DEVELOPING INTEGRATED ENVIRONMENTAL MANAGEMENT POLICIES FOR MEGHNA-DHONAGODA IRRIGATION PROJECT IN BANGLADESH

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ABSTRACT

Development projects generate environmental changes that may be positive or negative. Concerns about negative impacts are increasing though beneficial effects may justify the projects. Recently environmental impact assessment has become a part of project planning process through which the adverse effects are accounted. The importance of environmental management policies for development projects is gradually increasing and many donor agencies have made it mandatory for their projects Many experts and institutions have developed their own guidelines for Environmental Management Policy

In this study, Meghna-Dhonagoda Irrigation Project at Chandpur has been considered for developing Integrated Environmental Management Policy MDIP was undertaken in 1977 and it's constructed was completed in 1987. Several environmental components like fisheries, soil fertility, drainage congestion and irrigation facility have been affected seriously and others may be affected in the future. A few techniques have been developed for environmental management. Some of these techniques are complex and need large resources and technological support. The main objective of the present study is to find out the mitigation measures for the adverse impacts of environmental components The model known as AHP has been utilised to analyse for developing Integrated Environmental Management Policy The methodology was designed for operationalization of the AHP model. Data was collected from Experts and users of MDIP. The AHP model analysed for MDIP indicates that - to mitigate the adverse impact on fisheries, '*closed water fish culture*' is the best policy. To mitigate the adverse impact on soil fertility, '*use of modern machinery*' is the best and '*reduction of crop cultivation season*' is the second preferred policy. To remove the drainage congestion and to develop the irrigation facility, '*provide appropriate slope in irrigation and drainage canal*' is the best policy

Presently there is no monitoring system of adverse impacts by the project management. A programme for detailed monitoring has been proposed It is possible to overcome most of the adverse impacts and also to enhance the positive ones, if appropriate steps, based on the results of impact assessment are introduced.

ABBREVIATIONS

ADB	-	Asian Development Bank
AHP	-	Analytic Hierarchy Process
BCAS	-	Bangladesh Centre for Advanced Studies
BETS	-	Bangladesh Engineering & Technological Services
BUET	-	Bangladesh University of Engineering and Technology
BWDB	-	Bangladesh Water Development Board
c/s	-	country side
CARE	-	Co-operative for American Relief Everywhere
CIRDAP	-	Centre on Integrated Rural Development for Asia and the Pacific
CKC	-	Chuo Kaihastu Corporation
DAE	-	Directorate of Agriculture Extension
DOE	-	Department of Extension
DTW	-	Deep Tubewell
EC	-	Expert Choice
EMP	-	Environmental Management Plan
FAO	-	Food and Agriculture
FAP	-	Flood Action Plan
FCD	-	Flood Control and Drainage
FCD/I	-	Flood Control, Drainage and Irrigation
HYV	-	High Yielding Variety
ICDDRB	-	International Centre for Diarrhoeal Disease and Research, Bangladesh
IEE	-	Initial Environmental Examination
IEMP	-	Integrated Environmental Management Plan
IFCDR	-	Institute of Flood Control and Drainage Research
LGED	-	Local Government Engineering Department
LLP	-	Low Lift Pump
MDIP	-	Meghna-Dhonagoda Irrigation Project
MES	-	Monitoring and Evaluation System
MURP	-	Master of Urban and Regional Planning
MV	-	Modern Variety
NGO	-	Non Government Organization
O&M	-	Operation and Maintenance
OM	-	Organic Matter
PCR	-	Project completion Report
PWD	-	Public Works Department
r/s	-	river side
RRA	-	Rapid Rural Appraisal
SE	-	Superintending Engineer
UP	-	Union Parishad
URP	-	Urban and Regional Planning
WRE	-	Water Resource Engineering

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CHAPTER - 1

INTRODUCTION

1.1 INTRODUCTION

Many Flood Control, Drainage and Irrigation (FCDI) projects have been constructed in Bangladesh since 1960. These development programs are formulated to generate benefits for a society as well as for increasing a country's food production. However, due to neglect of environmental consideration, many FCDI projects are now beset with a number of social and environmental problems offsetting many initial gains. Environmental monitoring of the FCDI projects is the first pre-condition to formulate remedial measures in order to make these projects sustainable in the long run.

