV boro, HYV aus and wheat. On the other hand, cultivators use little fertilizer on B. Aman and most of the rabi crop.

Table 5.6

Per acre utilization of major agricultural inputs in CIP

Crops	Human-labor (man-days)	Animal power (pair-days)	Fertilizers (lbs)
B. Aus	119 (56)	7.28 (17)	79 (165)
HYV aus	174 (69)	8.42 (18)	289 (396)
Local T. aman	89 (65)	6.82 (18)	117 (200)
LIV aman	129	7.67	151
HYV aman	126 (71)	6.31 (18)	112 (334)
HYV boro	195 (71)	9.45 (19)	304 (396)
Chillies	93	7.12	38
Jute	159 (92)	6.66 (16)	146 (168)
Pulses	32 (30)	1.06 (9)	0 (69)
Wheat	86 (46)	7.46 (22)	226 (423)
Onion	87	2.35	2

Note: Figures within brackets indicate the recommended inputs by MPO (1984).

Table 5.6 shows that, while the human labour utilization is substantially higher than that recommended by MPO (1984), the animal power and fertilizers used in CIP is awefully less than recommended doses. This indicates the surplus of labourers and the inability of farmers to afford chemical fertilizers.

5.2.5 Population and food balance

In the feasibility studies, the population of the CIP area was estimated as shown in Table 5.7. Also the requirement of rice was calculated based on the assumption that the per capita consumption of clean rice would be 406.3 lbs per year in the improved future conditions as compared to 344 lbs at that time (EPWAPDA, 1969). On this basis, the food requirement of the project area was calculated for present and future conditions. All these have been presented in Table 5.7.

BWDB office of Chandpur also estimated the actual population on the basis of actual population census and it was found to be slightly higher than that estimated by EPWAPDA (1969). Table 5.8 shows the project population year wise. And, based on the Agro-Socio-Economic Survey of CIP in 1978 which indicates a per capita clear rice consumption per year of 360 lbs, the food requirement of the project area was calculated and comparing it with the actual paddy yield, the deficiency/surplus of rice was estimated.

Figure 5.17 shows the actual food requirement, estimated food requirement and actual rice production in the project area. It can be observed that, though the population growth was faster than estimated, the actual food requirement is still lower than projected values. This is because of the fact that the per capita per year consumption of clean rice which increase from 344 lbs in 1969 to only 360 lbs in 1978, is far from reaching its projected value, i.e., 406.3 lbs.

Also it is evident from the same figure that the margin between the requirement and production of rice in the project area is becoming norrower every year, indicating that the increase in production can no longer cope with the increase in population.

It was estimated that wheat consumption would be 8,000 and 8,700 tons in 1981 and 1986 respectively as compared to actual production of 2,576 and 3,214 tons in CIP area in 1980-81 and 1985-86 respectively. As for vegetables, the total production (rabi and kharif-I) in 1980-81 and 1984-85 were 14,754 and 24,063 tons respectively whereas the projected requirements were 33,200 and 36,300 tons for 1981 and 1986 respectively. It can be noted that while rice production has increased sufficiently to meet the requirements of CIP population, the production of other crops did not increase enough to match with the projected requirements.

However, the per capita consumption of fish in CIP area is 0.08 kg per day or 64.4 pounds per year which is much higher than 28.9 pounds per year per capita projected at the time of feasibility study. But this cannot be attributed to CIP but is a result of other development works in fisheries sector.

Table 5.7

Estimated population and food requirement of CIP area at feasibility stage.

Year	Population	Rice(clean) requirement	Paddy requirement
1968	540,00	97,900	146,197
1971	570,000	103,300	154,261
1976	625,000	113,300	169,195
1981	685,000	124,200	185,472
1986	750,000	136,000	203,093

Source: Adopted from EPWAPDA (1969)

Note: Average consumption 406.3 lb of clean rice per year or i.e., 7.4 mds(paddy) or 0.27 tons (paddy) per year as per East Pakistan Nutrition Survey Report, March 1965.

Table 5.8

Actual population and food requirement of CIP area.

Year	Population (000s)	Annual rice requirement (tons)	Annual rice production (tons)	Deficit/ Surplus
75-76	642	154,080	69,655	-84,425
76-77	658	157,920	67,855	-90,065
77-78	674	161,890	96,542	-65,348
78-79	691	165,914	134,535	-31,379
79-80	708	170,062	214,627	44,565
80-81	726	174,317	199,603	25,286
81-82	744	178,675	190,720	12,045
82-83	763	183,144	243,936	60,792
83-84	782	186,585	228,838	42,253
84-85	801	192,425	209,002	16,577

Note: Population growth @ 2.5% and per capita consumption @ 360 lbs (clean rice) per year, i.e., 6.56 mds (paddy) or 0.24 tons (paddy) per year as per Agri-Socio-Economic Survey, 1978 of CIP.

In an earlier section, it was mentioned that the irrigation facilities in the winter season had made farmers inclined to cultivate HYV boro instead of aus in kharif-I, thus decreasing the land devoted to kharif-I almost 3 times. It is interesting to investigate the situation with flood control alone without winter irrigation and to see rice balance under this hypothetical circumstances. It is logical that under those circumstances, the land for kharif-I would be 3 times the land presently used or approximately equal to the land used in pre-project days. This analysis is shown in Table 5.9 and it indicates that the paddy production under this condition varied roughly between 75% to 95% of the total paddy requirement of CIP area. It can be concluded that, with slightly more effort, only flood protection could have made this area self-sufficient in food grains.

Table 5.9

Food balance under the hypothetical condition of flood protection without irrigation(in 000 tons).

Year	Aus (total)	Aman (total)	3Aus + Aman	Reqr'd	3 Aus+Aman as % of reqr'd
79-80	27.0	80.9	161.9	170.0	95.2%
80-81	13.3	108.7	148.6	174.3	85.2%
81-82	24.8	62.8	137.2	178.7	76.8%
82-83	17.0	117.7	168.7	183.1	92.2%
83-84	14.9	93.4	138.1	186.6	74.0%
84-85	13.4	101.2	141.4	192.4	73.5%
85-86	22.8	105.3	173.7	197.1	88.1%

Note: Aus (total) includes all paddy of kharif-I
Aus (total) includes all paddy of kharif-II.

5.2.6 Impact on fisheries

A major impact on fisheries inside the polder is obvious because the open water system is replaced by a closed water system as a result of empolderment. The habitat of fish and shrimp would be reduced by a great extent due to any flood control scheme and obviously the impact on fishereis is severe inside the project area.

The feasibility reports CIP by LDL(1969), besides 'guessing' a probable negative impact on the fish culture, did not give any recognition to the effect on the living aquatic resources of the empoldered area. However, shortly after the appraisal of the project in early 1970, the Fisheries Directorate became concerned about the possible impact of irrigation and flood control development on the fishing industry in the project area. Subsequently, a survey was undertaken to estimate the possible impact that the shutting off the area from adjacent Meghna and Dakatia rivers by project works would have on natural carp and prawn restocking and the level of catch before the reactivated project was approved. It was believed, at that time, that the livelihood of 15,000 to 20,000 people might be affected by the closure of the project area (World Bank 1981). However, a brief survey indicated that some 3,000 full-time and an unknown number of part-time subsistence fishermen in the project area were likely to be affected by the project. It was also estimated that their total annual catch was around 1,000 metric tonnes of carp and 55 metric tonnes of prawn with a total market value of Tk. 2 million.

When the project was revised and taken up for implementation in 1976, a sub-project was included to provide facilities for propagation of fingerling carp and juvenile prawn to annually stock rivers, khals and ponds in the CIP area. And it was supposed to be completed by 1974, before the completion of the CIP constructions. But, just like the CIP itself, the fisheries sub-project could not be realized until 1980 when the a modern hatchery at Raipur became partially operational.

In the mean time the adverse effect of the project on the aquatic resources was acutely felt. In early 1977 when the regulators were first closed, it was reported that the daily catch and the number of fishing days has been significantly reduced. At that time a number of fishermen reportedly had pawned their fishing equipment to village money-lenders who then employed them on a share-catch basis to fish in various ponds which the money-lenders had rented. (World Bank 1981).

It is not possible to have a precise measure of the impact of the project on fish catch. However, the World Bank made an estimate of the loss. According to their estimate, the loss of fish and prawn catch amounts to Tk. 20 million in 1977, Tk. 40 million in 1978, Tk. 60 million in 1979, Tk. 40 million in 1980 and Tk. 20 million in 1981. The basic impacts of CIP has two distinct facets - one being the destruction of the riverine character of the habitat and the other being the restriction of the passage of fry, juveniles and adults of migratory species. Both prawns and finfishes were found to be affected by the project, but of course, in different ways. Even the three commercially important species of prawn of the total nine found in the area, experienced the impact in quite different ways. One prawn of small size escaped the adverse effects due to construction and operation of pump and regulator which a prawn of larger size has sufffered. The latter species showed a slight decrease in growth and its male-female ratio was 2.7 inside the project area as opposed to 1.3 outside the project (MPO,1984). Other species of prawns also were found to have undergone distortion in the sex ratio and their growth rate was found faster inside the empoldered envirenemerrt than outside. The regulated environment became the favoured habitat for growth, maturation and reproduction of the small, non-commercial resident prawns which, if left alone, could have replaced the important, commercial large prawns. But the Raipur hatchery interrupted the process.

Now let us see how the project affected the fisheries in the concerned area. The rivers, along with the numerous khals, are important for carp and prawn fishing. In particular, the area is one of the major sources of giant freshwater prawns, a source of export revenue for Bangladesh. The carp used to spawn in the nearby flowing streams while the prawns used to spawn in brackish waters, south of the project area. After the civil works, river and khal closures by the embankments prevented entry of the young fish and fish stocks ceased to be replenished. As a result, the fish catch and number of fishing days declined sharply making 3,000 fishermen out of work. Another change that the project has induced is that not only has migration into the area stopped but also any chance of natural breeding has been eliminated. It has also compounded the problem of aquatic vegetation and has reduced the nursery area for growth of natural fish and prawn stocks, i.e., the flooded paddy fields. (Directorate of Fisheries, 1982).

Though the effects of project are detrimental for the natural fishery, it is, benificial for a managed fishery, especially in ponds. Because flooding no longer occurs, more control over predators, wild fish and water quality is achieved, allowing much higher production under a well managed programme than from the natural fishery prior to the project. The Directorate of Fisheries is now working in this direction with Raipur Fish Hatchery and Training Centre as the inital step. In this centre, some 120 million hatchlings are produced annually and are distributed both inside and outside the CIP area. Also is there the facility to train local people in fish culture so that they can culture fish independently in their own ponds.

The changes in the ecosystem due to the regulation of water were beneficial for many coastal plain freshwater fishes which prefer stagnant water and their population increased after the project. Many other resident fishwater species showed no effect. On the other hand, many species of tidal/estuarine fishes were adveresely affected by the project. The most important among them are the Hilsa and major carp. In general the CIP has changed the fish fauna from a natural mixture of tidal/estuarine and freshwater species to a population of almost entirely resident freshwater species.

MPO (1985) has given some latest findings of the impact on fisheries as follows. Overall fish production from openwater resources within the project area declined 35% over the first 2 years of operartion of project. Since the embankment, some 18 species of tidal or estuarine origns fish are now obstructed from entering the river by the project regulators and embankments.

At present, this grave situation has been overcome by the activities of Raipur Hatchery. It is reported that the present consumption of fish is 64.4 lbs per person per year in the project area compared to 28.9 lbs per person per year projected during feasibility studies of CIP.

5.3 Social and environmental impacts

5.3.1 Employment opportunities

Agricultural Employment: The project has a positive impact on the agricultural employment, that is, the employment capacity of the area has increased in terms of man-days. The reasons of this increase are, in the first place, the change in cropping pattern itself and secondly the fact that labour requirement per acre of land is higher in transplanted paddy varieties compared to the traditional broadcast varieties. For example, labour requirement for local B. Aus is 72 man-days compared to 117 man-days for HYV aus per acre, or 55 for local T. Aman compared to 82 for LIV aman and 74 for HYV aman (BUP 1982). This study also estimated the increase is agricultural employment to be about 4.0 million man-days annually, about 55% increase over the without project situation. Indeed, the findings show an impressive increase in the use of labour per acre of arable land from 106 man-days to 162 man-days as a result of the project.

The increase of demand for labour has also been accompanied by an increase in daily wage during the peak period and from Tk. 6.75 to Tk. 11.25 during the slack period over a time span of 3 years (1978 to 1981) as compared to the national figures of from Tk. 9.44 to Tk. 13.98 over the same period (BUP 1982). During the visit to the project area in early 1987, it was found to vary from Tk. 60-80.

Another positive impact of the project is the reduction in the magnitude of seasonal under-mployment which is a chronic problem in the field of agricultural employment in Bangladesh. The slack period is generally from mid-July to mid-November at which time the seasonal under employment is found to occur.

Non-farm Employment Opportunities: The impact of the project on non-agricultural employment, which is still the primary occupation of most of the people, is direct and tangible. The estimates of the number of persons engaged in major non-farm activities by BUP(1982) before the beginning of the project and in 1981 are given in Table 5.10. As a result of the improvement of roads resulting from the prevention of flood, the number of rickshaw pullers increased from 961 in 1978 to 5,731 in 1981 and to over 7,000 in 1987 (see Appendix B). Rickshaw pulling and daily labourship were also indicated by some farmers as new opening brought by the project during the survey in 1987. The earning of a daily labour in CIP area is reportedly Tk. 70-80 while just outside the CIP area it is Tk 35-40. This is a result of the more labour consumption in farm activities. The BUP (1982) study also provides similar information that some of the rickshaw pullers had been construction workers or near-landless farmers before coming to this job.

Table 5.10

Changes in Non-farm Employment in CIP: 1978-81.

Non-farm Activities	No. of persons engaged		% increase over 1978
	1978	1981	
Rickshaw pulling	961	5731	496
Trade/business	3140	4440	41
Industrial/construction activity	4038	6779	68
Boatmen	2946	483	-84
Fishermen	1864	1707	-8
All activities	12949	19140	48

Source: BUP (1982).

Due to the boost-up in agricultural production and the rise in the living standard, the number and location of marketing centres, rice mills, bakery, repairing shop, restaurant etc. has also changed significantly. Table 5.11 summarizes the changes from 1978 to 1981, i.e., the initial years of the project.

Table 5.11

Development of Marketing centres of CIP

Type of activity	No. of units			No. of persons employed	Average increase in the size of business(%)
	1978	1981	% increase		
Rice mill	27	61	126	168	-15
Bakery	8	23	188	135	3
Repairing shop	21	48	129	98	32
Tea stall	81	127	57	604	25
Restaurant	21	39	63	232	19
Trading Construction Materials	36	71	97	134	34
Agricult-ural Inp-uts	45	73	62	157	26
Other Traders	57	68	19	158	12
Aratdars	103	70	-32	277	-25
All types	402	580	44	1963	13

Source: BUP (1982)

It may be seen from the table that the number of units has increased for every type of activities other than aratdars which might have reduced due to smooth transport facilities after the project. Along with the number of establishments, the quality of them has also improved. For example, during the visit in February 1987 to a remote village bazar in Faridganj Upazilla a tea stall was found decorated with modern ammenities such as refrigerator which is really rare in rural Bangladesh.

The size of non-farm activities has increase 44% as a whole. The increase in employment may be higher than this, because the enterprises have also reportedly increased in size of business after the completion of the project

(BUP 1982). The present situation, however, could not be analysed in this way due to lack of data, though officials as well as farmers indicated a significant rise in non-farm employment.

5.3.2 Transportation and navigation

The project has noticeable direct impact on the transportation and navigation system both within and across the empoldered area.

The embankment is being used exclusively as a road which provides access to otherwise difficult to reach regions such as Hayimchar. Some portion of it is brick-soled and the rest is still earthen which is vulnerable to rain-wash. Such embankment is made further vulnerable by the loosening of soils by cultivation of the berms. The top width (14 feet) of the embankment is enough for light vehicle movement and rickshaws.

The prevention of flood has made possible construction of rural roads with relatively lower height and at any time of the year. Hence the cost of road construction in CIP has decreased. This has not been quantified due to lack of data. Most of the work of this type is presently done under food-for-work program which is not generally well-documented. However, the new rural roads inside the polder area are at much lower level than those constructed in pre-project days as was seen during field evaluation.

After the completion of the project, the feeder roads are now usable even during the rainy season because of the flood protection and drainage provided by the project. Transport by rickshaws and old motor-cars has increased significantly along the embankments and interior roads.

The impact of CIP on river navigation is, however, negative. The percentage of navigable khals and channels inside CIP was around 75 before project which has reduced drastically after the project implementation mainly due to accumulation of water hyacinth and silting up of the channels. This has made transport by boat difficult and the importance of boats as a mode of transport is less compared to that of rickshaw (see Appendix B). However, the navigation locks are functioning smoothly and they are sufficient compared to the volume of traffic. The navigation accross the CIP which was possible before embankment construction has also severely affected but this was predicted in the feasibility studies and thus is not unexpected.

5.3.3 Water logging and drainage problem

Water logging is a problem mainly to some specific locations, one near the embankments and other at the low-lying areas adjacent to the South Dakatia. The original design and completed project, relied on the borrow pit canal, inside the embankment, to provide gravity drainage for much of the project area. However, drainage by this system proved to be too slow resulting in early floods in times of heavy rainfall, and water logging in areas close to the embankment (Thompson 1986). In one such case, the situation became so grave that the local people reportedly started cutting the embankment for the outlet of accumulated water. However, to overcome this problem, 6 manually operated sluices have been intalled - 3 on the western side and 3 on the eastern side of the area. The provision of sluices was in the original proposal but it was not contructed before the embankment was closed, thus leaving room for drainage problem just discussed above.

The low-lying area adjacent to the South Dakatia river was supposed to be used for pisciculture according to original plan which unfortunately was never realized. At present the regulated water of the South Dakatia, though necessary and justified for the overall project area, is doing harm to the agriculture of this area, specially during the monsoon. About 1000 acres of low-lying land experience about 20% damage in terms of yield (see Appendix B). In the mean time, small dykes have been built to protect this area from the overflow of the South Dakatia but there are instances of frequent breaches of them, possibly due to sub-standard design.

The canals, borrowpits and embankment are under the direct supervision of BWDB but the maintenance of them does not seem to be adequate. About 20% (or about 709 miles) of the canals inside CIP needs re-excavation every year but due to lack of fund this need is only partially met. Moreover, the water level on the land is higher than the water level at the canals as a result of LLP irrigation. This makes the seepage into the canal and subsequent loosening of bank soils and siltation in the canals. During the survey, everybody agreed with the severity of siltation problem. To avoid this problem farmers are advised to cultivable at least 10 ft away from the canal but unfortunately nobody pays any heed to this. In addition to this, the bamboo bridges (<u>shakos</u>) and fishing nets placed across the canals make the flow retarded.

All these along with water hyacinth, result in the poor drainage in the project area. This drainage problem is more pronounced at the south than the north. The Hazimara Regulator is frequently blocked by water hyacinth which even also blocked the Charbagadi pumps in 1978-79 boro season (Thompson 1986).

5.3.4 Water Hyacinth Problem

As a result of the river and canal closure from the outer rivers, the aquatic weed growth, mainly water hyacinth, has posed a serious problem to the project management. Before the project the water hyacinth used to be washed away with the flowing water from the project area into the adjacent Meghna river. But after the project it has stopped and the water hyacinth population is growing with unprecedented rapidity resulting into a menace. In some places it is causing the water flow to alarmingly low rate. This problem is often escalated by the bamboo bridges (small bridges made of bambo locally called shako) which bars the weeds to spread away into large area and thus raises intense localized problems.

A survey was conducted by the Fisheries Directorate and Small Environmental group in the CIP area in November, 1981, which aimed at determining the condition of the borrow pits, among others (Directorate of Fisheries 1982). It was found that 49.6% of the water area was covered with water hyacinth, 4.2% by water shield, 11.4% by hydrilla and only 34.4% was free from aquatic vegetation. This was the overall condition of the borrow pit canals along the 63 miles long embankment but the fact that, some portions of it such as at Haiderganj, North Debipur etc. were totally choked up with weed, should not escape our attention. Because at these places, water flow was dangerously barred by vegetation which subsequently is responsible for the poor control over water. Generally speaking, this problem is less intense in the northern portion of the project from where the water flows to the south. The situation was reportedly most grave near the Hajumara regulator through which the water of South Dakatia River falls into the Meghna River.

Submerged aquatic weeds can be controlled biologically by an effective grass carp stocking program. But though grass carp will feed on the roots of water hyacinth, but it will not usually effect any real control. Also it is expensive and time consuming to control it by chemical or mechanical means. So we are left with no alternative but to utilize our abundant man power to remove water hyacinth by hand and inexpensive small country boats. That seems to be the best idea as because the removed water hyeinth can be used to feed cows and other animals, to compost manure or to feed fish. However, it is difficult to demonstrate the direct monetary benefit of such a program to the general public and thus it sometimes seems best to awaken the social consciousness of the people first. In that way it may be possible to reduce aquatic weeds, which are sharing valuable nutrients of the fish, slackening the water flow harmfully and making problem to navigation, without putting much burden on the shoulder of government. The different village cooperatives can initiate such a program.