Very often environmental damages are noticed at such a time, when there is no scope to go back to the original state (pre-project situation) or effectively recover the damages already incurred. The aim of environmental planning or monitoring is not to cease a development project, but to achieve maximum benefit out of it and at the same time minimise the negative effects making the project more viable and acceptable to the community (Mirza, 1991). This has led to the concept of Integrated Environmental Management Plan (IEMP) which now has become synonymous to environment and economic management.

1.2 ENVIRONMENTAL IMPACTS DUE TO FCDI PROJECT

The construction of embankments along the major rivers undoubtedly has environmental bearings. The major benefit of these projects emanates from the progressive reduction or elimination of flood damages to crops, livestock, habitation and development infrastructures. They also create opportunities for additional development and employment.

On the other hand, such programs may also create adverse impacts. The river itself is a dynamic system carrying large quantities of silt and sweet water. The fresh water, besides providing sustenance, dilutes and disperses effluent. The silt builds up soil downstream and nourishes aquatic life FCDI projects disrupt fish breeding grounds in the flood plains. This is specially important in a country where 70% of animal protein is derived from fishes FCDI projects have also brought adverse changes in physical and chemical properties of soil, rural health and sanitation, seasonal and perennial wild life habitats etc (IFCDR, 1994)

Sinha (1985) notes that the use of static water for agriculture does not lead to increase in output year after year Chances of crop yields being sustained are limited. The markets are slow to develop which initially acts as a constraint and mono-crop regimes tend to prevail This leads to shortage of certain trace elements and acts as a constraint on yields being maintained over years. Susceptibility to disease increases. This raises the cost of production apart from lowering the output

The continued flow of water in irrigated areas leads to a gradual but perceptible change in the eco-system; the sub-soil water levels raise, the soil structure is affected, vegetation changes. The water flowing in the micro-system not used by the crop for evapo-transpiration percolates below the surface or flows in the fields. The first leads to a rise in the water level and the second to soil erosion, carrying away soluble nutrients, salts and suspended waste particles, to unintended areas and accumulation of water in depressions. Accumulation of water gives rise to multiplication of mosquitoes and consequent incidence of malaria Unchecked rise in groundwater leads to salinity and consequent reduction in yields, an effect felt over large coastal areas

Irrigation projects affect eco-system in different ways Due to continuous flow of water, low-lying areas are filled up by seepage leading to reduction or non-availability of grazing land Also high yielding varieties of fodder have considerably fewer yields than traditional varieties.

1.3 BACKGROUND OF THE STUDY

During the past two decades, Environmental Impacts Assessment (EIA) has become an integral component of the feasibility plans prepared for development projects in many countries Subsequent to the 1988 flood, wide ranges of flood control-related development plans were proposed, ranging from major river training and embankment construction to community based flood proofing. The sensitive Bangladesh environment combined with the complex adjustments to flooding that rural people have historically established, has necessitated a careful review of the social and environmental impacts of proposed development plans.

Meghna-Dhonagoda Irrigation Project (MDIP) is a combined flood control, drainage and irrigation project. It has a gross area of 17,584 ha. and occupies the major portions of 14 out of the 22 Unions of Motlab Thana of Chandpur district. The total project area is an island surrounded by 60 km. flood embankment and is bound by the river Meghna on North and West and by the river Dhonagoda on East and South. Before the project, large areas were flooded with a depth of 2 to 3 meters every year and almost all areas experienced some flooding, while soil moisture was deficient for agriculture in the Rabi and early Kharif seasons (from June to October) The project objective was to protect the interior of the island from river flooding, to remove the drainage congestion of MV aman, to increase the security of the population, crops and livestock during the monsoon and to promote rabi crop cultivation and especially MV boro, by providing an irrigation system (FAP-12, 1992a).

After the implementation of the project, the project area has become completely free from river flooding and drainage congestion It embraces a gross area of 17,584 ha. of land out of which 14,367 ha of land is irrigable. Agricultural performance of the project subsequently has been very good and there are clear indications of increased well being in the project population The cropping intensity has increased from 151% in pre-project condition to 244% in post-project condition The per-acre yield of paddy has increased to 40-45 mounds from 15-17 mounds in pre-project condition The total amount of crop has increased from 32,000 tons to 1,28,000 tons in 1992-93 (BWDB, 1993 quoted in IFCDR, 1994b)
There have been many secondary benefits due to this project. The increased crop production has increased employment opportunities The flood embankments have provided better security to crops, better transportation network and better security to infrastructures. Very importantly, the MDIP has provided increased educational opportunities by providing flood free environment round the year.

FAP-12(1992a), in a study identified some environmental impacts of the project. According to FAP the negative effects are -

1. Soil erosion in Dhonagoda embankment, especially between Nandalalpur and Durgapur.

2. Decline of soil physical characteristics under the now-prevalent rice monoculture and to the limited involvement of the local people in project operation and maintenance.
3. Institutional performance, especially during the design and construction stages is poor.
4 Such changes include the reduction in natural wetland extent, accompanied by the marked decline in birds, fish and other wildlife. In the last three years, fish disease has added a further marked negative trend.

And the positive effects are

1 Improved soil moisture status and land capability.
2. Increased Crop cultivation reflecting potential impact.
3. Agro-industrial and associated activities, which have flourished following the increased agricultural production

A study by IFCDR (1994) identified some adverse and beneficial impacts of the project. Agriculture, health and nutrition, employment opportunities, economy and service, communication, tree planting and livestock have been the beneficial impacts while fisheries, soil fertility, water pollution, navigation, wild life, water logging and ground water table were the adverse impact of the project. ICDDR,B (1994) point out that there has been no major negative impact on the health or nutritional status of people living in areas inside the embankment. It also points out that MDIP was implemented from 1977 to 1991 to increase agricultural production, create employment opportunities and to improve living condition of the people of the area. But the pond water inside the embankment was significantly more polluted than outside the embankment in the dry season

Hoque et al.(quoted in BETS and BCAS, 1994) portrayed the project as a typical example of poorly implemented, top-down and hazards-evoking one producing more disadvantages than benefits, specially concerned to social and environmental implications. Specific adverse impacts in agriculture sector indicated by them include (a) water contamination in the impounded drainage canals, (b) deterioration of soil fertility, (c) non-improvement of internal roads to replace boat traffic.

The Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) in it's final report (1987) presented some socio-economic data and indicated some results which need attention for actions, for example, poor transport infrastructure, non-improvement in crop diversity, drought power shortage, chronic malnutrition, water contamination etc.

In the study of Socio-Environmental Assessment of Meghna-Dhonagoda Irrigation Project, Bangladesh Centre for Advance Studies (BCAS, 1994) and Bangladesh Engineering and Technological Services (BETS, 1994) with the financial support from the Asian Development Bank (ADB, 1994) made an assessment on the extent of loss of capture fisheries in and around the Meghna-Dhonagoda Project area In this study, a significant impact of the embankment on the natural fisheries has been reported The study has also revealed that all categories of fishermen, fish traders and others dependent on the capture fisheries production for their livelihood, income, and survival have been seriously affected. They also found out that, soil fertility is decreasing because farmers were bound to apply high doses (quantities) of chemical fertilisers to make up the nutrient deficit for reasonable crop production.

The project Completion Report (PCR) of the Meghna-Dhonagoda Irrigation Project, 1990 (PCR: BAN 21177) by ADB concluded that the embankment, and the irrigation and drainage facilities dramatically changed the agro-environment of the area enabling the farmers to increase crop production, but activities in irrigation (for agriculture development) remained to be implemented to achieve the full target. The report included some project related and some general recommendations which include attention for restoring the beneficiary farmers' confidence in flood protection, irrigated crop yields and net income, on-farm development procedures to be implemented; irrigated crop extension service

From the above discussion, it becomes clear that MDIP has generated both positive and negative effects on the environment There is no denying the fact that the project has helped increase agricultural production along with some associated negative environment impacts. Thus to sustain the positive effects and to minimise the negative effects, there is a need to adopt policy, which would provide an integrated framework for sustainable development.

1.4 INTEGRATED ENVIRONMENTAL MANAGEMENT POLICY IN PROJECT PLANNING

The growing environmental awareness and increasing understanding of development action and possible environmental consequences have led to incorporation of environmental factors in decision-making process and this is achieved through Environmental Impact Assessment (EIA) in planning. The purpose of EIAs is to assist the planning and decision making process. EIAs are used to foster environmentally sound decisions and to aid in the development of an Environmental Management Plan (EMP) for the respective projects

The 1989, G7 Summit determined that all FAP projects should be formulated with full consideration of socio-economic, technical and environmental aspects Both the Bangladesh Environment Policy of 1992 and the National Conservation Strategy for Bangladesh, incorporate a national requirement for EIA The environmental concern was substantially emphasized at the Second Conference on the FAP in Dhaka, March 1992, where donors agreed that all FAP projects should be subject to EIA (FAP-16 and FAP-19, 1993).