5.3.5 Cooperatives and credits

There had been cooperative activities in the project area from mid sixties, well before the project implementation. However, both in the feasibility studies and project proforma, it was noted that the formation of primary village cooperative societies would be the foundation of the 1200 LLP groups which would be organized within the project area (Alamgir 1983). As there are 1200 pump points within the project area, the necessity of forming pump groups for irrigation arose just after project completion. It may be noted that the formation of pump groups can be attributed solely to the project and that other cooperatives, though not been initiated by the project, have also been ifluenced by the project.

Important cooperatives, apart from pump grous, are Farmers cooperatives (KSS) Landless cooperatives (BSS) and Womens cooperatives (MSS). These are directed and administered by Upazilla Central Cooperative Association (UCCA). There are 6 UCCAs in the project area for 6 upazillas but the area of jurisdiction of them follow adminstritive lines rather than project boundaries. The present status of these cooperatives has been presented in Table 5.12. It can be noticed that KSSs are by far the most important organizations both in terms of members and total capital. Table 5.13 summarizes, the acheivements of KSSs from the project implementation. The decline in the number of KSS after 80-81 is due to the formation of pump groups which was apparently more attractive to the farmers. In other aspects, specially deposit per number among them, the KSS performance is positively good.

One of the most important services rendered by the cooperatives is to provide short term loans to the needy farmers.

Table 5.12

Cooperatives in CIP area upto January, 1986.

Activities	KSS	BSS	MSS	Total
Total number	987	176	148	1311
Members	47158	5672	4312	57142
Share deposit (local Tk.)	20.52	1.70	1.09	23.31
Total capital (local Tk.)	64.24	7.72	8.45	80.41
Loan recovery rate	76%	100%	100%	

Source: BRDB, Chandpur.

Table 5.13

Progess of KSS in CIP

Activities	77-78[1]	80-81[1]	Jan.,86[2]
No. of KSSs	880	1165	987
No. of members	33246	48647	47158
Average no. of member per KSS	37.78	41.75	41.70
Total share holdings (000 Tk.)	909.3	1702.6	2052.0
Share holding per member (Tk.)	27.35	30.00	43.51
Total deposits (000 Tk.)	2065.9	3889.5	6424.0
Deposit per member (Tk.)	62.14	79.95	136.22
% of household heads covered by KSSs	25.6	33.6	NA

Source : [1]BUP (1982), [2]BRDB, Chandpur

The loan recovery rate is good for BSS and MSS (100%) compared to KSS (76%). The cooperatives also encourage people to maintain personal accounts and thus save money. Generally, KSSs give credit for agricultural purposes, BSSs for handicrafts, carpentry, rickshaw groups, fish cultivation, milk cows etc. While MSSs give credit for some of the activities carried out by BSSs besides paddy threshing and processing.

The BUP (1982) study of the project area indicated that the existing situation at that time was impressive as a whole but also pointed out one factor that, when removed, would let the performance of KSSs improve still more. This is the fact that the joint responsibility of loan repayment has created problems for those who pay up their dues regularly.

Most interesting thing is, as Alamgir (1983) observed, that from the very initial stage the pump groups have been working separately from KSSs and there is no link between them. The primary objective of the pump groups is to organize a number of adjacent farmers to form the group and hire the pump for irrigation. In 1981, the total expenditure behind one pump was Tk. 11,814 or Tk. 386 per acre of land (BUP 1982). The rent per pump was Tk. 1,471 and fuel cost was Tk 2,594. Although originally administered by BWDB directly, pump charges are now collected via the UCCAs. The UCCAs pay all the hire charges to the BWDB and the collects the charges from pump groups.

Besides the various types of cooperatives. Bangladesh Krishi Bank as well as other nationalized commercial banks are now involved in the distribution of institutional credit among the farmers. And the purpose of the credit programmes is not only to enhance credit facilities for the land-owning farmers but also other groups such as sharecroppers, landless labourers, small traders and other disadvantaged groups in the rural areas (BUP 1982). There was not any noticeable difference of the project villages from the control villages in this regard in this study. It came out from the field investigations that the farmers face considerable problem in getting credit (see Appendix B) and the officials did not deny it wholly. But this is a common problem throughout Bangladesh.

5.4 Discussion

A flood control project may be said to be successful if there had been no instance of overflow of water from the adjacent rivers into the project area after the embankment construction. Of course, there might have been some cases of local floods due to drainage congestion resulting from heavy local rainfall. In 1981 such an event occured in CIP. This local flood of 1981, accompaned by lower LLps fielding and non-operation of turnouts (according to unpublished BWDB data, only 61 LLPs were fileded in kharif-II season of 80-81 as compared to 276 LLPs and 36 operational turnouts in the previous year) resulted in low crop yield (as low as pre project condition). But the role of different factors contributing to the poor agricultural performance in 80-81 can not be ascertained in any definite way. However, based on the limited information available, it can be said that the project performance is now more dependent on the operational and managerial efficiency of project authority.

Apart from the year 80-81, the overall agricultural performance is quite satisfactory, although there is still some scope of improvment through better irrigation and cooperatives. Conveyance of the drainage canals may be increased by re-exavating and cleaning water hyacinth and thus a better drainage condition may be created. Water hyacinth can be composted to produce natural manure. However, there seems to be no definite proposal or program in this regard either from authority or from farmers.

Improvement in the road transportation is one of the direct benefits of the project other than increased crop production. Indirect and secondary benefits in the areas of employment opportunity, development of cooperatives, food balance in the project area etc. were found to be significant. Navigation in the internal rivers and canals was the only area where, instead of expected improvement, the situation has rather worsened after project implementation. In pre-project days there was not sufficient water in the canals and khals in winter season which made nagivation difficult. It was expected that after project, the water level that would be maintained in dry season would make navigation possible. Unfortunately it was not the case. This is largely due to the presence of excessive water hyacinth in the canals.

The area most adversely affected by the project is fisheries and the fate of the fishermen. Management of this negative ecological impact was not duely considered by the beforehand. But subsequently development of closed water fisheries by Fisheries Directorate has demonstrated that the adverse effect on openwater fisheries can be overcome by replacing it with close water fisheries. This adverse aspect of the project could also be avoided from the beginning had the remedial measures been taken at the project implementation time.

The shift towards HYVs of rice is more than expected and this shows the farmers' willingness to accept new techniques without hasitation, once they realize their beneficial effects.

Chapter 6

Discussion and Conclusion

6.1 Flood Control Benefits: Evaluation adopted in Bangladesh

As there is no way to measure precisely the benefits from a proposed project beforehand, the determination of benefits is at best an 'intellegent guess' at the planning phase (Kuiper 1971). And the comparison of costs and benefits of a contempleted project at the project formulation stage remains largely a hypothetical exersice where the future costs and benefits are estimated by some 'suitable' methods. In Bangladesh, the benefits in agricultural sector is given the highest priority. As it came out from the review of the benefit quantification of the selected projects, only the benefits from agricultural sector are included in the economic analysis and are employed in the determination of the cost-benefit comparison.

However, evaluation of benefits from agricultural sector is related to several assumptions such as that effective cooperatives of farmers, sufficient input use, effective project management etc. would also be achieved in a desired manner along with protection from flood, irrigation facilities etc. Moreover, agreements are reached at and assurance is made by the government that proper input supply, organization of farmers, motivation of general people etc. would be ensured by government agencies like BADC, IRDP, BRDB etc. It is these assumptions and assurances that the projections are based upon but, unfortunately, it involves too many institutions and the optimum conditions are not always fulfilled as may be seen in the indepth study of Chandpur Irrigation Project. These constraints in the way of utilizing full project facilities have also been observed by many investigators. (MPO 1982, Bhuiyan and Nishat 1977, Thompson 1986, Biswas 1984,1985) for different water resources projects. Therefore, while estimating the projected benefits, due consideration should be given to the management and monitoring of the project and the responsibilities of different organization operating in the project area. It is no good to assume an optimum condition if it cannot be acheived in reality.

The next point regarding the benefit evaluation in Bangladesh is that there is neither any basis nor any attempt has been made to incorporate the secondary as well as indirect benefits into the economic analysis. Planners/engineers responsible for project analysis simply identify the secondary/indirect benefits without attempting to quantify them and thus improve the reliability of economic analysis of the project. As it was observed in Chapter 4, the economic analysis of five projects out of six projects was solely based on direct, tangible agricultural benefits. The only exception was Chandpur Irrigation Project where the direct benefits resulting from reduced navigation and transportation cost in the project area and domestic water supply were taken into account but no clear basis of their quantification was given in the feasibility report. While road transport has improved, the navigation has reduced after project implementation and, interestingly enough, nothing like domestic water supply can be heard in the project area. This happended because of the fact that no difinite way of evaluating benefits was prescribed by either IECO nor the then EPWPDA at that time. Uptil now, MPO has not come up with any definite proposal in this regard. Hence, attempt should be made to establish some relationship between secondary/indirect benefits and direct agricultural benefits for an agrarian country like Bangladesh as has been done in other countries.

Regarding the negative impacts or disbenefits of the flood control projects, only passing remorks have been made in the feasibility reports of four projects out of six. In case of Meghna-Dhongoda Irrigation Project and Chalan Beel Project, some concern is shown regarding the possible negative impact of the projects on open fisheries and recommendation have been made to compensate it by closed fisheries development. But there was no definite proposal prescribed nor the task was assigned to any particular organization. Development of closed water fisheries at a subsequent date in CIP has demonstrated that by proper culture of it, not only the negative impacts can be overcome but it may also be turned into a positive aspect. The drastic consequences of empoldering on fisheries has well demonstrated the intimate inter-dependence of water resources development and the environment. Therefore, these aspects deserve special attention and adequate investigation at the time of project formulation.

Lastly, the approach of evaluation so far adopted in Bangladesh may be described briefly. The development in any project area cannot be attributed wholly to that particular project alone. There are other factors such as diffusion of improved farming techniques from adjacent areas, activities of other rural development agencies and other aspects that take place with time rather than as a result of water development projects. In order to separate out the actual contribution of the project, 'pre- and post-projec' comparison which is extensively used in feasibility studies, alone is not enough. The improvement due to factors other than project itself is illustrated in Figure 5.11 which compares the changes in cropping intensity of CIP area and adjacent Matlab Upazilla. Therefore, in order to visualize the actual contribution of a project in future time, a 'with and without' evaluation is necessary (Figure 3.1).

6.2 Evaluation of the performance of CIP

In this study, a substantial effort was devoted to the evaluation of benefits from Chandpur Irrigation Project. As the data on agriculture from the time prior to completion of the project were available, the performance of CIP in this regard was evaluated in an eleborate manner. But the limitations put by insufficient data available on other sectors made it difficult to quantify the impact of the project in other areas. However, one thing came out of this study that the indirect and secondary impacts of the project are of considerable magnitude. And if they can be quantified properly and be incorporated with the agricultural benefits, then this knowledge can be applied to the planning of other new projects. The adverse impact of CIP on open water fisheries was also found to be of great importance but it also, like other indirect impacts, could not be quantified in such a manner as to permit its comparison with direct benefits.

Chandpur Irrigation Project has induced many positive improvements in the project area. Most visible among them is, of course, the change in agriculture. Radical change in cropping pattern has taken place as discussed in Chapter 5. The adoption of HYV rice varieties was quicker and the land under them is more than that expected. Protection from flood and provision of irrigation facilities have enabled farmers to use the land throughout the year. Whereas it was hardly possible to harvest two crops in the past, now three crops are being successfully harvested every year after the completion of the project. Cropping intensity has jumped from 160-170% in pre-project stage to 225% after project implementation. Yields for indivisual crops have also increased. For instance, the average increase in yield after project is 64.6% for T. Aman (HYV) 102.3% for oilseeds, 57.5% for rabi vegetables, 86% for pulses, 21.5% for Boro (HYV) 15.1% for B. Aus (Local), 17.6% for T. Aus (HYV), 40.1% for jute and 66.8% for sugarcane. It cannot be denied that these are great acheivements of the project. Consequently the total production of rice and other crops has increased tremendously which has made the project area food surplus from a food deficit one in spite of the fact that the actual population increase rate is more than the projected rate.

Employment opportunity has increased in agricultural sector as well as other non-farm activities. Different trade and comercial establishments have increased in number and size. The project has also reduced the seasonal under-employment which is a chronic problem in other flood prone areas.

Direct benefits are also obvious in case of road transport. Embankments are used extensively now as a road and the village roads are now accessible in monsoon. Navigation within the project is the only aspect where, instead of the expected improvement, the situation has rather worsened. Once this manece is under control, benefit in navigation be achieved as expected.

A probable adverse effect on open water fisheries of the project was 'guessed' during the feasibility studies but its magnitude could not be ascertained at that time and possibly proper attention was not paid to it. After implementation, the negative impact was found to be of great concern. Overall fish production from the open water resources within the project area declined 35% over the first 2 years of operation of project and some species of higher commercial value (such as giant prawns and hilsa) disappeared from the rivers and canals. The impact of CIP on fisheries is a glaring example of the ecological consequences of water development projects in Bangladesh. But at the same time it shows how successfully the adverse impacts can be overcome by taking proper remedial measures.

6.3 Conclusion and Recommendations

Based on the methodology adopted for this study as discussed in Chapter 3, six projects were studied to obtain the general pattern of benefit evaluation in Bangladesh and one project was taken for indepth evaluation. This study has led to the following conclusions which are discribed here along with some recommendations.

1) Only agricultural benefit which is direct and tangible is quantified

during the time of project formulation. All other benefits are excluded from the economic analysis.

2) The benefits in agricultural sector are evaluated by comparing pre and post-project situation based on some assumptions such as effective cooperatives, improved cropping pattern, ensured input supply and their proper use, efficient project management etc. which may not always be acheieved in reality. It may be recommended that more realistic assumptions should from the basis of benefit projection.

3) Benefits other than agricultural benefit are not quantified. But the indepth investigation of CIP reveals that (a) direct and trangible benefits in transportation and navigation, (b) indirect and tangible benefits from enhanced trade, commerce and other non-farm activities, (c) direct and tangible benefit from increased agricultural employment, (d) indirect and tangible benefits from increased employment opportunity in trade, commerce and construction and (e) direct and tangible disbenefits from reduced open water fisheries resources do occur. Therefore, these benefits (and disbenefits) should be quantified and should be included in economic analysis of the project.

4) In a project where both flood protection and irrigation are provided (as in CIP), the benefit from Kharif-I and Kharif-II may be broadly attributed to flood protection and that from boro and rabi crops to irrigation facilities.

5) Major changes have taken place in agricultural sector within three years of project implementation. After that the performance of CIP in agriculture have stabilized with some minor and incidental variations.

6) At the time of project formulation, the benefit evaluation is mainly based on a pre- and post-project comparison but at the same time a with and without project comparison may be done in order to obtain a greater insight into the viability of the project.

7) In some countries like USA the indirect/ secondary benefits are estimated as a percentage of the direct benefits originally derived from case studies. Nothing of that sort is used in Bangladesh. Hence it may be recommended that such relationship between direct and indirect benefits be established and be used in project planning.

8) Impact of flood control projects on open fisheries is drastic but can be compensated for by replacing it with managed closed water fisheries.

6.4 Suggestions for further studies

The experience gathered during this study has opened many possible avenues in which further research can be extended. Some of the most important ones are discussed below and are recommended for further studies.

1) Further research may be done to establish some relationship between direct and indirect/secondary benefits of water development projects in an agrarian country like Bangladesh so that this knowledge can be exploited properly in the time of formulating new projects. This will necessitate, of course, indepth and thorough evaluation of some completed projects on a large scale of study.

2) The lack of organized information is a big obstacle in the way of carrying out a study like the present one where a reliable data base is required for analysis. The huge amount of data gathered by the benchmark survey of BUP (1982) may be properly utilized if a survey of similar magnitude is done in future. This would enable to evaluate the long -term impacts of CIP.

3) The adverse impact of CIP on open water fisheries is enormous but it could not be quantified due to lack of data. However, investigation is being carried out by Directorate of Fisheries in this regard. Future research may be carried out to generalize their findings for other projects. In this connection, the water hyacinth problem can also be studied.

4) Research work may be directed towards finding the cause of drainage congestion and water logging problem in CIP. The variation of agricultural performance with land level may also be investigated at the same time.

Bibliography and References

Adams, H. W.(1956), Economic Aspects of Flood Plain Zoning, ASCE, vol. 82, paper 882, 1956.

Alamgir, A. T. M.(1983), Chandpur Irrigation Project: Cost & Benefit, december, 1983, Comilla.

Appelbaum, S. J.(1985), Determination of Urban Flood Damages, ASCE, March, 1985.

Bangladesh Directorate of Fisheries with Snell Environmental Group(1982), Fishery Development in Irrigation and Flood Control Systems, Fifth Annual Report, August, 1982.

Bennett, N. B.(1958), Cost Allocation for Multipurpose Water Projects, ASCE, 1958.

Bhuiyan, S. I. and Nishat, A.(1977), Evaluation of Constraints to Efficient Water Utilization in Small Scale Irrigation Schemes in Bangladesh, paper presented at the National seminer on "Water Management and Control at the Farm Level" held in Rangoon, February, 1977.

Biswas, A. K.(1984), Monitoring and Evaluation of an Irrigation System, International Journal of Water Resources Development, vol. 2, no. 1, 1984.

Biswas, A. K.(1985), Evaluating the Impacts of Irrigation Projects, paper presented in the seminer on "Methodologies to Evaluate the Performance of Irrigation Systems" held in Dhaka, June, 1985.

Bowles, E. M.(1965), East Pakistan's Master Plan for Water and Poewr Development, ASCE, vol. 35, No. 8, August, 1965.

BUP(1982), A Socio-economic Evaluation of the Chandpur Irrigation Project, June, 1982, Dhaka.

BWDB(1977), Feasibility Report on Barnal-Salimpur-Kolabashukhali Project, prepared by Special Project Preparation Cell, Dacca, October 1977.

BEDB(1977), Feasibility Study Report of Meghna-Dhonogoda Irrigation Project, prepared by Chuo Kaihatsu Corporation and Prokoushali Sangsad Limited, Tokyo, August 1977.

BWDB(1979), Feasibility Report on Chalan Beel project, prepared by NEDECO, The Hague, July 1979.

BWDB(1985), Meghna-Dhonogoda Irrigation Project: Agriculcural Development Program, prepared by Chuo Kaihatsu Corporation and Prokoushali Sangsad Limited, June 1985.

BWDB(1985), Meghna-Dhonogoda Irrigation Project: Operation & Maintenance and Water Management Manual, prepared by Chuo Kaihatsu Corporation and Prokoushali Sangsad Limited, June 1985.

BWDB( ), Chandpur Irrigation Project, Chandpur.

Camacho, R. F. and Bottomley, A.(1978), The Use of Input-Output Analysis to Estimate Secondary Economic Benefits of irrigation Schemes, ICID, vol. 3, 1978.

de Jong, B. H. J.(1982), Ecological Impacts of Polder Construction in Suriname, in The Polders of The World, ILRI, The Netherlands.

Debo, T. N.(1985), Urban Flood Damage Estimating Curves, ASCE, July, 1985.

Demirci, Z. and Yapici, Y.(1978), Economic Evaluation of Reclamation Projects and Tokat Reclamation Works in Turkey, ICID, vol. 2, 1978.

Engineering Science Limited(1986), Report on Evaluation Studies of DFC-1: Chelchuri Beel Sub-project, November, 1986, Dhaka.

Engineering Sciences Limited(1986), Report on Evaluation Studies of DFC-1: Kolabasukhali Sub-project, November, 1986, Dhaka.

EPWAPDA(1967), Feasibility Report for Meghna-Dhonododa Irrigation Project, prepared by Techno-Consult, January 1967.

EPWAPDA(1968), Feasibility Study of Karnafuli Irrigation Project, prepared by JCHW, May 1968.

EPWAPDA(1969), Feasibility Report on Chandpur Irrigation Project, prepared by Leedshill deLeuw, September 1969.

EPWAPDA(1970), Feasibility Report on Chalan Beel Project, prepared by Engineering Consultants Inc. and Engineering Consultants, Dacca, 1970.

Ford, D. T.(1981), Interactive Nonstructural Flood Control Improvements, ASCE, October, 1981.

Foster, E. E.(1942), Evaluation of Flood Losses and Benefits, ASCE, vol. 91, 1942.

Framji, K. K. and Garg, B. C.(1976), Flood Control in The World: A Global Review (vol. 1), ICID Publication, New Delhi.

Garces, C., Lazaró, R. C. and Akhand, N. A.(1985), Status on Methodologies to Evaluate the Performance of Irrigation Systems in Bangladesh, paper presented in the seminer on "Methodologies to Evaluate the Performance of Irrigation Systems" held in Dhaka, June, 1985.

Gittinger, J. P.(1972), Economic Analysis of Agricultural Projects, The John Hopkins University Press, Baltimore, USA.

Gittinger, J. P.(1982), Economic Analysis of Agricultural Projects, The John Hopkins university Press, Baltimore, USA.

Gomosta, A. R.(1981), Submergence Tolerance in Rice, paper presented at BRRI/FAO/UNDP Training Course on Improved Cultural Practices for Deepwater Rice, Joydebpur, August, 1981.

Goldsmith, E. and Hildyard, N.(1983), The Social and Environmental Effects of Large Dams (vol. I and II), Wadebridge Ecological Centre, UK.

Greco, A.(1978), Contribution for the Selection of Criteria for the Preliminary and Indirect Control of Irrigation Effects on the environment, ICID, vol. 3, 1978.

Hardin, J. R.(1963), Flood Control of East Pakistan, Dacca.

Hufschmidt, M. M.(1967), Environmental Aspects of River Basin Planning, ASCE, vol. 93, HY6, November, 1967.

ICDDR,B(1983), A Proposal for a 10 Year Research Project: The Benefits of a Large Water Control Project in Rural Bangladesh, July, 1983, Dhaka.

IDA(1972a), Project Summary and Technical Note on Chandpur II Irrigation and Flood Protection Project, Special Projects Department, September, 1972.

IDA(1972b), Report and Recommendation of The Precident to The Executive Directors on a Proposed Credit to The People's Republic of Bangladesh for a Second Chandpur Irrigation Project, Report No. P-1118, September, 1972.

IECO(1964), Flood Control Plan for East pakistan, Dacca.

Itoh, A.(1963), Benefits of Lnd Improvements, ICID, vol. 3, 1963.

James, L. D.(1969), Computers in Flood Control Planning, ASCE, vol. 95, No. HY6, November, 1969.

James, L. D. and Lee, R. R.(1971), Economics of Water Resources Planning, McGraw-Hill Book Co., USA.

Johnson, W. K.(1985), Significance of Location in Computing Flood Damages, ASCE, January, 1985.

Jones, S.(1985), Considerations in the Evaluation of Flood Control, Drainage and Irrigation Projects, paper presented in the seminer on "Methodologies to Evaluate the Performance of Irrigation Systems" held in Dhaka, June, 1985.

Khan, A. H.(1984), Flood Control in bangladesh.

Knapp, J. W.(1978), Economic Impacts of Delays in The Construction of Irrigation and Drainage Projects, ICID, vol. 3, 1978.

Krishna, H. and Nigam, P. S.(1978), Socio-Economic Growth due to Sarda Sahayak Project, ICID, vol. 3, 1978.

Krug, J. A.(1957), Report of United Nations Technical Assistance Mission, New York.

Kuiper, E.(1965), Water Resources Development , Butterworth and Co. (Publishers) Ltd., London, 1965.

Kuiper, E.(1971), Water Resources Project Economics, Butterworth & Co. (Publishers) Ltd., London, 1971.

Linsley, R. K. and Franzini, J. B.(1979), Water Resources Engineering, McGraw-Hill Book Co. USA.

Marts, M. E.(1956), Use of Indirect Benefit Analysis in Establishing Repayment Responsibility for Irrigation Project, Economic Geography, April, 1956, (after James and Lee, 1971, p-172).

Ministry of Flood Control and Water Resources, Government of Bangladesh(1972), Seminer on Flood Control and Water Resources Development in Bangladesh, August, 1972.

Mian, M. M.(1985), Evaluation of Deep Tubewell Irrigation Systems, paper presented in the seminer on "Methodologies to Evaluate the Performance of Irrigation Systems" held in Dhaka, June, 1985.

McCroy, J. A., Douglas, J. L. and Jones, D. E. Jr.,(1976), Dealing With Variable Flood Hazards, ASCE, November, 1976.

McGauhey, P. H. and Erlich, H.(1959), Economic Evaluation of Water, ASCE, IR2, June, 1959.

Molnar, L. S.(1978), The Effect of Irrigation Projects (Irrigation Investments) Utilization on The Cost of Irrigation, ICID, vol. 2, 1978.

MPO(1984a), Second Interim Report (vol. I, Main Report, vol. IV: Floods and Drainage, vol. VI: Agriculture, vol. VII: Fisheries, vol. VIII: Economics and Socioeconomics, vol. IX: Modes of Development, vol. X: Cost Estimation), June, 1984.

MPO(1984b), Third Interim Report, December, 1984.

MPO(1985a), Draft Final Report(vol. I: Summary, Introduction, Sectoral and Cross-sectoral Analysis), July, 1985.

MPO(1985b), Impact of Water Sector Projects on Income Distribution, Technical Report No. 23.

MPO(1985c), Pathakhali-Konai Beel Flood Control and Drainage Project Field Evaluation, Draft Report.

MPO(1985d), General Guidelines on Undertaking Evaluation of Flood Control, Drainage and Irrigation Projects, Technical Report No. 25, November, 1985.

Nilufar, F.(1985), Flood Depth Analysis for the District of Sylhet, M. Sc. Engg. thesis, BUET, Dhaka, 1985.

Ortolano, L.(1979), Water Planning and Environment: 1776-1976, ASCE, March, 1979.

Pande, H. K., Mittra, B. N. and Ghosh, B. C.(1978), Flood Susceptibility of Semidwarf Rice and Their Suitability for Low-lying Areas, Proceedings of the 1978 International Deepwater Rice Workshop of IRRI, Phillipines, 1979.

Penning-Rowsell, E. C. and Chatterton, J. B.(1984), Gauging the Economic Viability of Agricultural Land Drainage Scheme, Journal of the Institution of Water Engineers and Scientists, vol. 38, no. 2, April, 1984.

Polman, G. K. R.(1982), Oostvaardersplassen, The Developing of Marshy Ecosystems Especially for Waterfowl, in Polders of The World(vol. 2), ILRI, The Netherlands.

Rahman, M. L.(1979), Chandpur Irrigation Project: Comprehensive Evaluation Report, 1979, BWDB, Dhaka.

Rasmussen, J. J.(1956), Economic Criteria for Water Development Projects, ASCE, vol. 82, paper 997

Thejsse, J. T, H.(1964), Report on Hydrology of East Pakistan, Dacca.

Thompson, P. M.(1985), The Benefits of Flood Alleviation anf Flood Warning, paper presented at World Meteorological Organization seminer on Flood Forecasting, Rangoon, December, 1985.

Thompson, P. M., Green, C. H., Parker, D. J. and Penning-rowsell, E. C.(1983), A Glossary of Terms in Flood Alleviation Cost Benefit Appraisal, Middlesex Polytechnic, January, 1983.

Uddin, M. M. and Islam, S.(1982), Polder Development in Bangladesh, Paper I: Past and Present Development, in The Polders of The World (vol. 2), ILRI, The Netherlands.

Weber, E. W.(1965), Environmental Effects of Flood Plain Regulations, ASCE, vol. 91, No. 8, July, 1965.

Weinkauff, H. C. C>,(1963), Economic Evaluation and Financing of Flood Control Works in the United Ststes, ICID, vol. 2, 1963.

Whipple, W. Jr.(1968), Optimum Investment in Structural Flood Control, ASCE, vol. 94, No. HY6, November, 1968.

White, W. M.(1965), Evaluation of Recreation in Water Development, ASCE, vol. 91, No. PO1, May, 1965.

Wisler, C. O. and Brater, E. F.(1959), Hydrology, John Wiley & Sons Inc, USA.

World Bank(1975), Appraisal of the Karnafuli Irrigation Project (Halda and Ichamati Units), December, 1975.

World Bank(1981), Project Performance Audit Report: Bangladesh Chandpur II Irrigation Project, January, 1981.

World Bank(1981), Project Completion Report: Bangladesh Chandpur II Irrigation Project.

Wurbs, R. A.(1983), Economic Feasibility of Flood Control Investments, ASCE, vol. 109, No. 1, January, 1983.

Zaman, S. M. H.(1981a), Deepwater Rice in Bangladesh, paper presented at BRRI/FAO/UNDP Training Course on Improved Cultural Practices for Deepwater Rice, Joydebpur, August, 1981.

Zaman, S. M. H.(1981b), Constraints of the Production of Deepwater Rice, paper presented at BRRI/FAO/UNDP Training Course Improved Cultural Practices for Deepwater Rice, Joydebpur, August, 1981.

QUESTIONAIRE FOR FARMERS OF CIP

Name:____________________________

Location:____________________________

Date of interview:____________________________

1. Irrigation water:
   - a) % of requirement actually supplied:____
   - b) supply regular/irregular
2. Who do you think should clean water hyacinth?
   - a) farmers on individual basis
   - b) farmers under cooperative
   - c) project authority
3. Availability of improved seed (HYV):
   - a) available and within reach
   - b) available but beyond reach
   - c) not available adequately
4. Avaibility of fertilizers, insecticides and pesticides:
   - a) available and within reach
   - b) available but beyond reach
   - c) not available adequately
5. Quality of fertilizers, insecticides anf pesticides:
   - a) satisfactory
   - b) not satisfactory
6. Avaibility of agricultural credits:
   - a) easily available
   - b) available but with difficulties
   - c) not available adequately
7. Impression of farmers about Agri. Extn. Service:
   - a)excellent
   - b) good
   - c) fair
   - d) poor

8. What do you need to improve farm production?________

____

____

9. Is ther any employment opportunity, opened by the project, that seems to be more attractive than agriculture (Y/N)____

If yes, please mention:______________________________

10. Impression on the project as a whole

a) excellent

b) good

c) fair

d) poor

11. Have you been helped by the project in any way or the other to be financially more solvent (Y/N)?____

12. State of natural fertility of land (keeping in mind that the prevention of the deposition of fine silt brought by the flood water as a result of empolderment):

a) increased

b) remains same

c) reduced slightly

d) reduced greatly

13. Impression about project management:

a) excellent

b) good

c) fair

d) poor

e) very poor

14. Impression about project officials:

a) indifferent to farmers

b) sympathetic but cannot help much

c) sympathetic and helping

15. Did you change the variety of rice after project (Y/N)?____

If yes give names:

Pre-project:______________________________

Post-project:______________________________

16. Name crop(s) introduced as a result of the project (if any):

____

17. Name crop(s) not cultivated now after the project (if any):

____

18. What else do you expect from the project authority other than that is available now? ______________________________

____

19. Name some positive sides/effects of the project: __________

____

____

20. Name some negative sides/effects of the project: __________

____

____

QUESTIONIARE FOR OFFICIALS OF CIP

Name: ____________________

Position/Organization: ____________________

Date of interview: __________ Area concerned: __________

1. Agricultural Inputs

Item	Avalability as % of required	
	Pre-project	Post-project
a) Irrigation Water	____	____
b) HYV seeds	____	____
c) Fertilizers	____	____
d) Insecticides/Pesticides	____	____
e) Labour force	____	____
f) Agri. Extn. Services	____	____
g) Credits	____	____

2. Identify problems in agriculture:

Item	Exists? (y/n)	farmers affected (%)	land affected (%)
a) Irrigation water	____	____	____
b) Drainage congestion	____	____	____
c) Water logging	____	____	____
d) Water hyacinth	____	____	____
e) Difficulties in getting credit	____	____	____
f) Inefficient cooperatives	____	____	____
g) Shortages of LLPs	____	____	____
h) Supply of improved seeds	____	____	____
i) Supply of fertilizers	____	____	____
j) Supply of insecticides, etc.	____	____	____

3. Comment on change in land use:______________________________

____

____

4. Development of industries in your area

a) any new industry after project (Y/N)?___

if yes, please name:____________________

b) any old industry flourished as a result of the project (Y/N)?___

if yes, please name:____________________

5. Employment

a) new opening (Y/N)?___

if yes, please name:____________________

b) more manpower consumption (Y/N)?___

if yes, give approximate % increase:____

6. Road Trasportation

a) Embankment is used as a road (please mark)

1) exclusively

2) moderately

3) rarely

7. Any new road inside CIP (Y/N)?___

if yes, please give name, location, length etc.:________

____

8. Identify modes of transport inside CIP area in the descending order of importance (as 1,2,3...)

Pre-project	Post-project
on foot#___	on foot#___
rickshaw#___	rickshaw#___
bullcarts#___	bullcarts#___
bicycles#___	bicycles#___
others#___	others#___

9. River navigation

a) Navigation locks are (please mark)

1) sufficient

2) merely doing well

3) insufficient

b) Percentage of navigable rivers and channels inside CIP is 1) pre-project:_____

2) post-project:_____

c) Other comments on navigation:______________________________

____

____

10. Impact of project on minor rivers and channels within CIP:

Item	effects of the project		
	increased	same	decreased
a) Meandering tendency	O	O	O
b) Silting	O	O	O
c) Scouring	O	O	O
d) Use for agriculture	O	O	O
e) maintenance costs	O	O	O

11. Waterlogging and drainage congestion

a) % of area suffered:___

b) time of the year:_____

c) approx. % of agricultural damage:____

d) suggest solution(s), if any:______________

____

12. Health and environment

a) After project, water-borne diseases (please mark)

1) incresed

2) remains same   Name of disease:__________

3) decreased   ______________________

b) any adverse effect of insecticides/pesticides

1) on pond fisheries (Y/N)?___

2) on crops (Y/N)?___

3) on public health (Y/N)?___

c) % of pucca (brick wall) houses in CIP:____

d) % of people getting drinking water from

1) tube wells:____

2) ponds:____

3) others:____

e) % of households having moderm amenities (such as radio, bicycle, watch, TV, motorbike etc.):____

f) approximate number (or %) of persons engaged in

1) rickshaw pulling:____

2) trade/business:____

3) industries/construction:____

4) boatmanship:____

5) fishermanship:____

Appendix B

Farmers Response:

In total 27 farmers were interviewed and their response is presented here. The response of the farmers are discussed question-wise.

(1a) Out of 27 respondents, 11 said that the % of requirement actually supplied was 100%, 8 said 90% and 8 said 80%.

(1b) Out of 27 respondents, 20 said that the irrigation water supply is regular and 7 said irregular.

(2) Out of 25 respondents, 22 holds that project authority should clean the water hyacinth, 3 said farmers under cooperative but none suggested that farmers should do it on individual basis.

(3) Out of 26 respondents, 23 said that the improved seeds are available but beyond rach, 2 said available and within reach and only 1 said not available adequately.

(4) Out of 25 respondents, 24 said that fertilizers, insecticides and pesticides are available but beyond reach, only 1 said available and within reach but none said not available adequately.

(5) Out of 20 respondents, 12 said that the quality of fertilizers, insecticides and pesticides are satisfactory and 8 said not satisfactory.

(6) Out of 27 respondents, 20 said that the agricultural credits are available but with difficulties, 7 said not available adequately but none said easily available.

(7) Out of 27 respondents, none said that their impression about agricultural Extension services excellent, only 1 said good, 5 said fair and 21 said poor.

(8) Out of 27 respondents, all suggested that subsidized supply of agricultural inputs (seeds, fertilizers, insecticides & pesticides) can help to improve their farm production. In addition to this, 10 mentioned about good agricultural extension service.

(9) Out of 20 respondents, 16 said there is no employment opportunity, opened by project, that seems to be more attractive than agriculture, 4 said

yes out of them 2 said daily labourship and 2 said rickshaw pulling.

(10) Out of 26 respondents, none said that their impression of project as a whole is excellent, 6 said good, 18 said fair and 2 said poor.

(11) Out of 19 respondents, everybody said that they have been helped by the project in any way or the other to be financially more solvent.

(12) Out of 23 respondents, 10 said that the natural fertility of land has reduced greatly as a result of the project, 10 said reduced slightly and 3 said remains same.

(13) Out of 27 respondents, none said that their impression about project management is excellent or good, 3 said fair, 15 said poor and 9 said very poor.

(14) Out of 25 respondents, 12 said that the project officials are indifferent to farmers, 13 said sympathetic but cannot help much but none said sympathetic and helping.

(15) Out of 26 respondents, all said that they changed the variety of rice after project. They said that while the pre-project varieties were mixed Aus/Aman, B.Aman, IRRI and other local varieties, the post-project varieties are mainly mixed Aus/Aman(HYV), Boro (HYV), T. Aman (HYV) etc.

(16) Out of 10 respondents, 7 said that T. Aman (Pajam), T. Aus (local/LIV) have been introduced as a result of the project and the rest 3 named ground nut and B.Aman (Pajam) in addition to these.

(17) Out of 8 respondents, all said that B.Aman (Pajam) and Maize are not cultivated now after the project completion.

(18) Out of 26 respondents, all said that they expect easily available sufficient credit from the project authority other than what is available now, 16 said good cooperatives in addition to it and 20 said subsidized agricultural inputs.

(19) Out of 16 respondents, all named the prevention of flood as a positive sides/effects of the project, 14 named irrigation water in addition to it, 13 named increased production.

(20) Out of 23 respondents, 22 named problems with credit distribution as a negative side/effect of the project, 18 named shortage of LLPs, 2 named drainage congestion.

Response of the Officials:

In total 16 officials were supplied with the questionaires and all of them answered them. Out of them were the engineers of CIP authority, agricultural extention service personnel, contractors and local representative of the people. The response is presented here question wise.

(1a) Out of 15 respondents, 12 said that the availability of irrigation water is 100% of that required, 3 said 90%.

(1b) Out of 12 respondents, 10 said that the availability of HYV seeds is 100% of that required, 2 said 95%.

(1c) Out of 11 respondents, 10 said that the availability of fertilizers is 90% of that required, 1 said 70%.

(1d) Out of 9 respondents, 8 said that the availability of insecticides/pesticides is 60% of that required, 1 said 50%.

(1e) Out of 14 respondents, 10 said that the availability of Agricultural Extention Services is 80% of that required, 3 said 70% and 1 said 60% .

(1f) Out of 10 respondents, 2 said that the availability of credits is 70%, 6 said 50% and 2 said 40%.

(2a) Out of 11 respondents, 10 said that there is no problem with irrigation water, only 1 said that it is a problem and 10% of the CIP area is affected.

(2b) Out of 9 respondents, 3 said there is no drainage congestion, 4 said it is and 20% of CIP area is affected, 2 said it is and 10% of CIP area is affected.

(2c) Out of 13 respondents, 5 said that there is no water logging problem, 8 said it is and 5% of CIP area is suffering.

(2d) Out of 16 respondents, all said that water hyacinth is a problem, 9 said 50% of the canals is affected, 4 said 40%, 3 said 30%.

(2e) Out of 12 respondents, 3 said there is no difficulties in getting credit, 9 said there is and 50% of farmers are suffering, 3 said there is and 60% of farmers are suffering.

(2f) Out of 9 respondents, 2 said that cooperatives are not insufficient, 7 said it is and 50% of the farmers are affected.

(2g) Out of 11 respondents, 2 said that there is no shortage of LLPs, 7 said there is and 200 more LLPs are required, 2 said there is and 300 more LLPs are required.

(2h) Out of 7 respondents, 2 said that there is no problem with the supply of improved seeds, 5 said there is.

(2i) Out of 8 respondents, 3 said that there is no problem with the fertilizers, 5 said there is.

(2j) Out of 5 respondents, all said there is no problem with the supply of insecticides and pesticides.

(3) None made any comment on change in land use.

(4a) Out of 12 respondents, 5 said that there has been no development of industries, 4 said there is and named repair shops and cold storage, 3 said there is and named repair shops and small agricultural tools factories.

(4b) Out of 12 respondents, 5 said that is no old industry flourished as a result of the project, 7 said there is and named rice mills etc.

(5a) Out of 12 respondents 5 said that there is no new opening of eemployment, 4 said there is and named rickshaw pulling and 3 said agribusiness in addition to it.

(5b) Out of 15 respondents, all said that there is more manpower consumption after project but could not till how much.

(6) Out of 14 respondents, 8 said that the embankment is used exclusively as a road, 6 said modderately but none said rarely.

(7) Out of 5 respondents, all said that there is no new road inside CIP area.

(8) Out of 11 respondents, all identified the modes of transport inside CIP area in the descending order of importance as follows:

Pre-Project	Post-Project
on foot # 1	on foot # 1
rickshaw # 5	rickshaw # 2
bi;;carts # 4	bullcarts # 4
bicycles # 3	bicycles # 3
boats # 2	boats # 5

(9a) Out of 9 respondents, all said that the navigation locks are sufficient.

(9b) Out of 5 respondents, 3 said that the % of navigable rivers and channels inside CIP is 70%)pre-project) and 86% (post-project) and 2 said 60% (pre-project) and 70% (post-project).

(9c) Out of 3 respondents, all of them mentioned that water hyacinth is creating a problem to navigation inside CIP area.

(10a) Out of 5 respondents, all said that the meandering tendency of the rivers and channels within CIP has decreased.

(10b) Out of 12 respondents, all said that the silting in channels has increased.

(10c) Out of 6 respondents, 4 said that the sowing in channels has decreased, 2 said reamins same.

(10d) Out of 11 respondents, all said that the use of channels for agriculture use has increased.

(10e) Out of 7 respondents, all said that the maintenance cost of channels has increased.

(11a) Out of 5 respondents, 2 said that about 20% of CIP area suffers from water logging and drainage congestion, 3 said about 1000 acres.

(11b) Out of 5 respondents, all said the time is generally June-July-August.

(11c) Out of 4 respondents, 3 said that the agricultural damage is 20%, 1 said 30%.