Environmental Management Plan (EMP) is a plan to undertake an array of follow up activities which provide for the sound environmental management of a project so that adverse environmental impacts are minimised and mitigated, beneficial environmental impacts are maximised and sustainable development is ensured.(FAP, 1992)

In the complex FCD/I environment, proper management of inter-sectoral activities are essential if benefits from improvement programs in any one sector are to be fully realized Therefore, the FCD/I project of Meghna-Dhonagoda has been formulated in the context of an Integrated Environmental Management Plan (IEMP) to provide an integrated framework wherein selected components are complementary to the flood control, drainage and irrigation program, and will mutually reinforce their impacts on an area-wide basis (FAP-8B, 1992)

1.5 RATIONALE OF THE STUDY

Several studies have been undertaken in MDIP, but these are sectoral such as Socio-economic, Agricultural, Environmental, Fisheries, and Technical. No attempt has been undertaken for integrated study where the different sectors are inter-related. It is therefore, necessary to carry out the study in detail, to arrive at the best of the Integrated Environmental Policies in MDIP

1.6 OBJECTIVES OF THE STUDY

The main objective of the study is to formulate integrated environmental policies that will help obtain sustainable development in the project area The specific objectives of the study are:

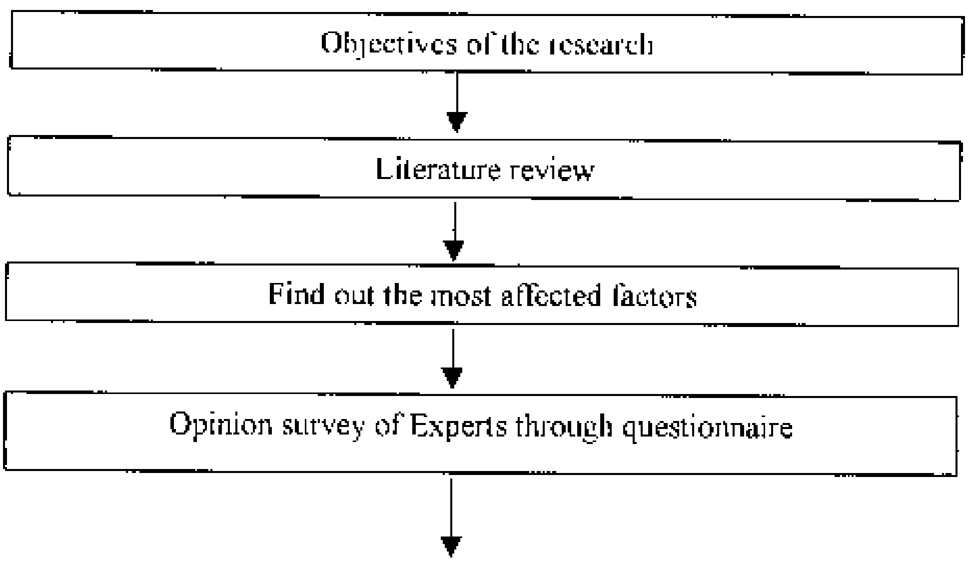
a Identify and analyze the major environmental impacts of the project.

b Identify possible policy measures that will help mitigate the adverse environmental impacts

c. Prepare integrated environmental management policies for the sustenance of positive impact and mitigation of negative impacts.

1.7 METHODOLOGY OF THE STUDY

To achieve the objectives of this research the following methodology (chronological development chart) has been adopted.



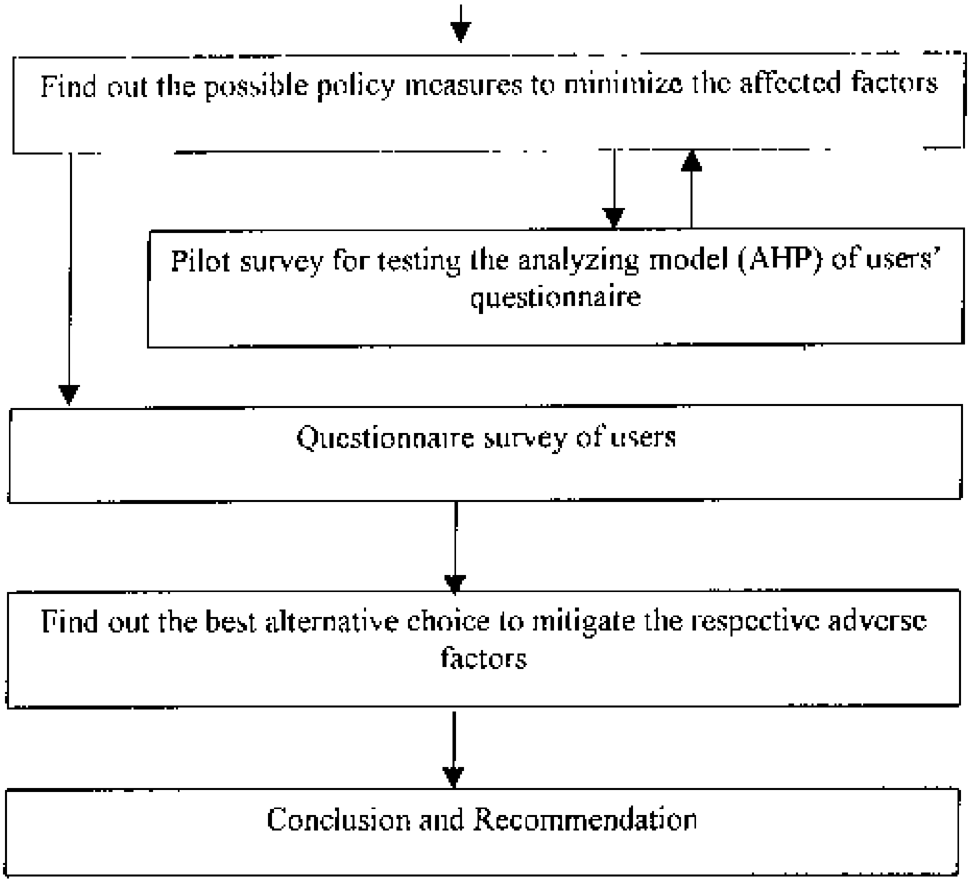


Fig: 1.1 Research Design

1.7.1 DATA COLLECTION TECHNIQUES:

A. Data collection from secondary sources:

To identify the problems of major environmental effects in MDIP, information related with this topic were collected from different books, reports, journals, unpublished thesis, seminar papers, magazines, newspapers. Some office records on this topic were collected to acquire knowledge about their success and failure

B. Opinion survey:

To identify the mitigation measures of adverse environmental impacts in the project opinions relating to the respective components were collected from secondary sources and discussed with experts and local people. For this purpose a questionnaire was prepared for listed MDIP experts In that questionnaire, some mitigation policies and also some possible side affects were mentioned for every environmental component Experts were required to identify options to take any policy and their corresponding side affects It was an open ended questionnaire to which policies and their corresponding side effects and also comments, could be added if experts found them necessary.

C. Field survey:
For Household (H/H) survey, questionnaire was designed to find out the best alternative measures to adverse environmental impacts The respondents were selected randomly from among the cross section of population of the study.

1.7.2 SAMPLING FRAME:

Sampling technique

In this research, for the questionnaire of opinion survey, persons select were experienced MDIP experts on environmental study and an 'Individual' was chosen as a sampling unit, for users' survey A random sampling Technique was applied to select the user group of MDIP, who are aware about the impacts on the project.

31 experts have given their opinion in the questionnaire of opinion survey. In the pilot survey 15 persons were considered, who are living in MDIP but now stay in Dhaka, for testing the analyzing model (AHP) of users' Questionnaire. Due to limitation of time and money, a sample of 130 individuals was selected for collecting data for user's survey. In the AHP model the individual respondent's preference weights were considered separately. The normalized weights and the corresponding consistency ratios were obtained from each matrix developed on the basis of their filled up questionnaires Only cases where consistency ratio is less than 10 percent were selected for further analysis. After sorting and screening (such as incomplete answer, invalid data, consistency ratio is greater than 10 percent) out of these 130 samples, only 99 samples were considered for further analysis and for model calibration. Thus the sample was quite small and result would tend to be indicative rather than definitive

Survey Period

The opinion survey was conducted in the month of January 1998. The pilot survey and the users' survey were undertaken during February-April 1998 An individual for questionnaire survey was selected randomly from their working place during daytime

Design of Questionnaire

For the questionnaire of opinion survey, experts had the options to add their opinions and comments in the questionnaire. An individual survey for users' was undertaken by structured questionnaire. The questionnaire had been distinctly divided into five parts, namely personal information, fisheries, soil fertility, drainage congestion and irrigation facility

1.7.3 DATA ANALYSIS AND PROCESSING:

Collected data have been presented both in tabular and graphical forms. Standard computer packages like MS-Office, SPSS for windows were used to analyse the data. Special software, *EXPERT CHOICE* has been applied for Analytic Hierarchy Process (AHP) technique to find out the hierarchy of policy.