(11d) Out of 3 respondents, 2 said that the possible remedy is reexavation of khals and better water management in the South Dhakalia River and 1 added 2 more sluice gates to it.

(12a) Out of 9 respondents, 2 said that the water-borne disease remains same, 7 said decreased and named cholera etc.

(12b) Out of 3 respondents, all said that there is no adverse effect of insecticides/pesticides on pond fisheries, crops and public health.

(12c) None responded.

(12d) None responded.

(12e) None responded.

(12f) Out of 4 respondents, all said that the numbers of persons engaged in rickshaw pulling increased, in trade/business increased, in industries/constructions increased, in boatmanship decreased and in fishermanship decreased, 2 said that the increase in rickshaw pulling is roughly 7 to 8 times.

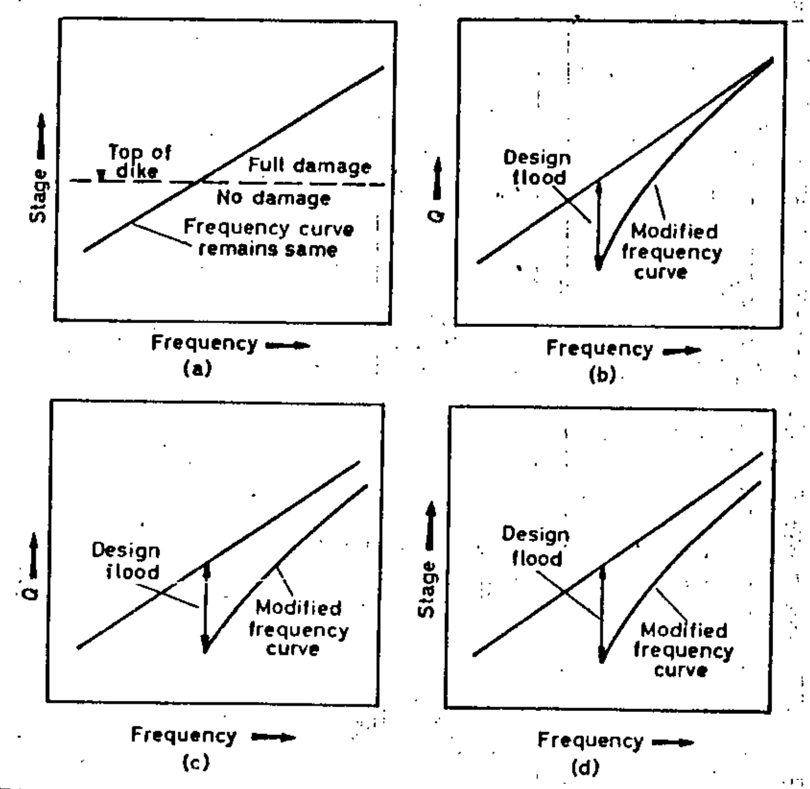


Fig. 1.1. *Effect of flood control measures: (a) dikes; (b) reservoirs; (c) diversions; (d) channel improvements*

(After Kuiper 1965)

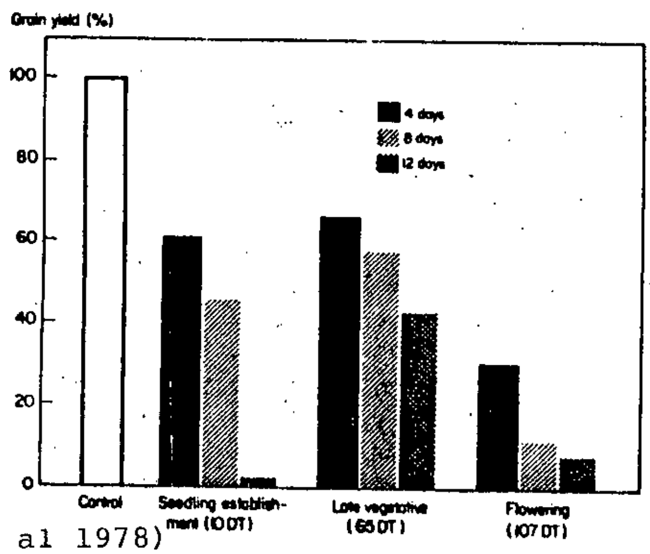


Figure 2.1
Effect of submergence on rice
(After Pande et al 1978)

Grain yield of the semidwarf rice variety Jaya as influenced by complete submergence for 4, 8, and 12 days at three growth stages. Indian Institute of Technology, Kharagpur, West Bengal, 1975 wet season. DT = days after transplanting.

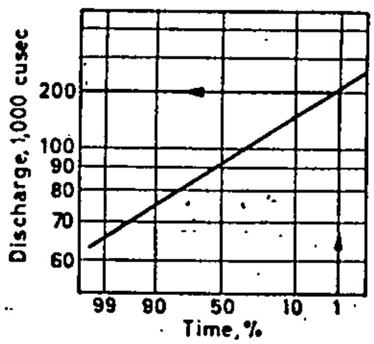


Fig.2.2 *Frequency curve of maximum annual flood flows*
(After Kuiper 1965)

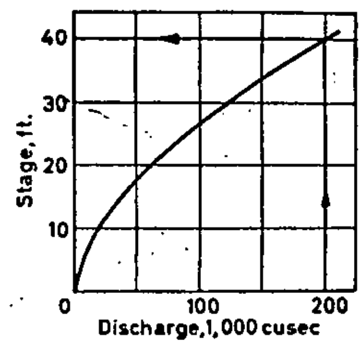


Fig. 2.3 *Rating curve of river at centre of area subject to flooding*
(After Kuiper 1965)

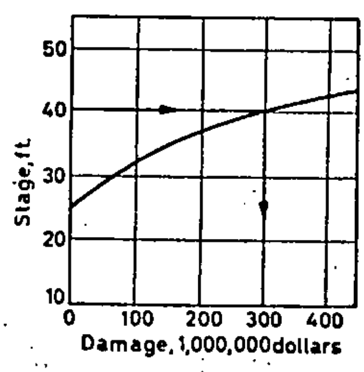
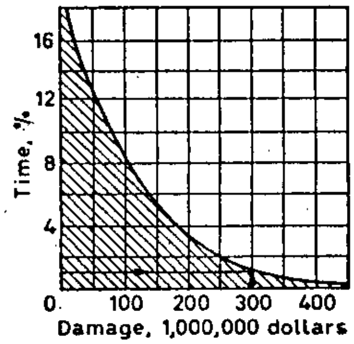


Fig.2.4 *Stage-damage curve of area subject to flooding*
(After Kuiper 1965)

Fig. 2.5 *Average annual damage in area subject to flooding (shaded area)*
(After Kuiper 1965)



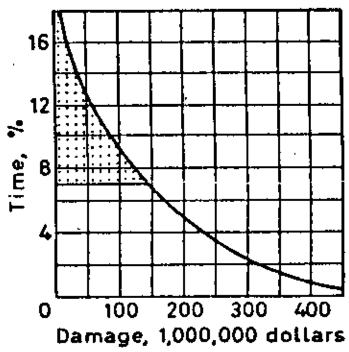
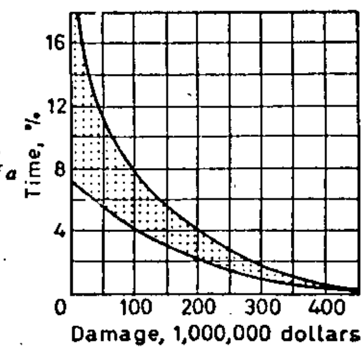


Fig. 2.6 *Average annual benefits as a result of the construction of a diking system (shaded area)*
(After Kuiper 1965)

Fig.2.7 *Average annual benefits as a result of a flood diversion or a reservoir (shaded area)*
(After Kuiper 1965)



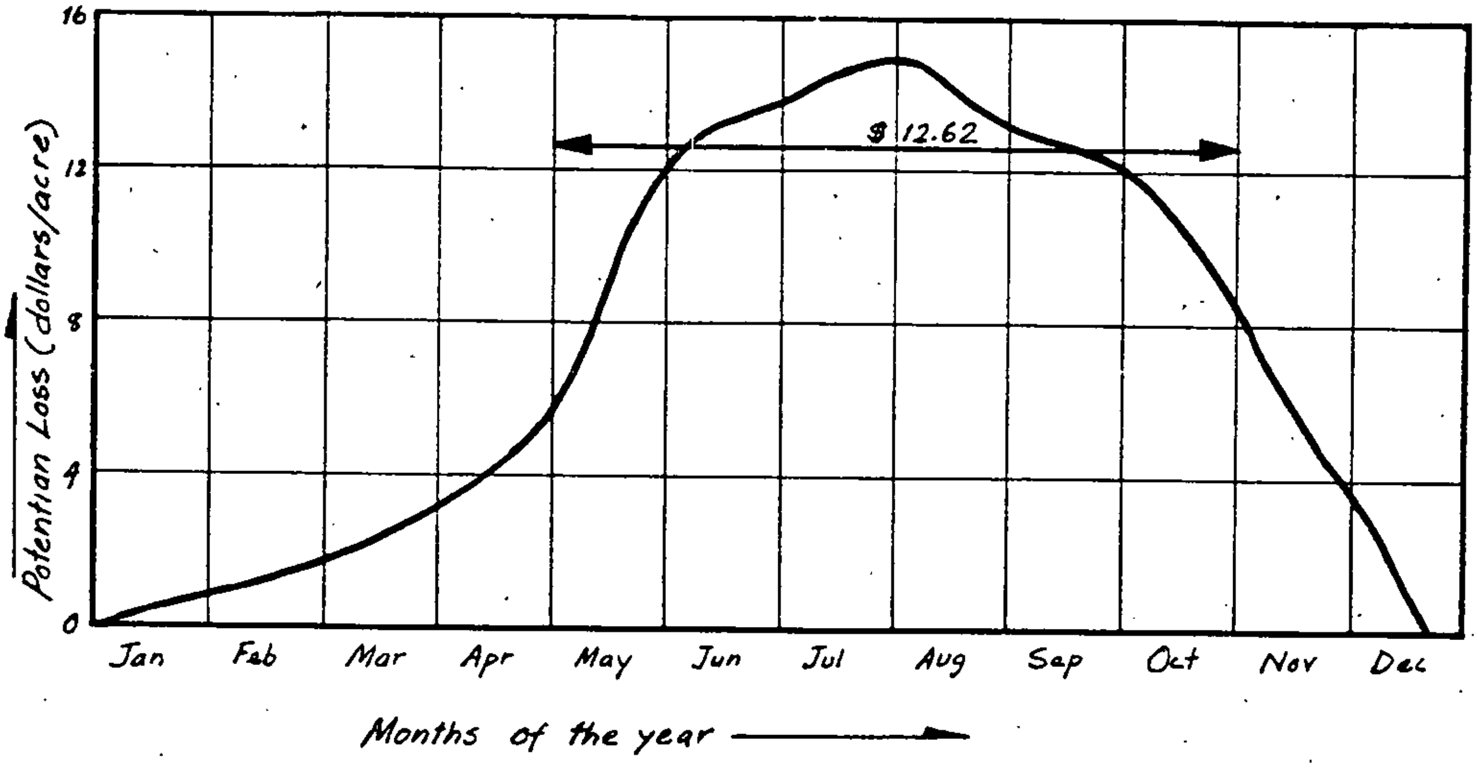


Figure 2.8
Potential crop loss
(After Foster 1942)

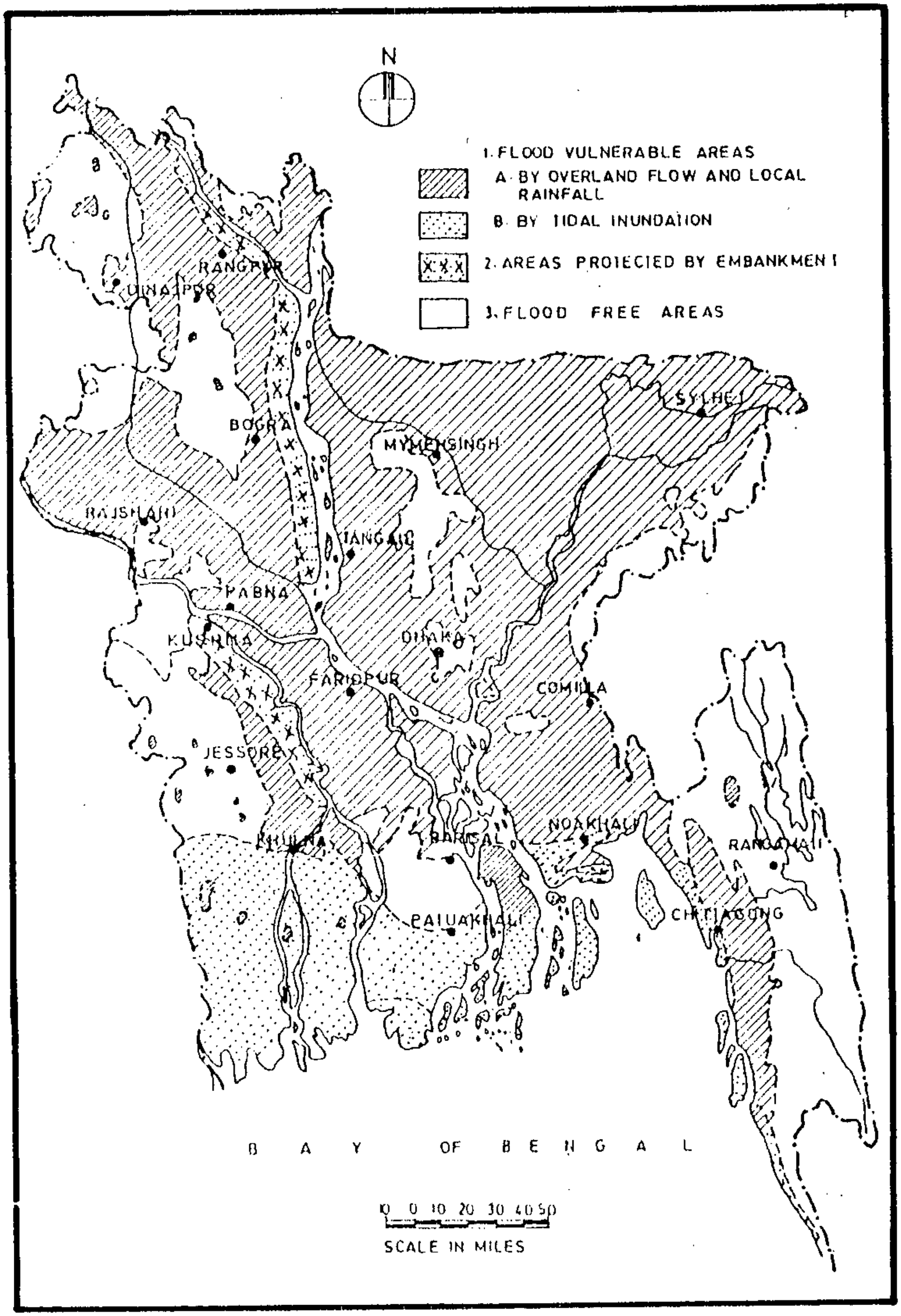
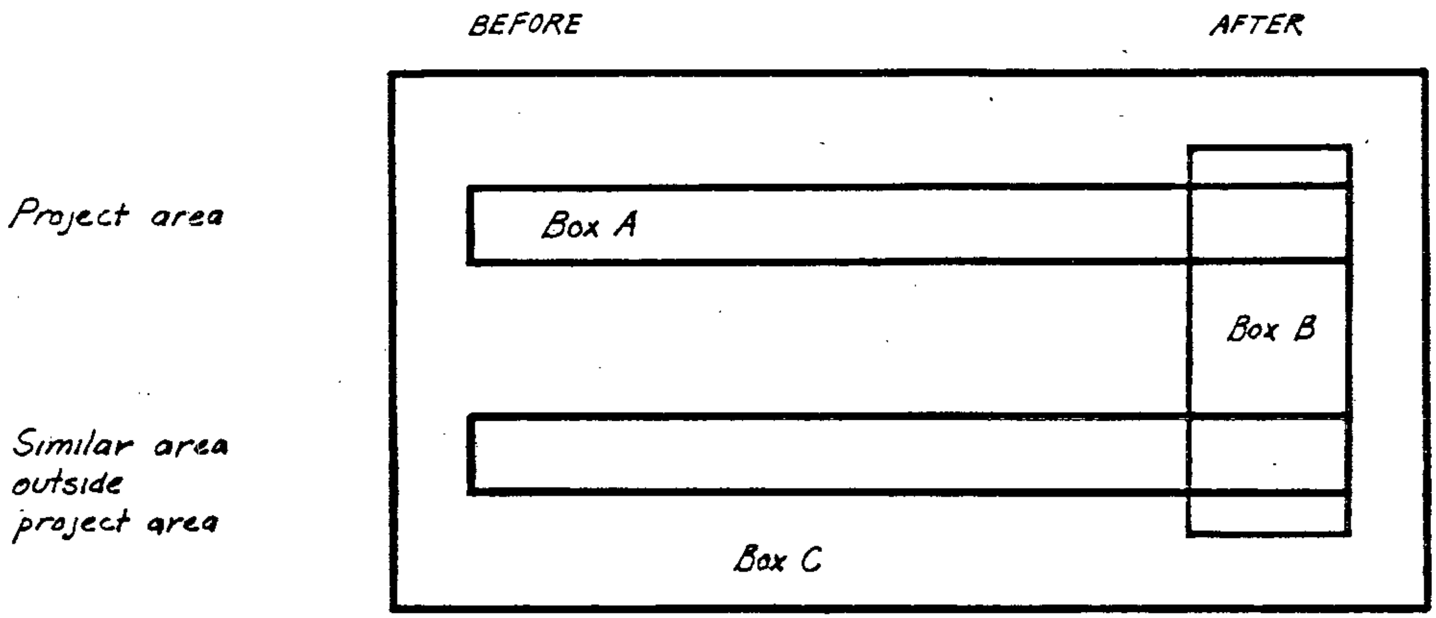
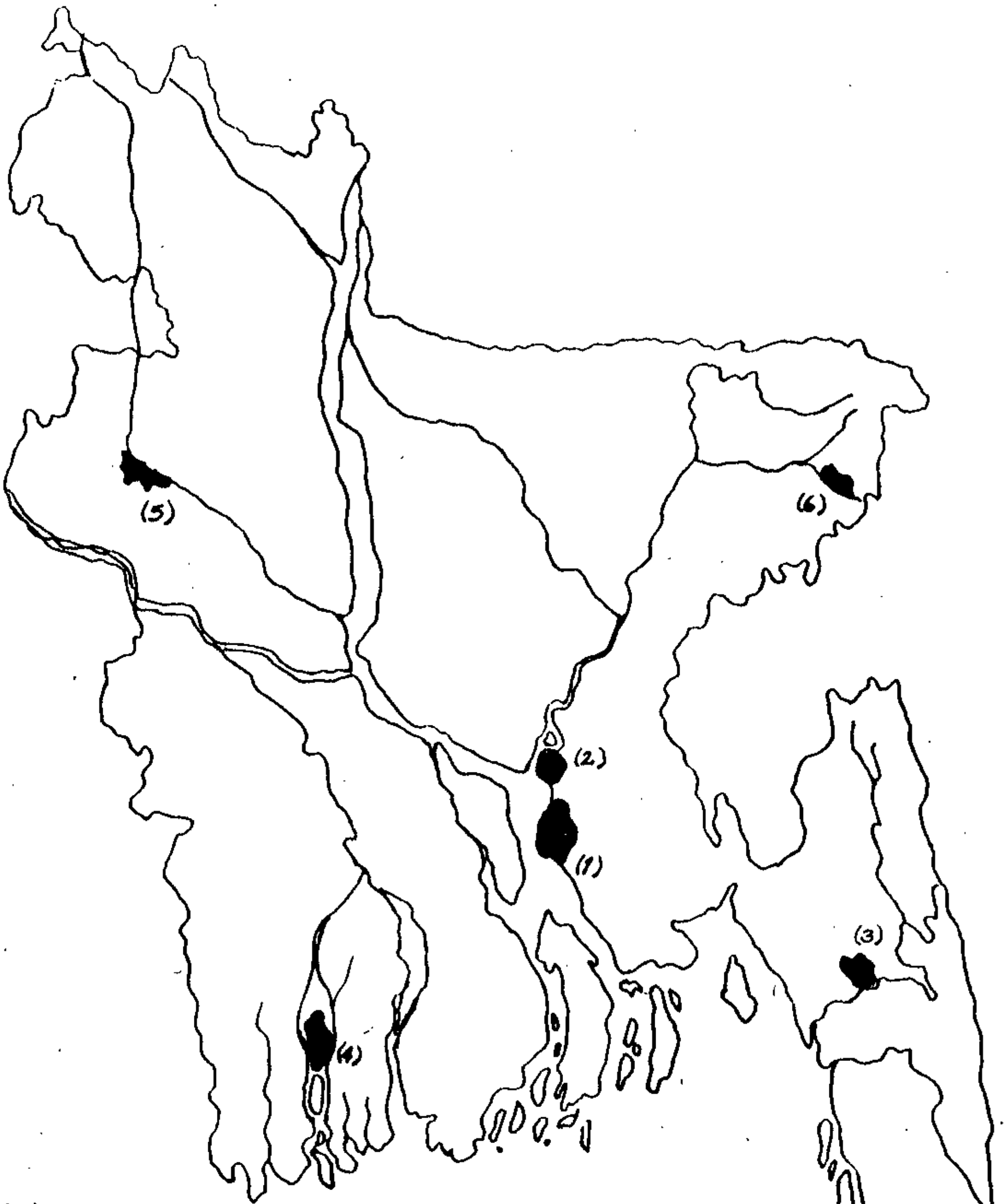