1.8 LIMITATIONS OF THE STUDY

Integrated Environmental Management Policy FCD/I project is a new type of study The study is beset with some limitations, which are as follows:

1. The technique AHP (as computer software Expert Choice - 8) is used to analyse the collected data The software has some inherent limitations.

2. It would have been better if more positive and negative impacts could be considered. But due to the time and resource constraint only four impacts have been considered

3. In this research socio-economic survey and cost-benefit analysis of mitigation measures has been ignored due to the extend of work which needs to be completed within limited time and resource

1.9 ORGANIZATION OF THE THESIS

The study has been organised into six chapters The first chapter sets out the research objectives and the methodologies to achieve those objectives. Chapter two describes the physical situation of the study area. Chapter three presents the existing environmental condition of the study area as well as the environmental components, which were affected by Meghna-Dhonagoda irrigation project Chapter four describes the experts' opinion to find out the mitigation measures and their side affects to minimise the adverse impact on environmental components by MDIP. Chapter five presents the detail analyses with Analytic Hierarchy Process (AHP) technique Lastly, chapter six provides a summary of the research and suggests policy recommendations and the need for further research direction.

CHAPTER - 2

THE STUDY AREA

2.1 INTRODUCTION

The study area is Meghna-Dhonagoda irrigation project whose location, description and selected features have been described in this chapter.

2.1.1 LOCATION

Meghna-Dhonagoda Irrigation Project (MDIP) is located in Matlab Thana of Chandpur district which is situated in south-eastern Bangladesh (Fig 2.1). The area lies between latitudes 23^0-20$''$ N and 23^0-29$'$-45$''$ N and between longitudes 90^0- 45$'$-15$''$ E to 90^0-35$'$-35$''$ E The project has a gross area of 17,584 ha. and occupies the major portion of 14 out of the 22 unions in Matlab thana It is located on an island surrounded by the Meghna-river on the north and west and the Dhonagoda, a branch of the Meghna, on the east and south (Fig: 2.2) There is no town or administrative centre above union level in the project area. The thana town of Matlab lies immediately south of the project across the Dhonagoda river.

2.1.2 PHYSICAL CHARACTERISTICS

The project area is a low flat alluvial delta and is completely surrounded by the rivers Meghna and Dhonagoda. The project area does not have any well-defined ground slope In general, the middle portion is slightly lower than the fringes. There are small patches of low lands scattered mostly in the eastern part of the project area. Land types based on flood depth of Matlab thana which includes the project is given in Table 2.1. Topographically, the area may be classified as follows:

i The northern half of the area is an undulating terrain having a ridgeline running from Northeast to Southeast.

ii. The expansion from the central part to the southern part forms a natural levee of complex terrain
iii. The southern part forms low lands having a number of khals intertwined to form a creek area

Annual Rainfall averages 2300 mm Before the project, large areas were inundated to a depth of 6-9 feet every year and almost all areas experienced some flooding, while soil moisture for agriculture was deficient in the rabi and early kharif seasons. Over most of the area either only a single aman paddy crop, or a mixed aus/aman crop followed by rabi crops of low water demand, was grown A network of fresh water but weakly tidal khals (natural channels) intersects the project area These provided the main means of access during pre-project but were in little use for irrigation (FAP-12, 1992a).

2.1.3 SOIL CONDITION

Genetically, the soils are immature in the project area. None have prominent genetic soil horizons within the column. Soil profiles are little developed. General soil type and its extent in Matlab thana is given in Table 2 2 and distribution of soil texture in different land types is given in Table 2 3 It may be noted that the project area covers only 67 percent of the total area of the Matlab thana.