Figure 2.9 Flood vurnerability map of Bangladesh
(after Moniruzzaman et al, 1981)



Note: Box A: before and after comparison
Box B: with and without comparison
Box C: combination of Box A and Box B

Figure 3.1
Appoaches to proje-t evaluation
(after MPO, 1985)



Note:

(1) Chandpur Irrigation Project
(2) Meghna-Dhonogoda Irrigation Project
(3) Karnafuli Irrigation Project, Halda Unit
(4) Barnal-Salimpur-Kolabashukhali Project
(5) Chalan Beel Project
(6) Dhalai River Project

Figure 3.2
Location of the selected projects

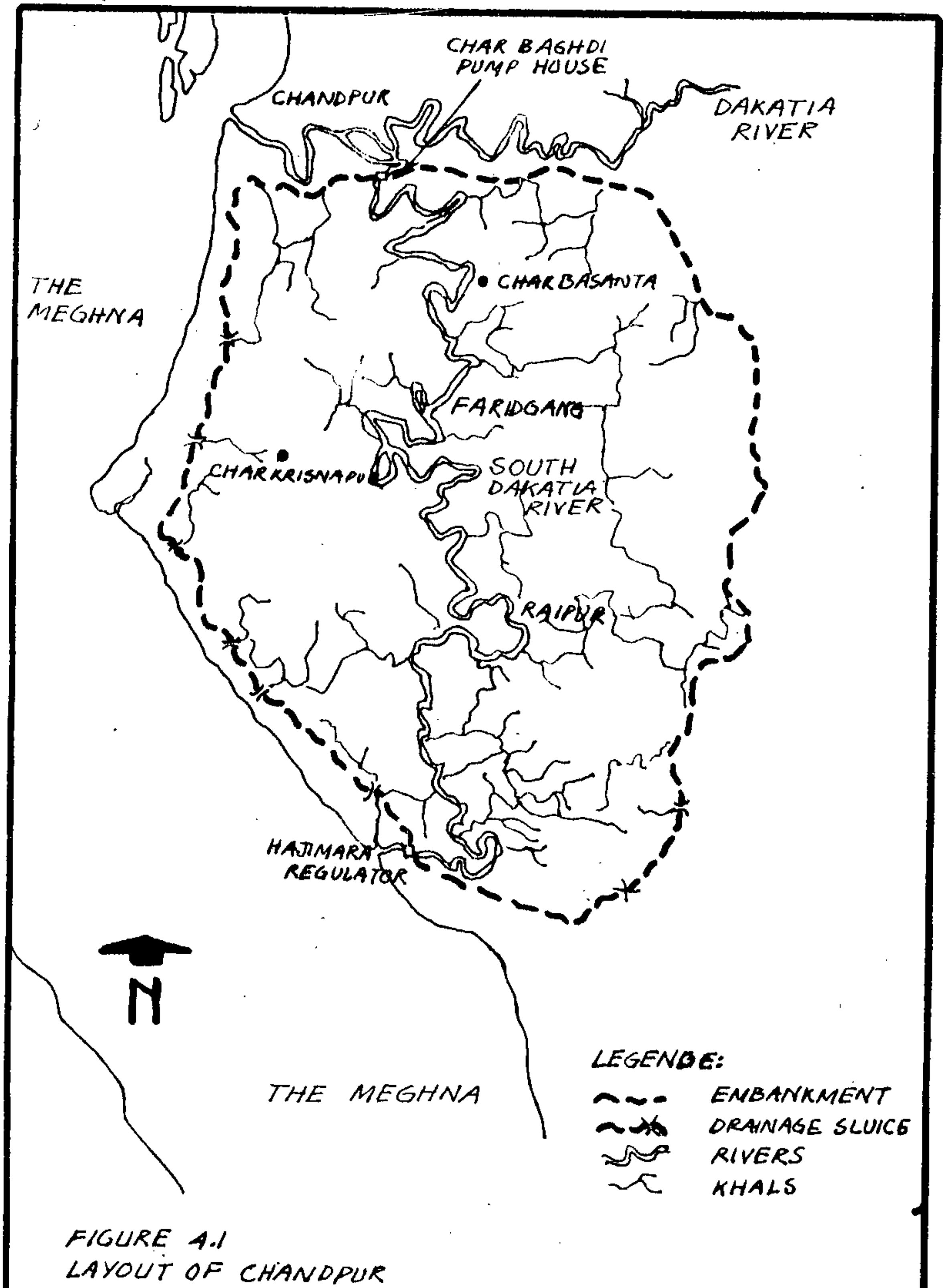


FIGURE 4.1
LAYOUT OF CHANDPUR
IRRIGATION PROJECT

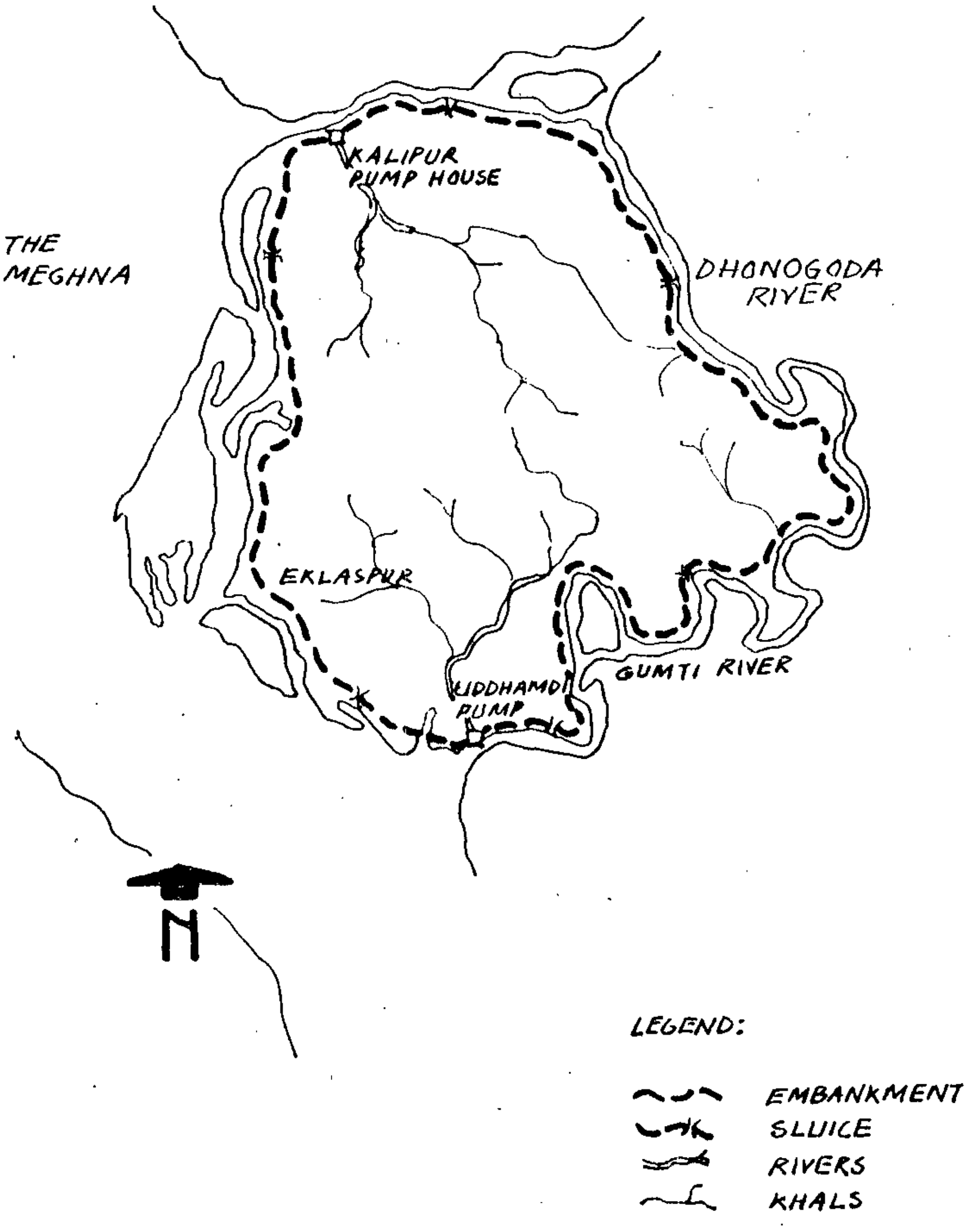


FIGURE 4.2
LAYOUT OF MEGHNA-DHONOGODA IRRIGATION PROJECT

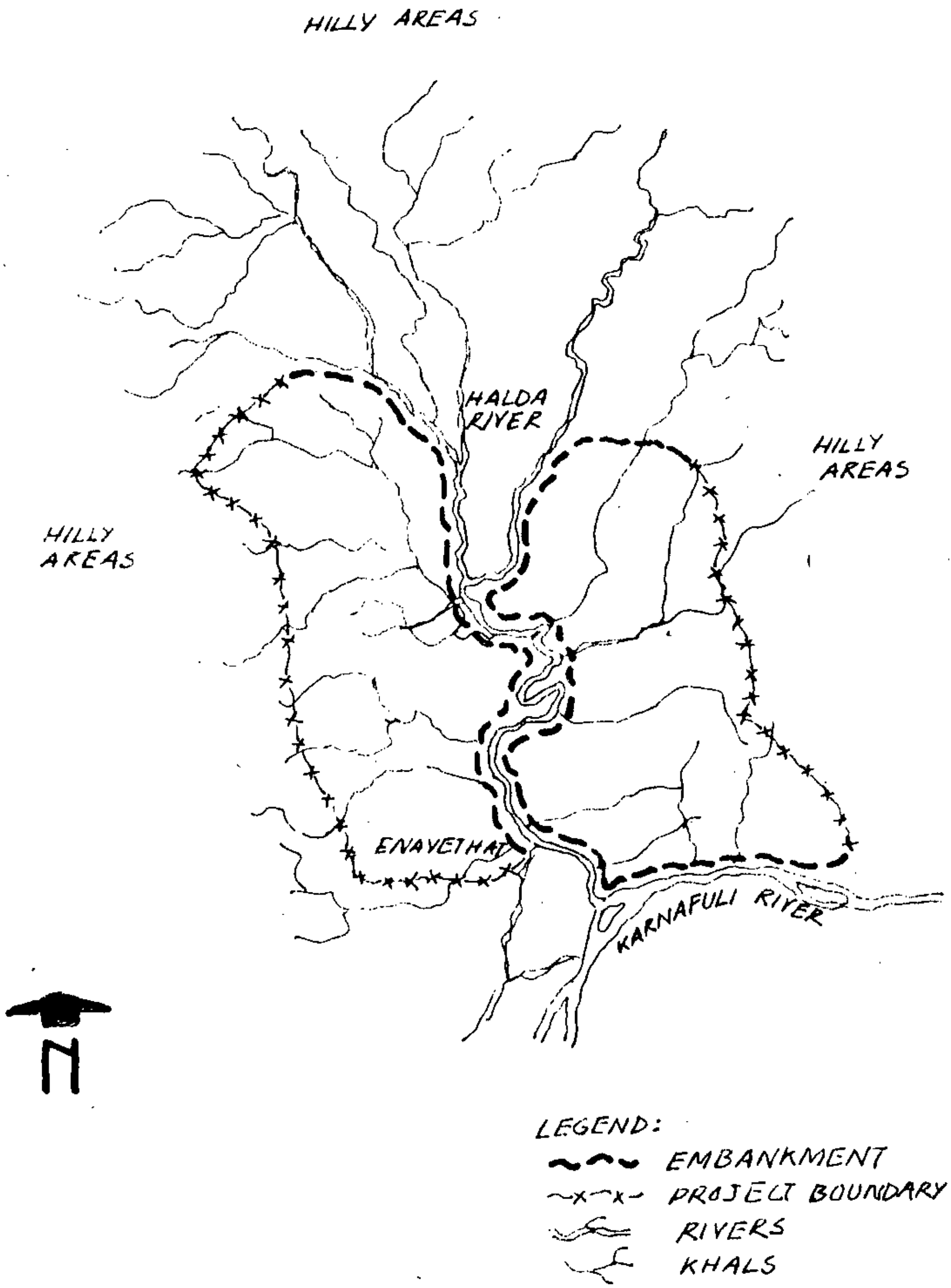


FIGURE 4.3
LAYOUT OF KARNAFULI IRRIGATION PROJECT (HALDA UNIT)

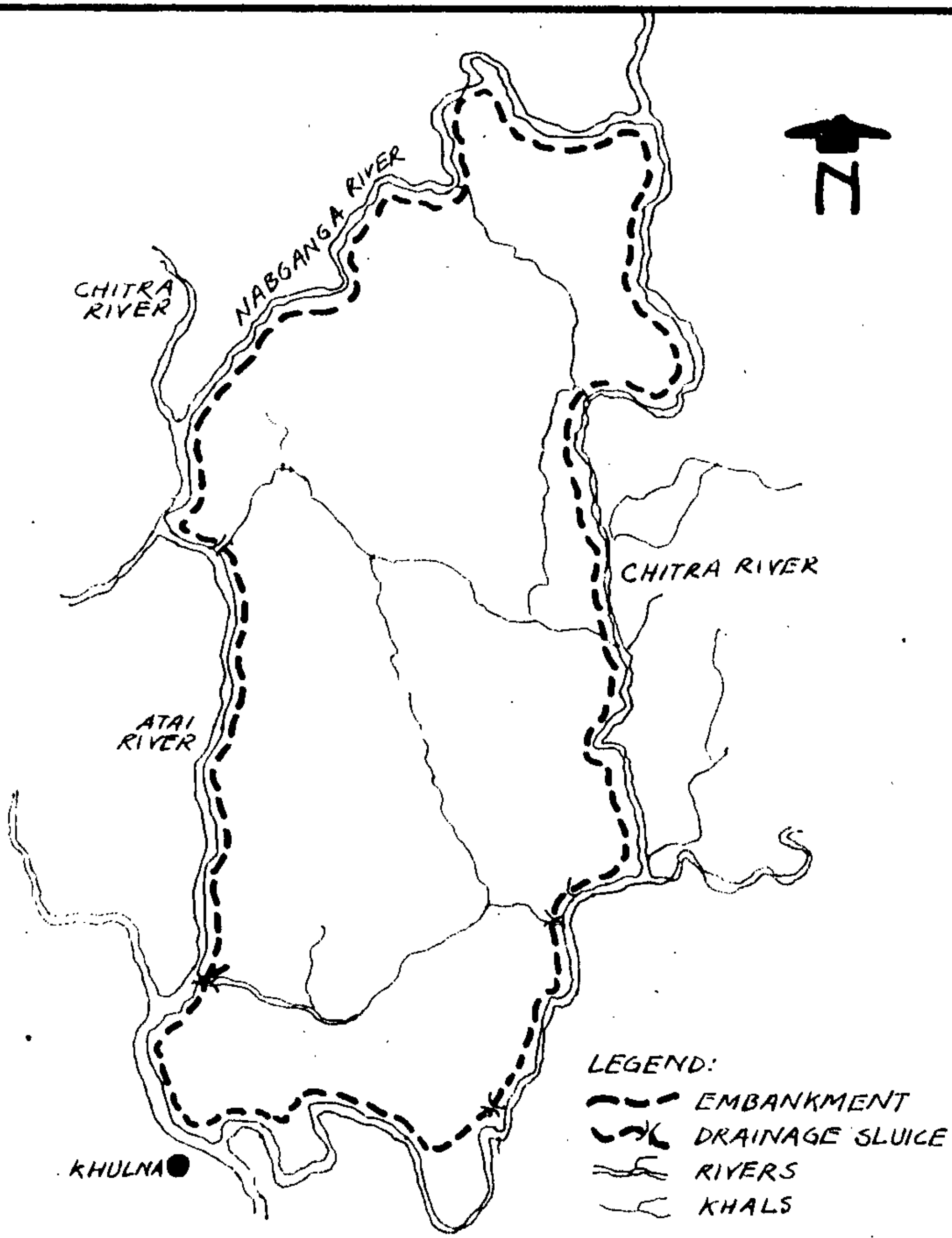


FIGURE 4.4
LAYOUT OF BARNAL-SALIMPUR-KOLABASHUKHALI PROJECT

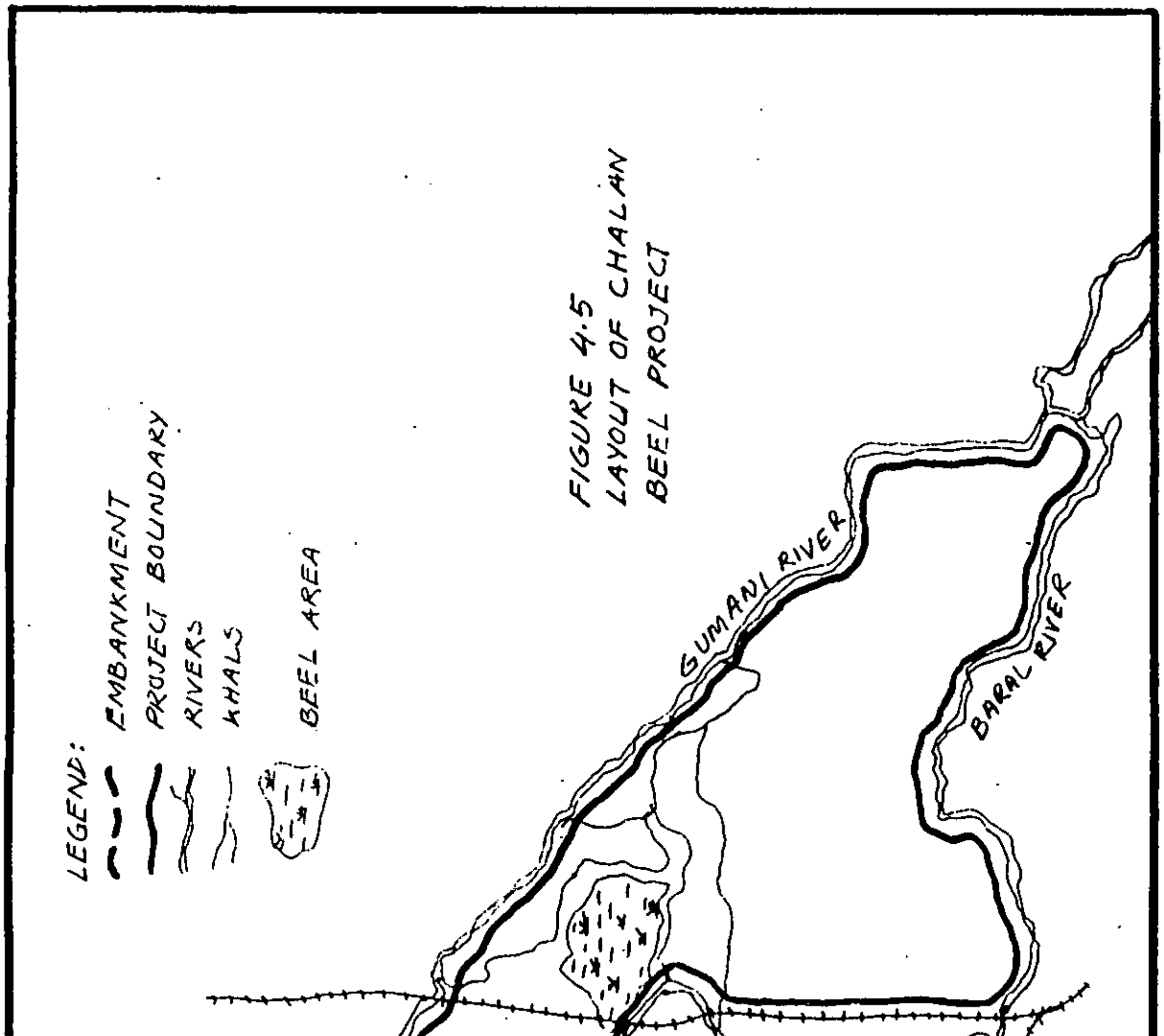


FIGURE 4.5
LAYOUT OF CHALAN
BEEL PROJECT

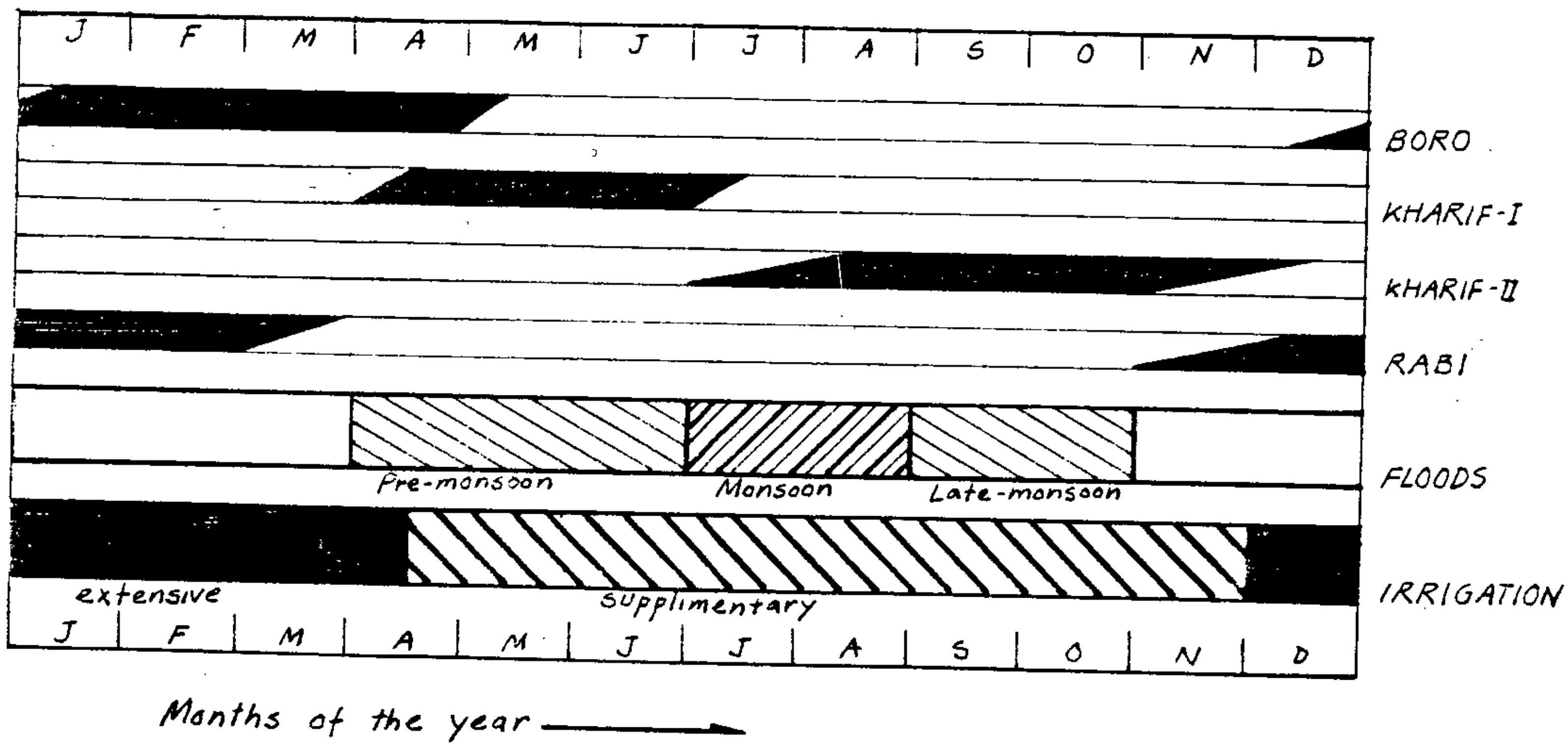


Figure 5.1
Relation of crop seasons with flood and irrigation

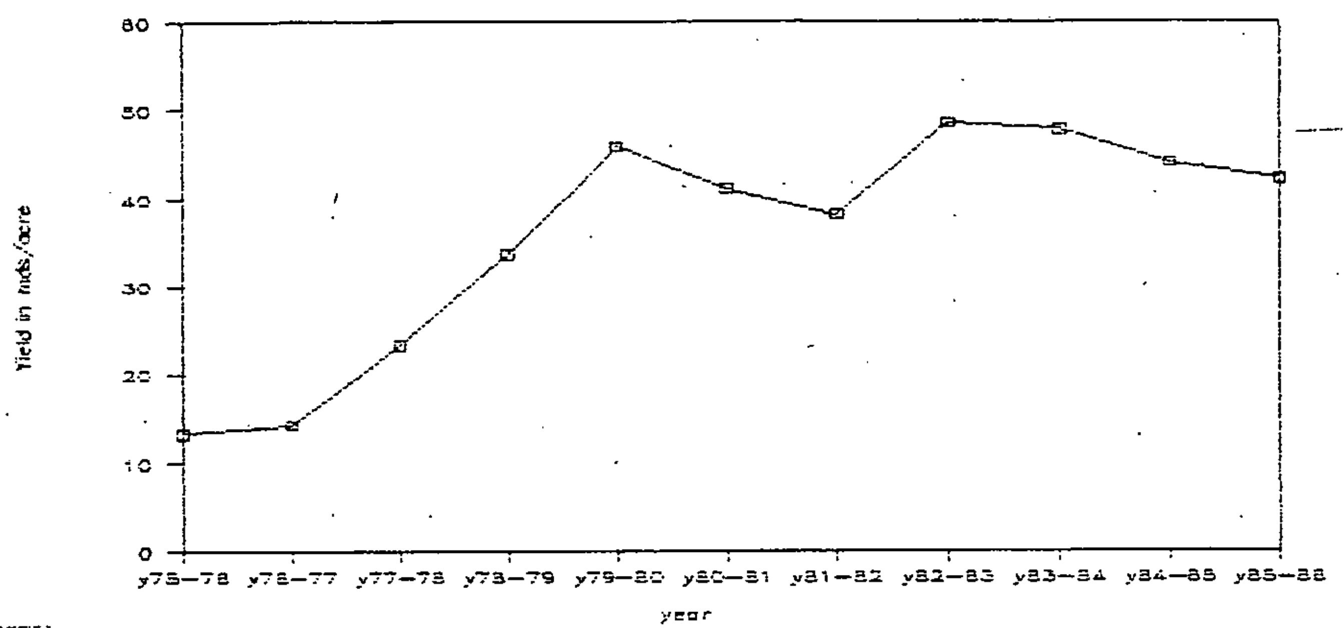


Figure 5.2
Average paddy yield in CIP

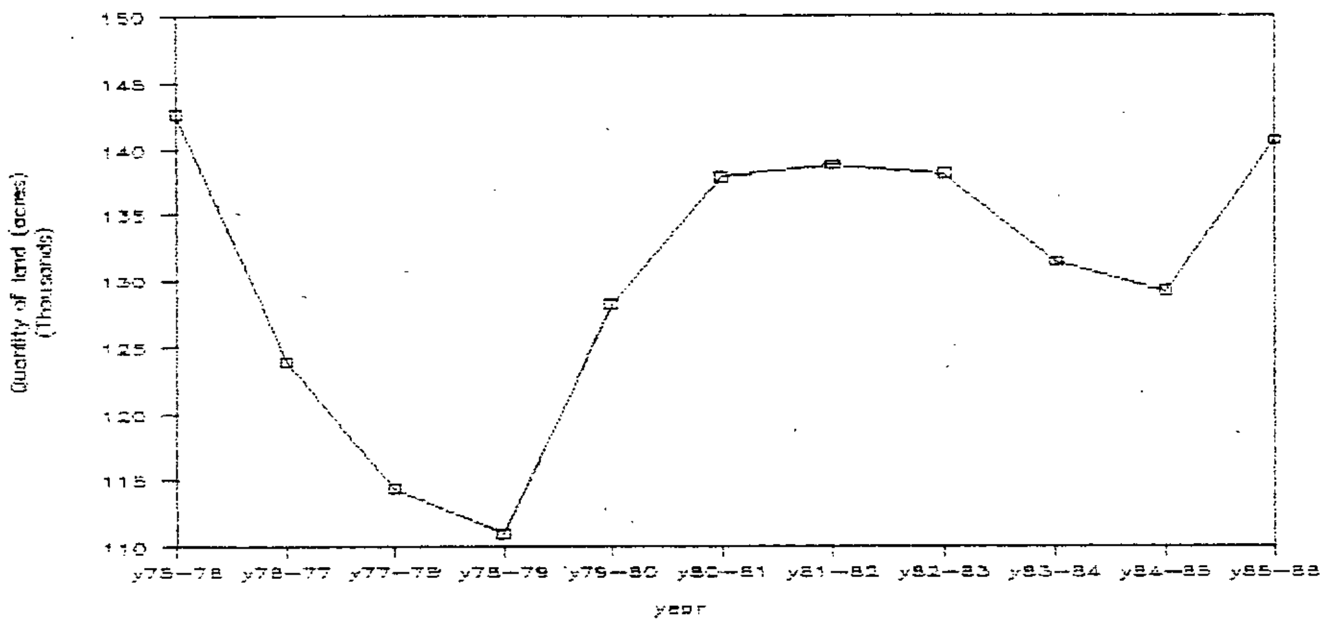


Figure 5.3
Total land devoted to paddy in CIP

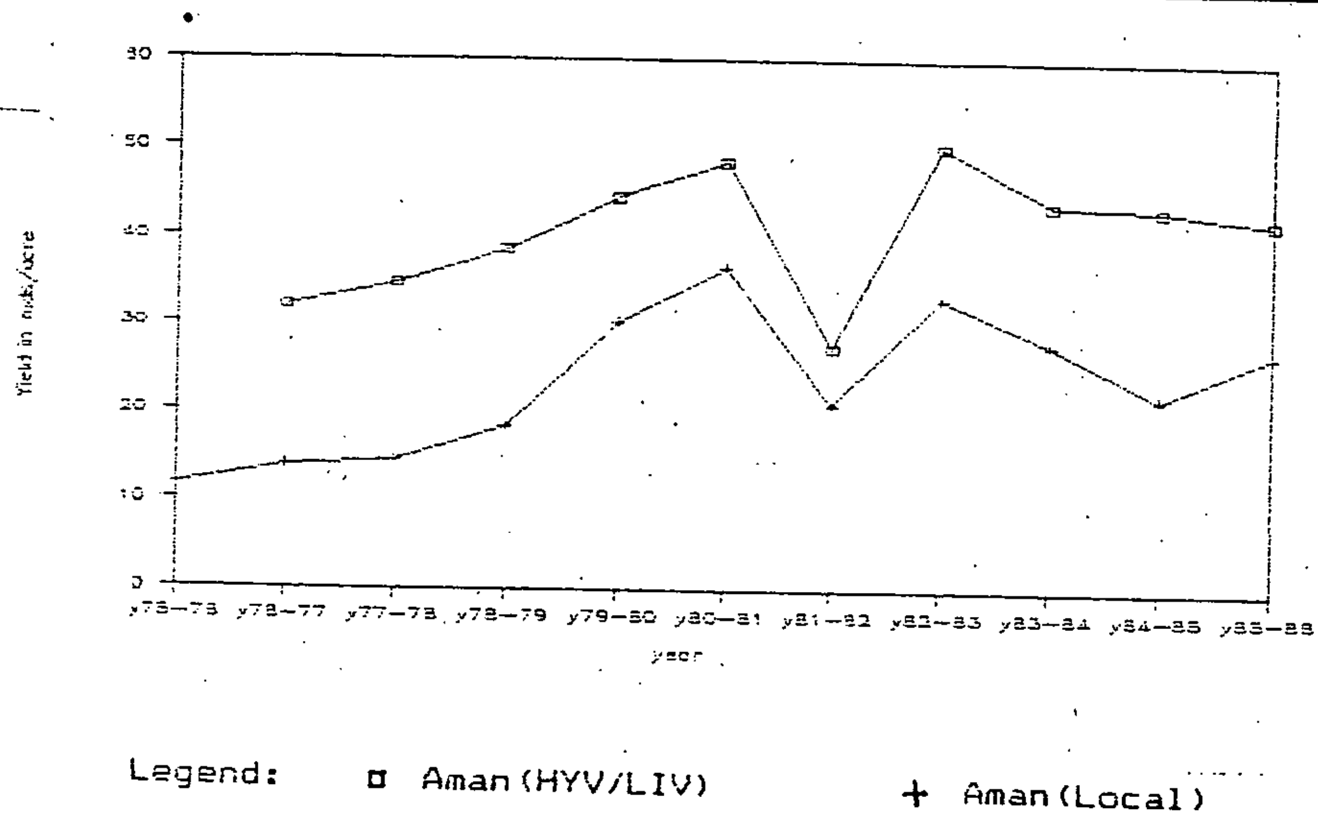


Figure 5.4
Aman yield in CIP

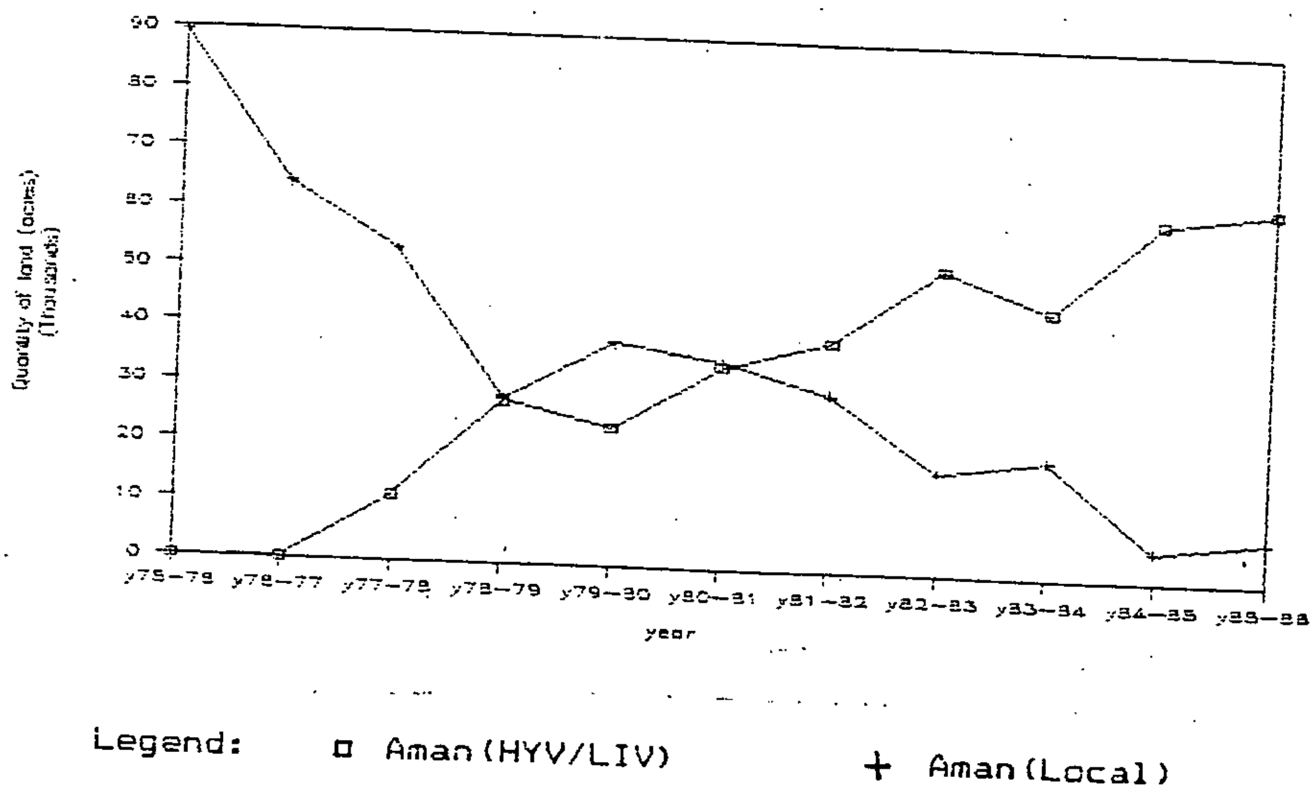


Figure 5.5
Land devoted to Aman in CIP

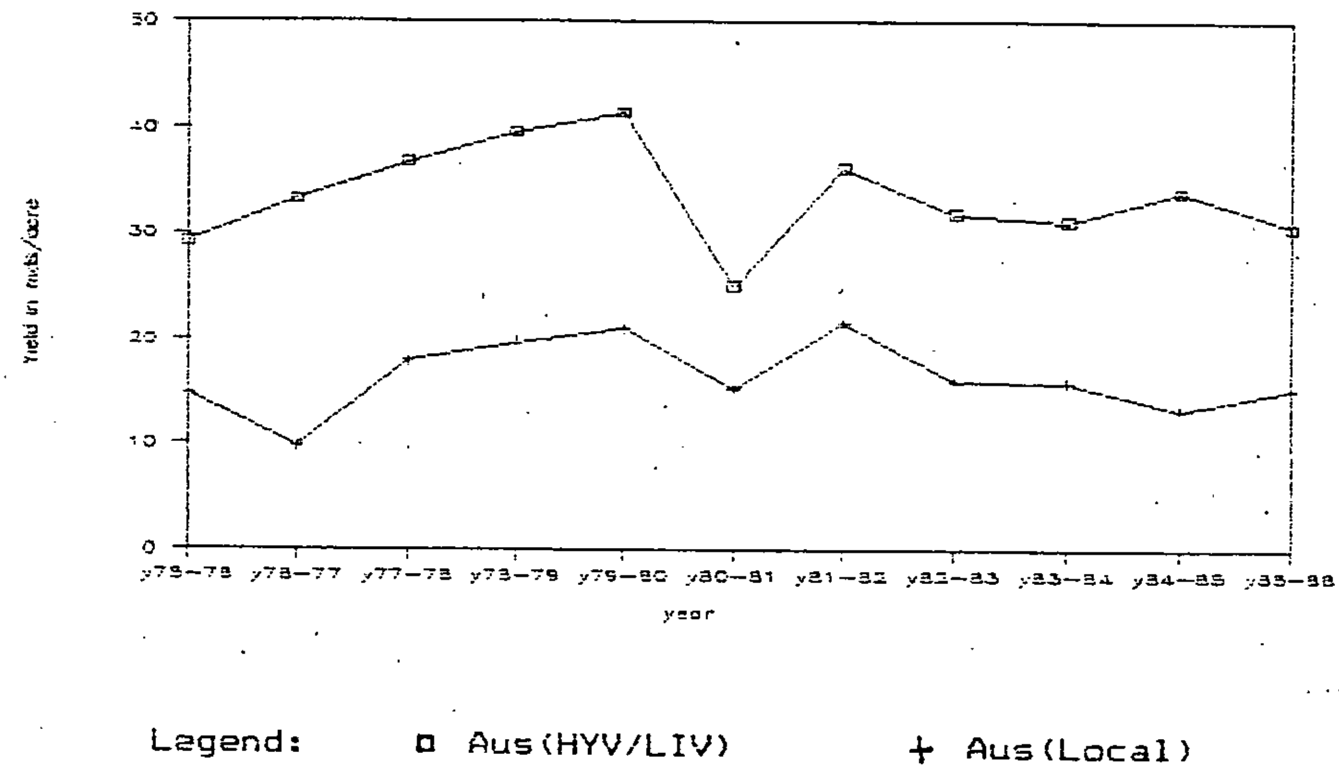
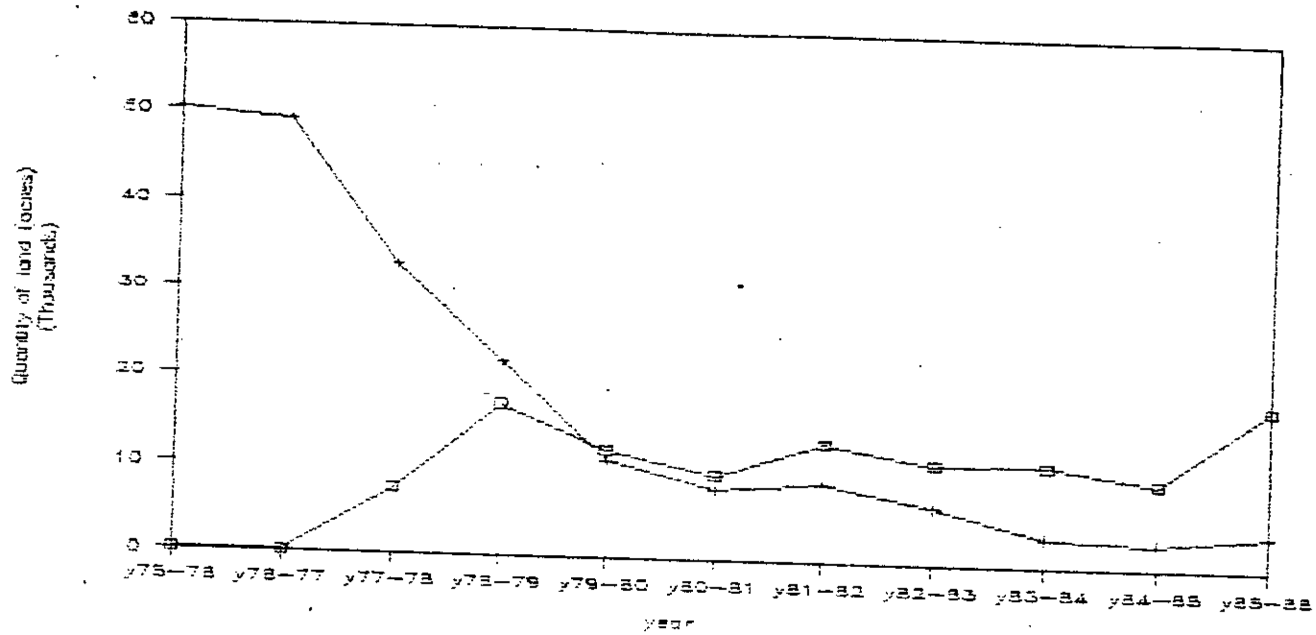


Figure 5.6
Aus yield in CIP



Legend: ◻ Aus(HYV/LIV) + Aus(Local)

Figure 5.7
Land devoted to Aus in CIP

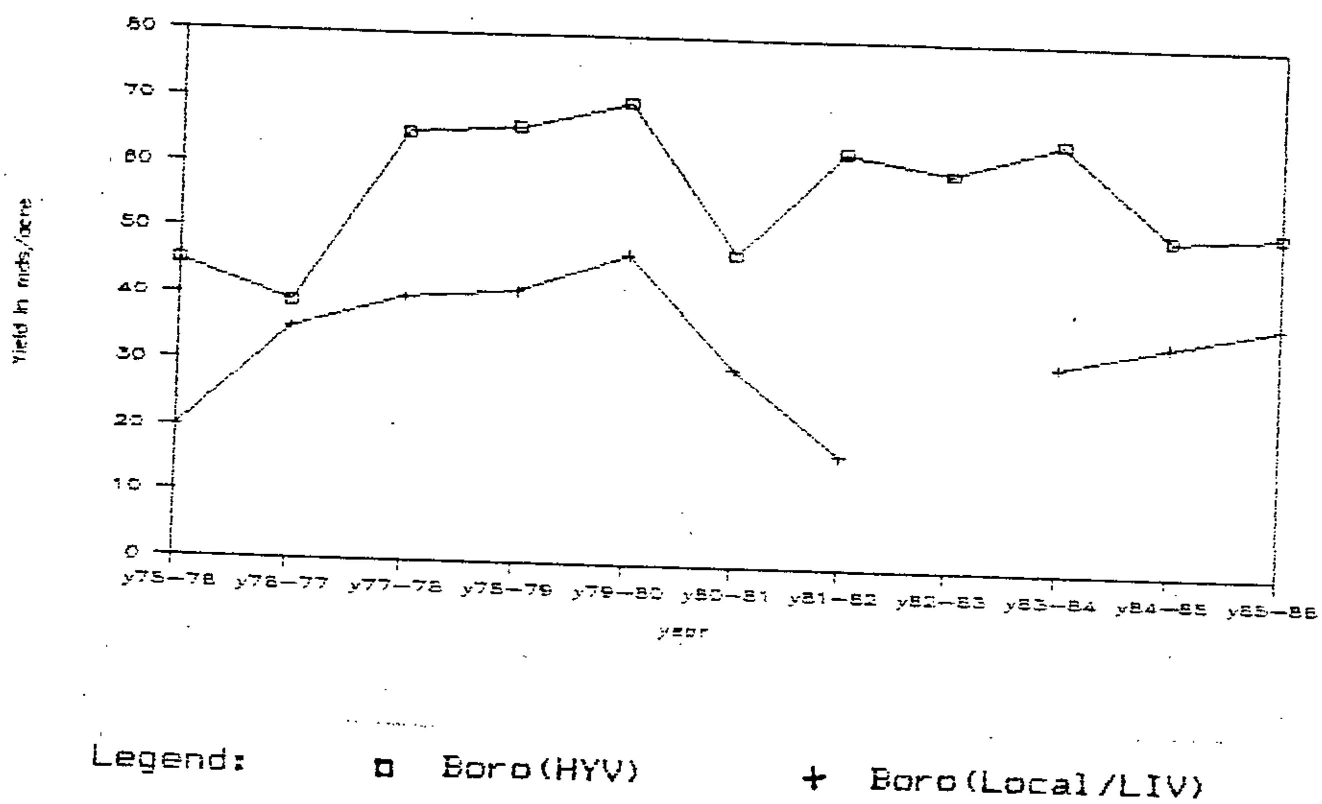


Figure 5.8
Boro yield in CIP

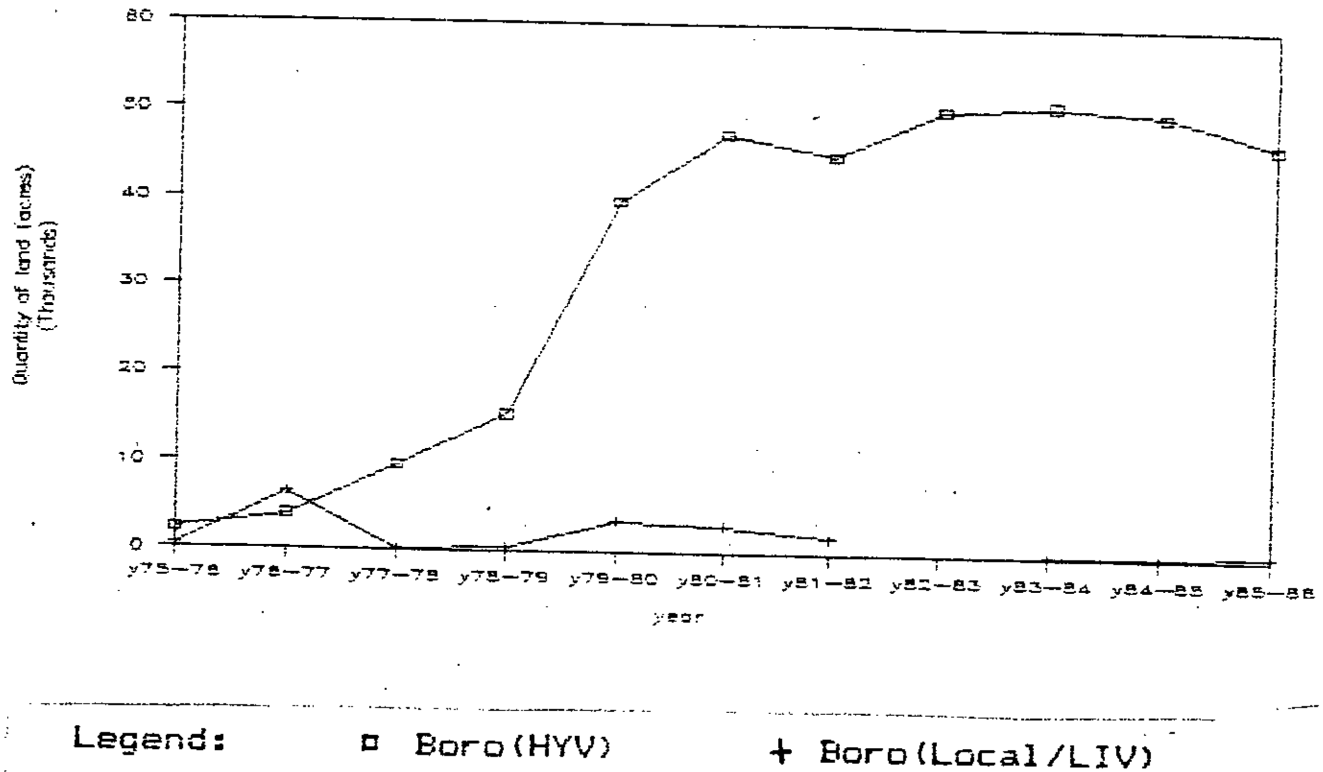


Figure 5.9
Land devoted to Boro in CIP

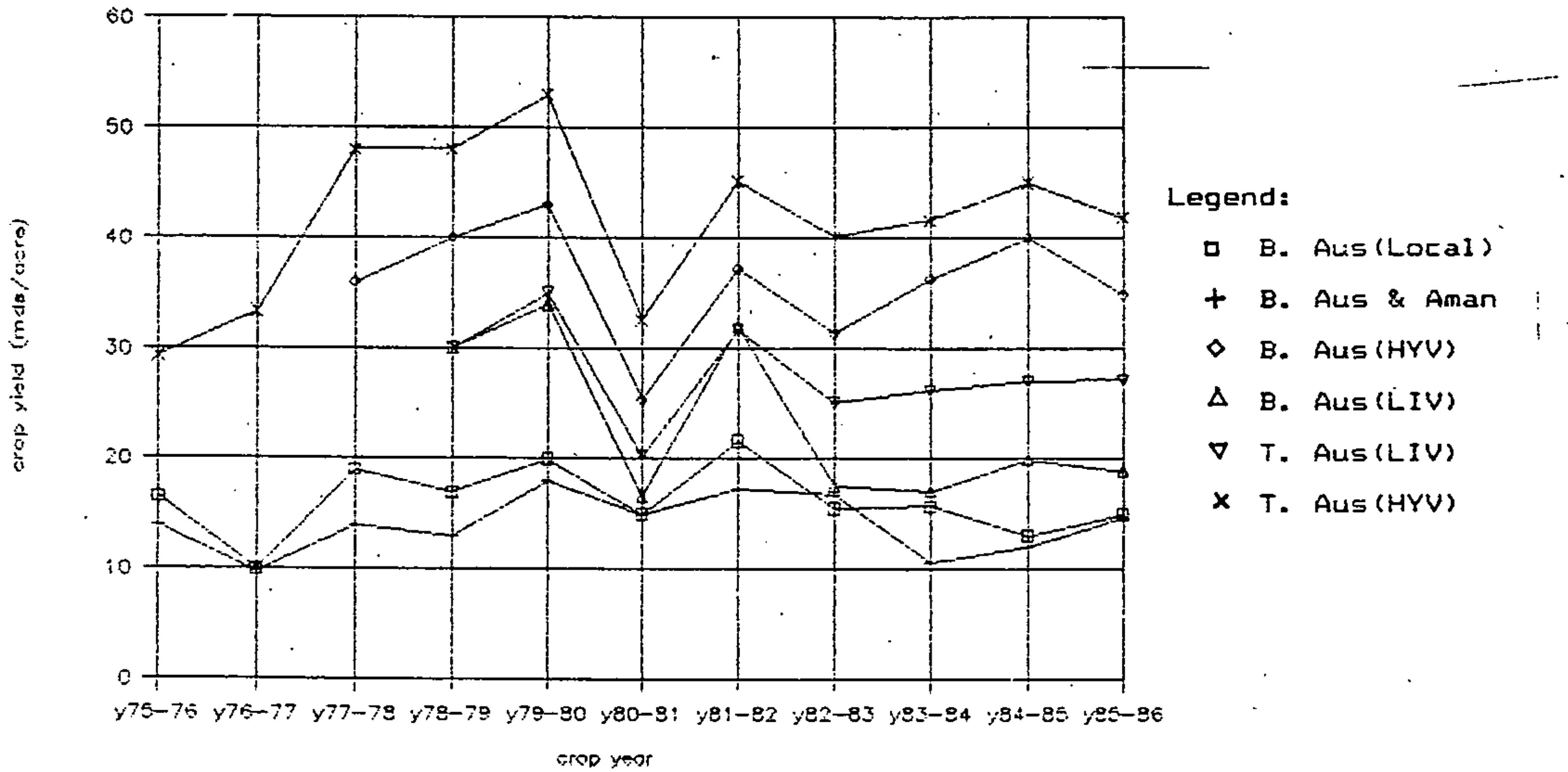


Figure 5.10
Yield variation of kharif-I crops in CIP

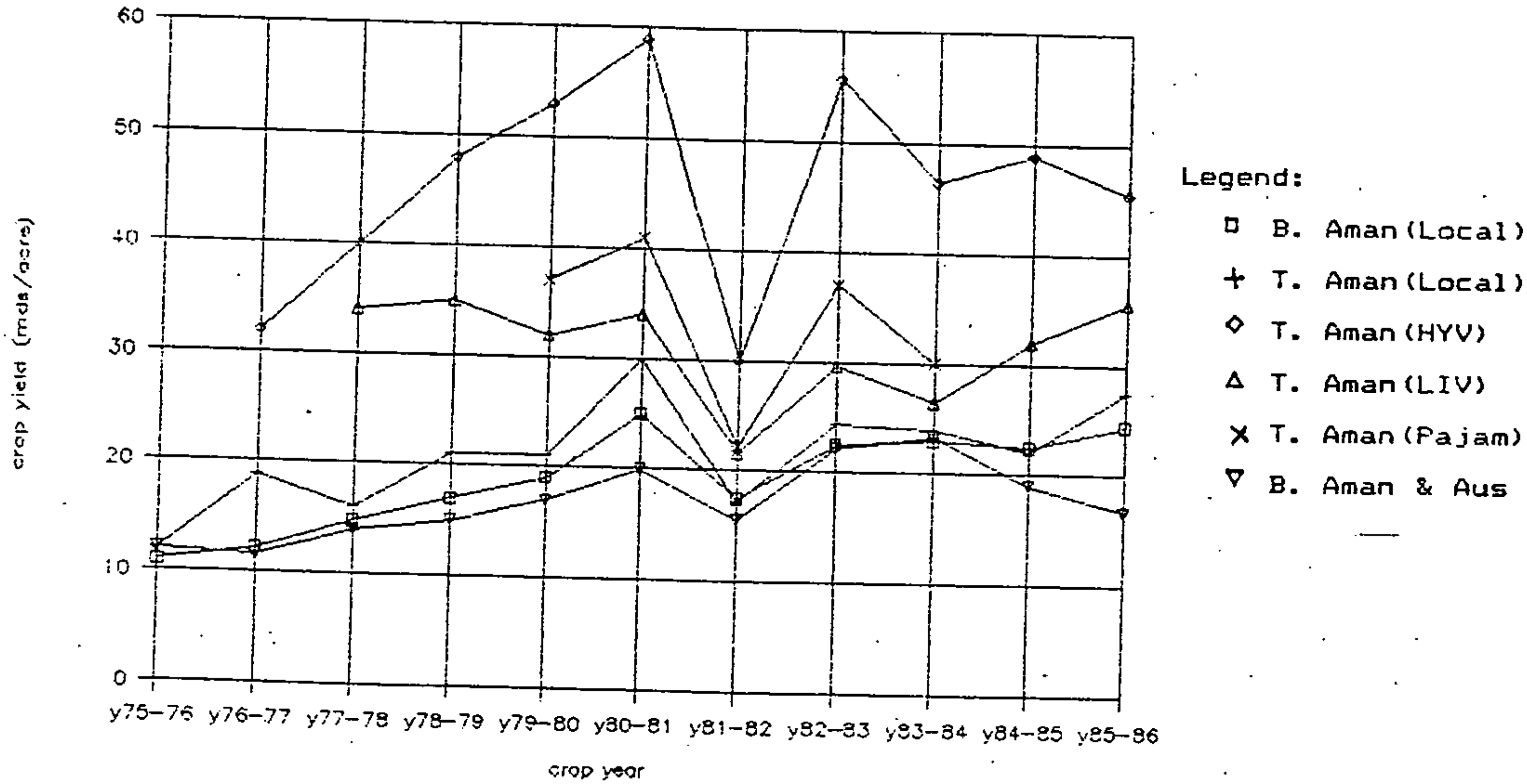


Figure 5.11
Yield variation of kharif-II crops in CIP

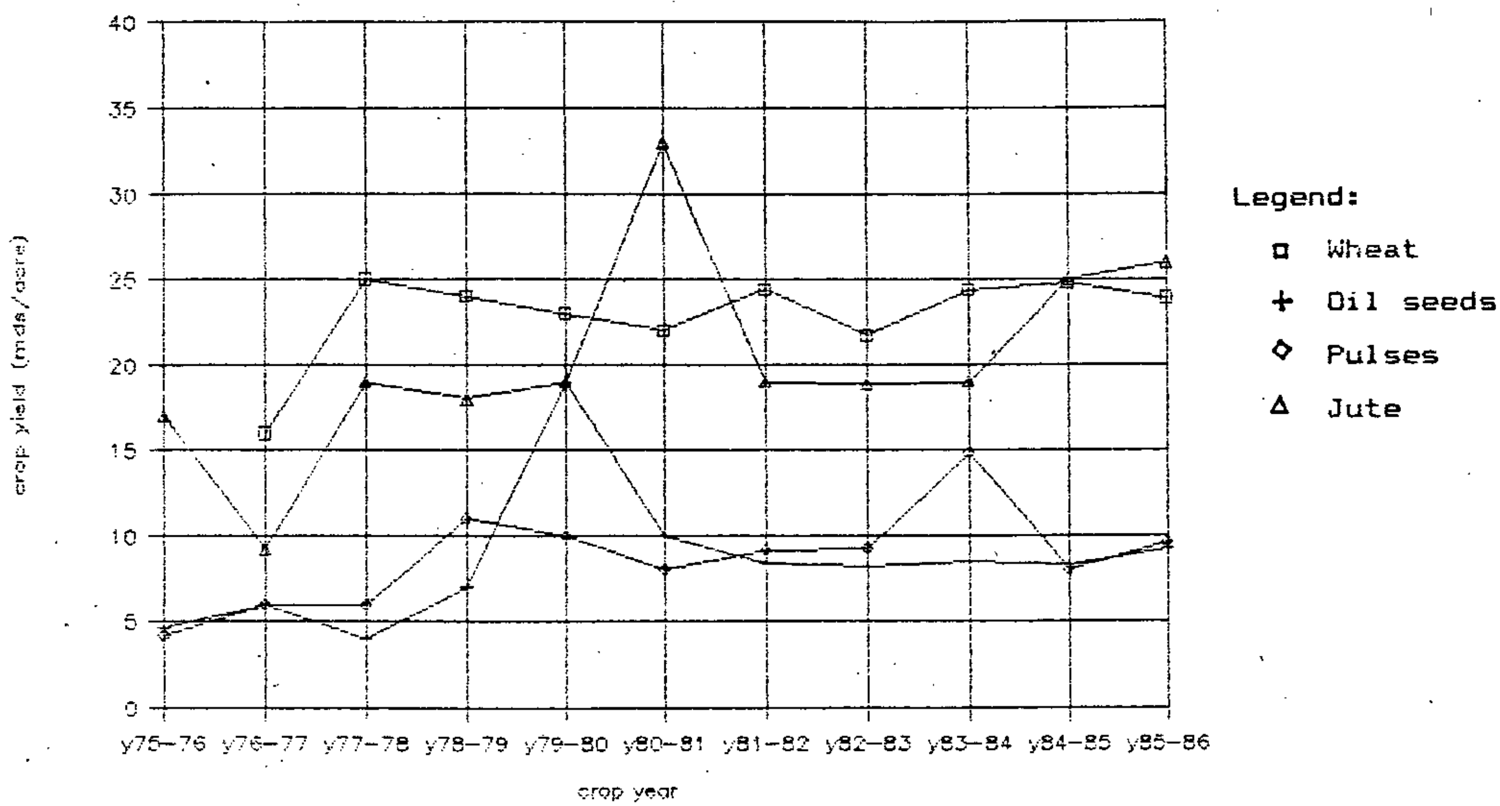


Figure 5.12
Yield variation of some selected crops (a)

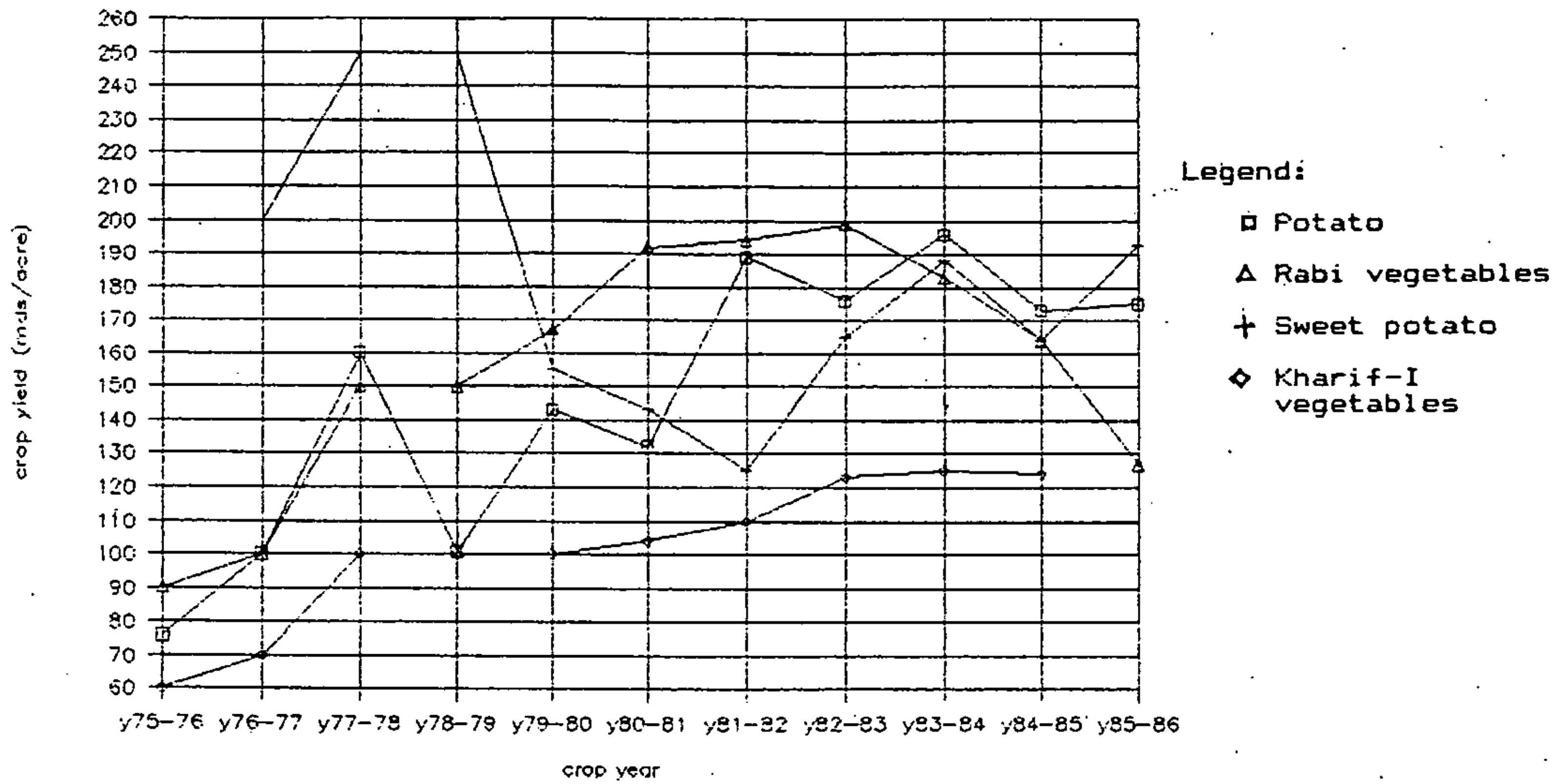


Figure 5.13
Yield variation of some selected crops (b)

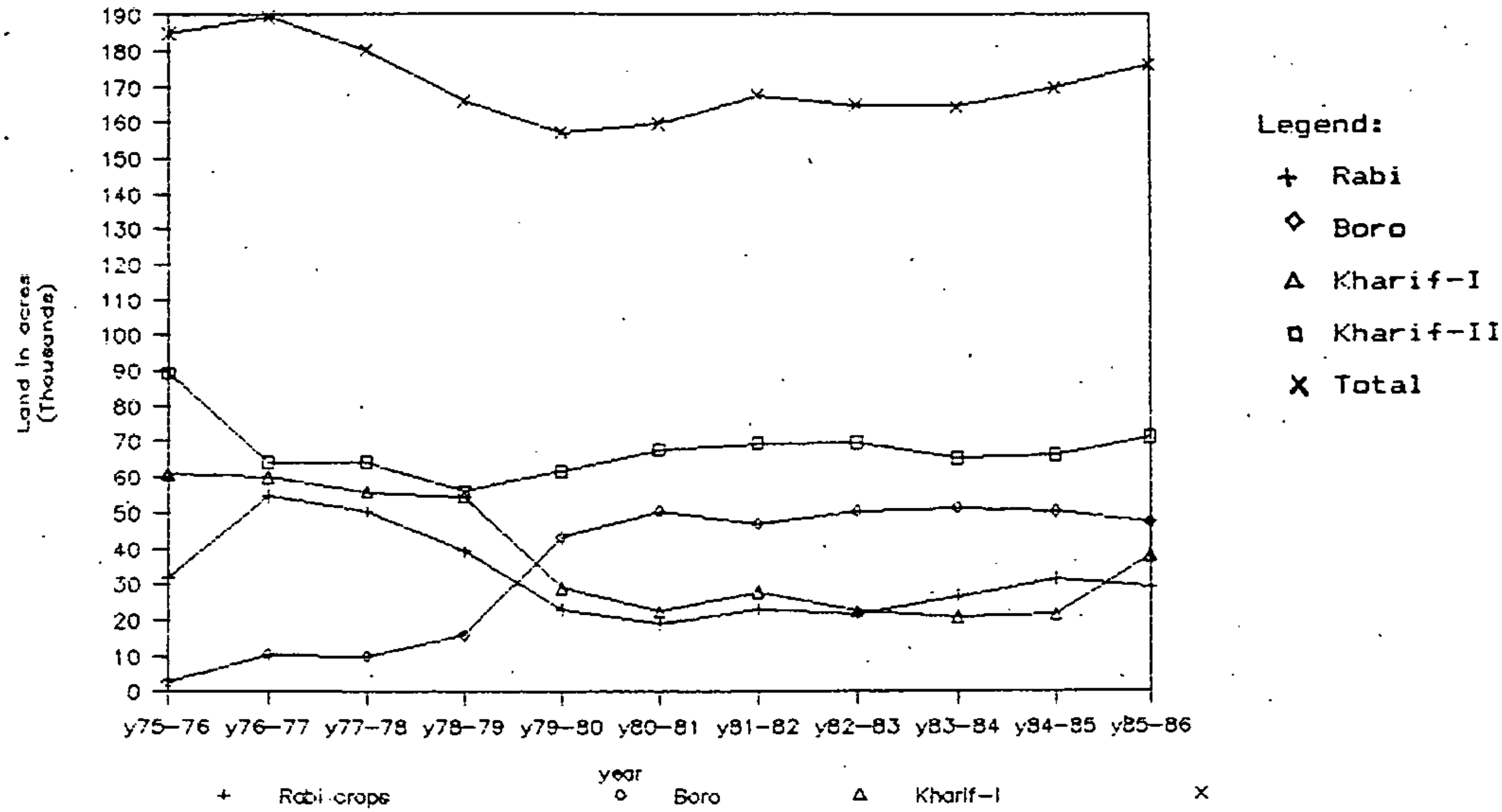


Figure 5.14
Land use in different crop seasons in CIP

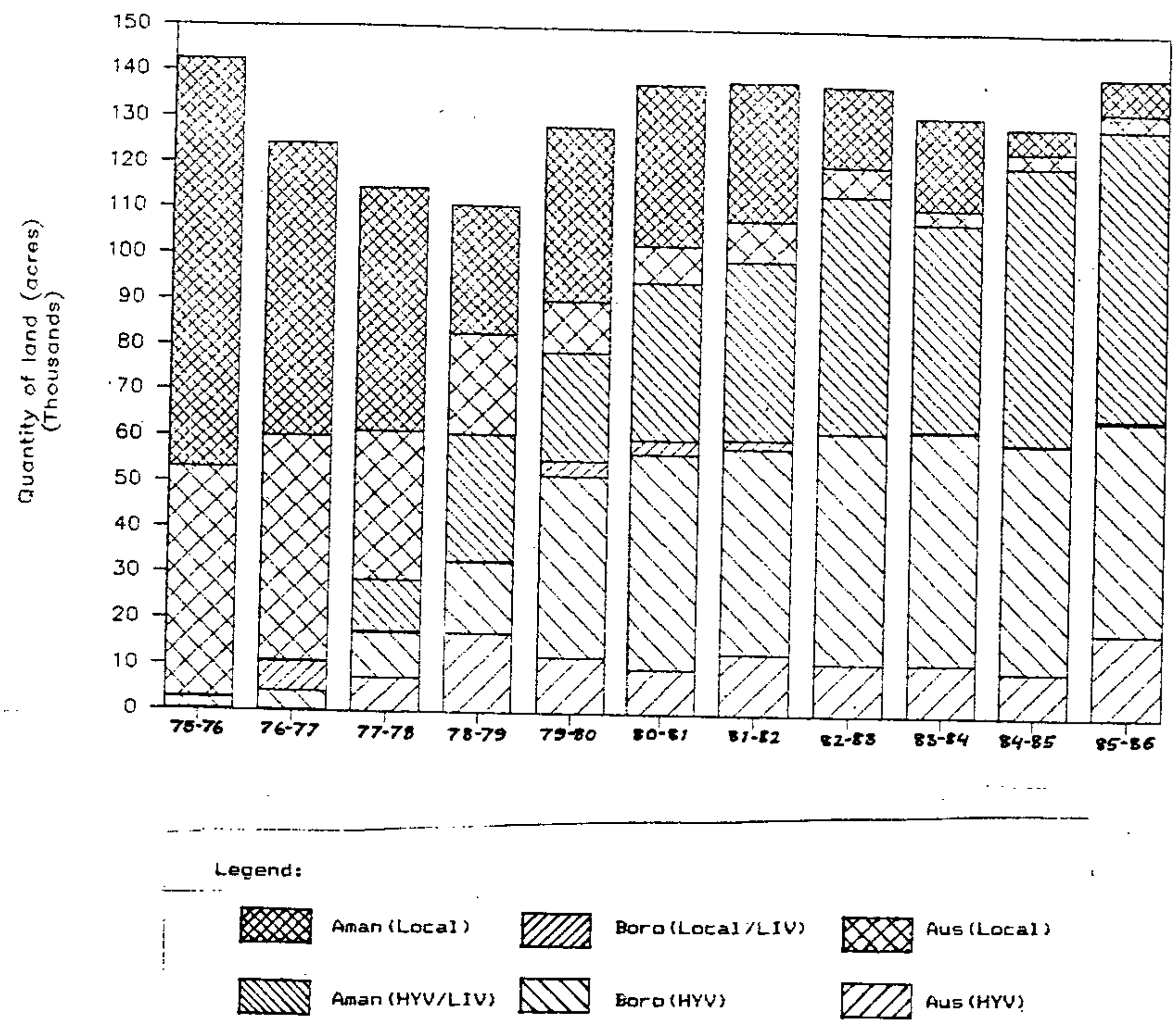


Figure 5.15
Land devoted to different types of paddy in CIF

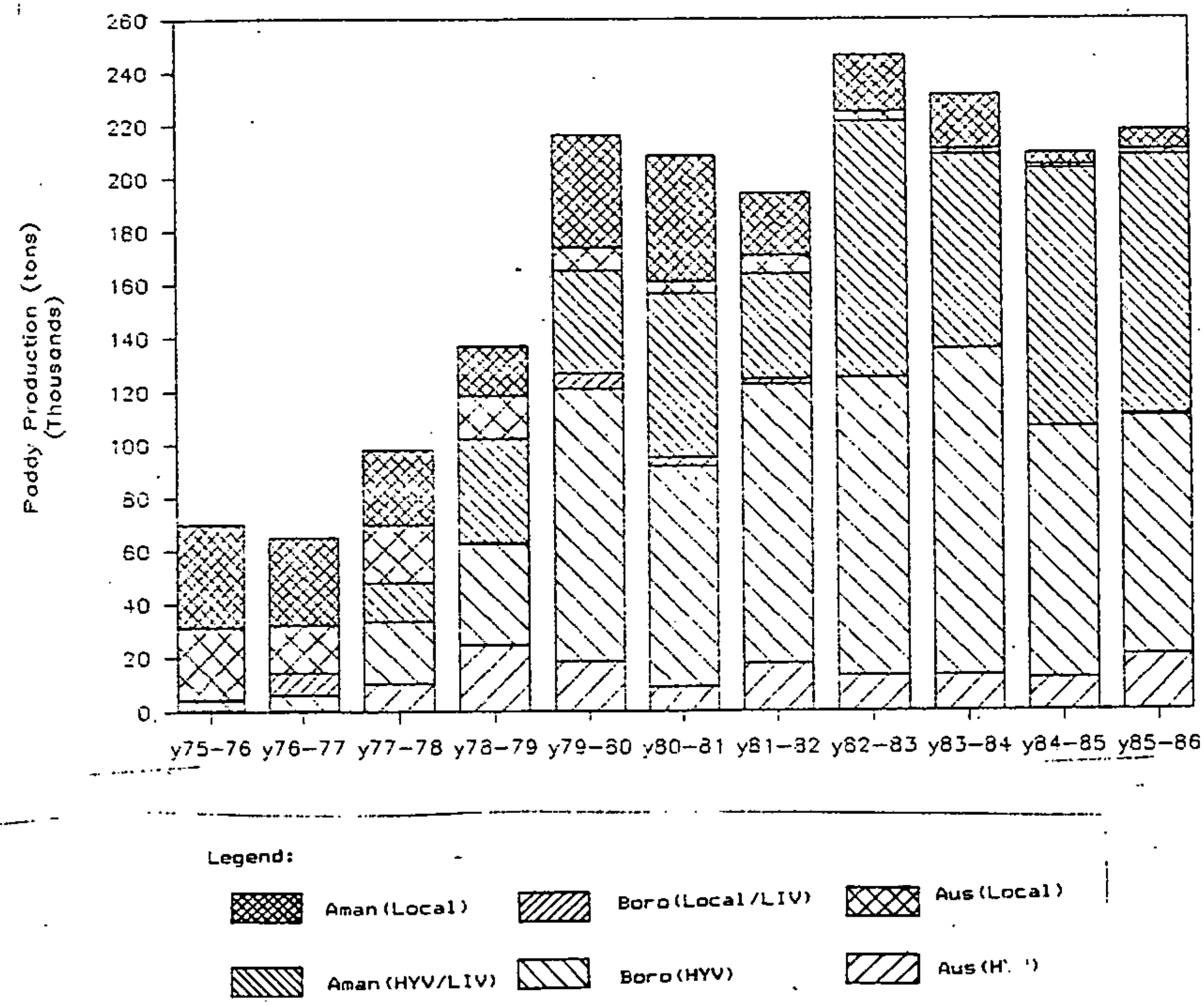


Figure 5.16
Total paddy production in CIP

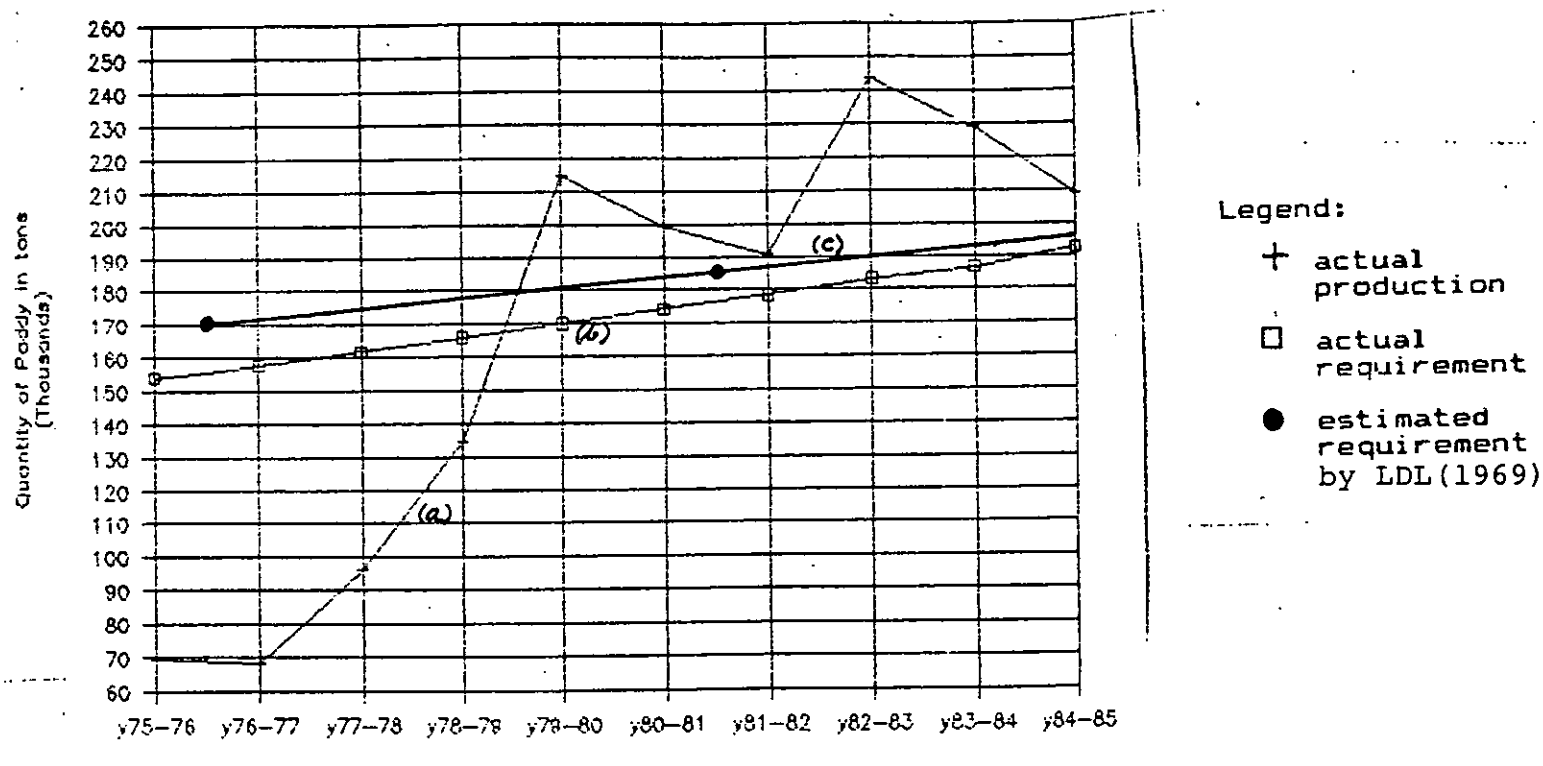


Figure 5.17
Food requirement and rice production ir CIP

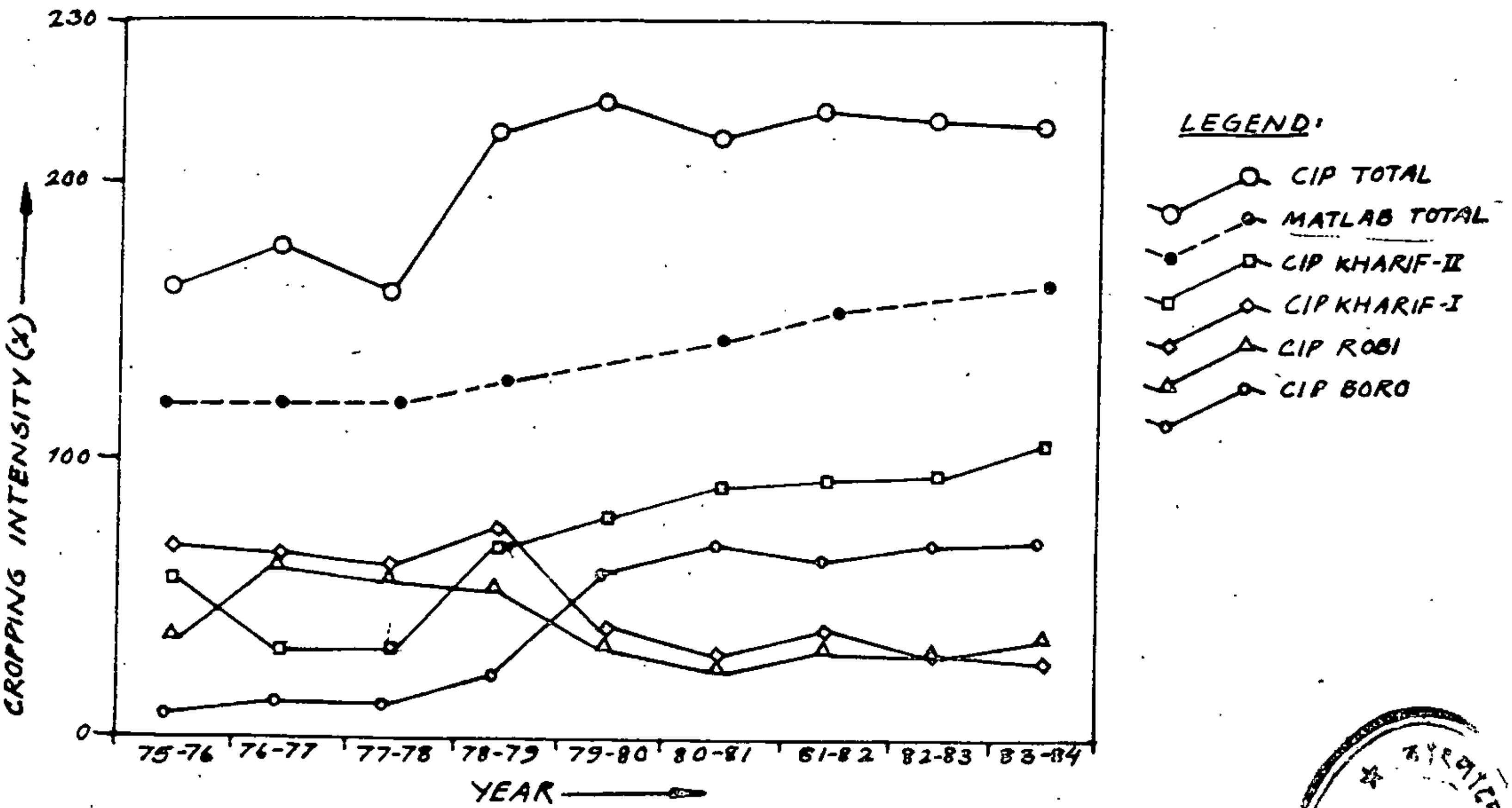


Figure 5.18
Cropping intensities of CIP and Matlab Upazilla