Table 2.1 Land type based on flooding depth in Matlab thana

	High land <0.3m	Medium high land 0.3-0.9	Medium low .9-1.8m	Low land 1.8-3.6	Very low >3.6m	Total land
Area(ha.)	13	405	20,972	4,893	0	26,282
%of total	0.05	1.54	79.80	18.62	0	100

Source: IFCDR, 1992, p-7.3

Table 2 2 General soil type and its extent in Matlab thana

Soil type	Extent (ha)	Percent
Calcareous grey floodplain soil	1,347	5 13
Noncalcareous grey floodplain soil	17,476	66 49
Noncalcareous dark grey floodplain soil	7,447	28.33
Made land	13	0.05

Source IFCDR, 1992, p-7.3

MAP OF BANGLADESH

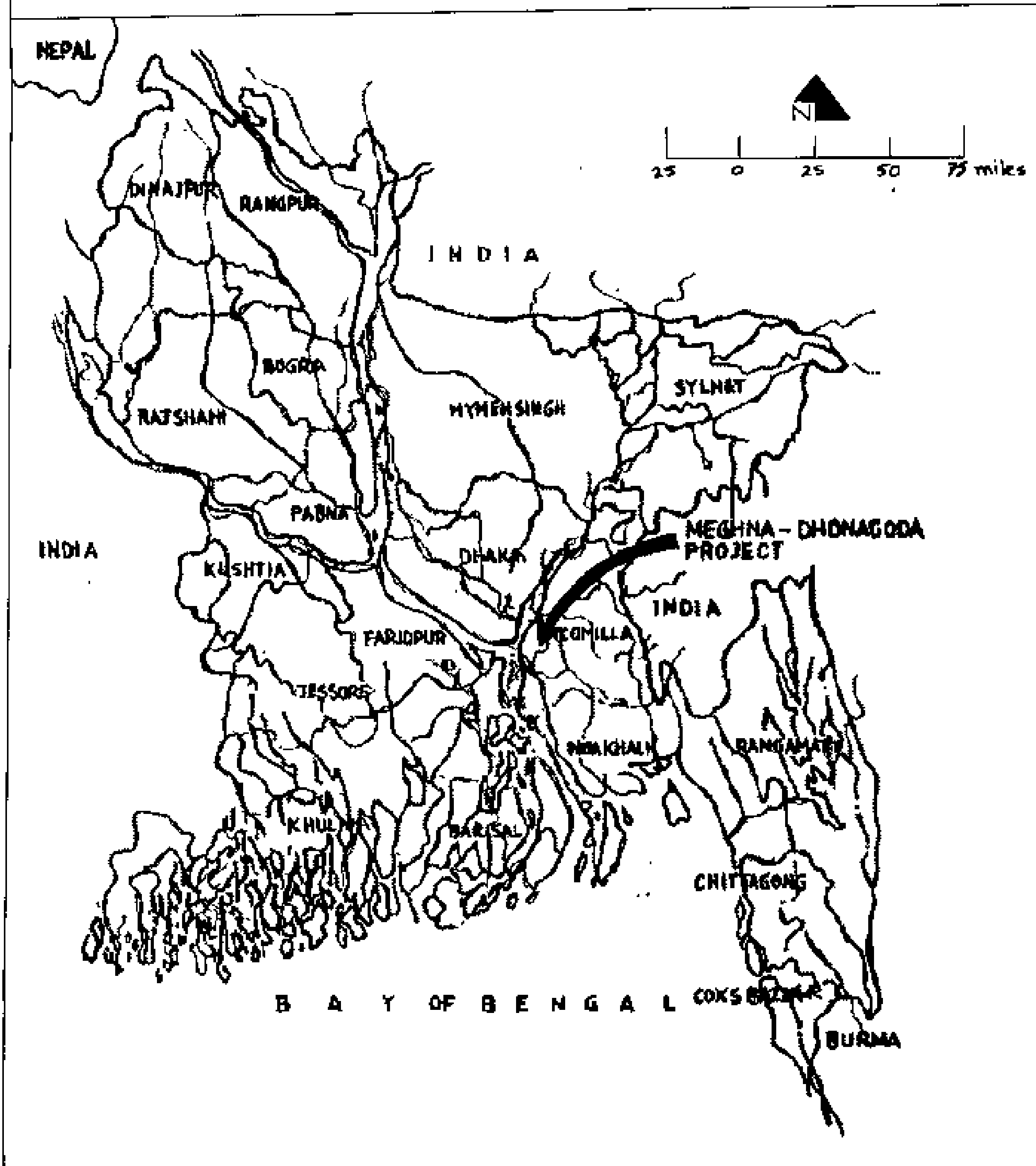


Figure : 2.1 Location of MDIP in Bangladesh
Source IFCDR, 1995

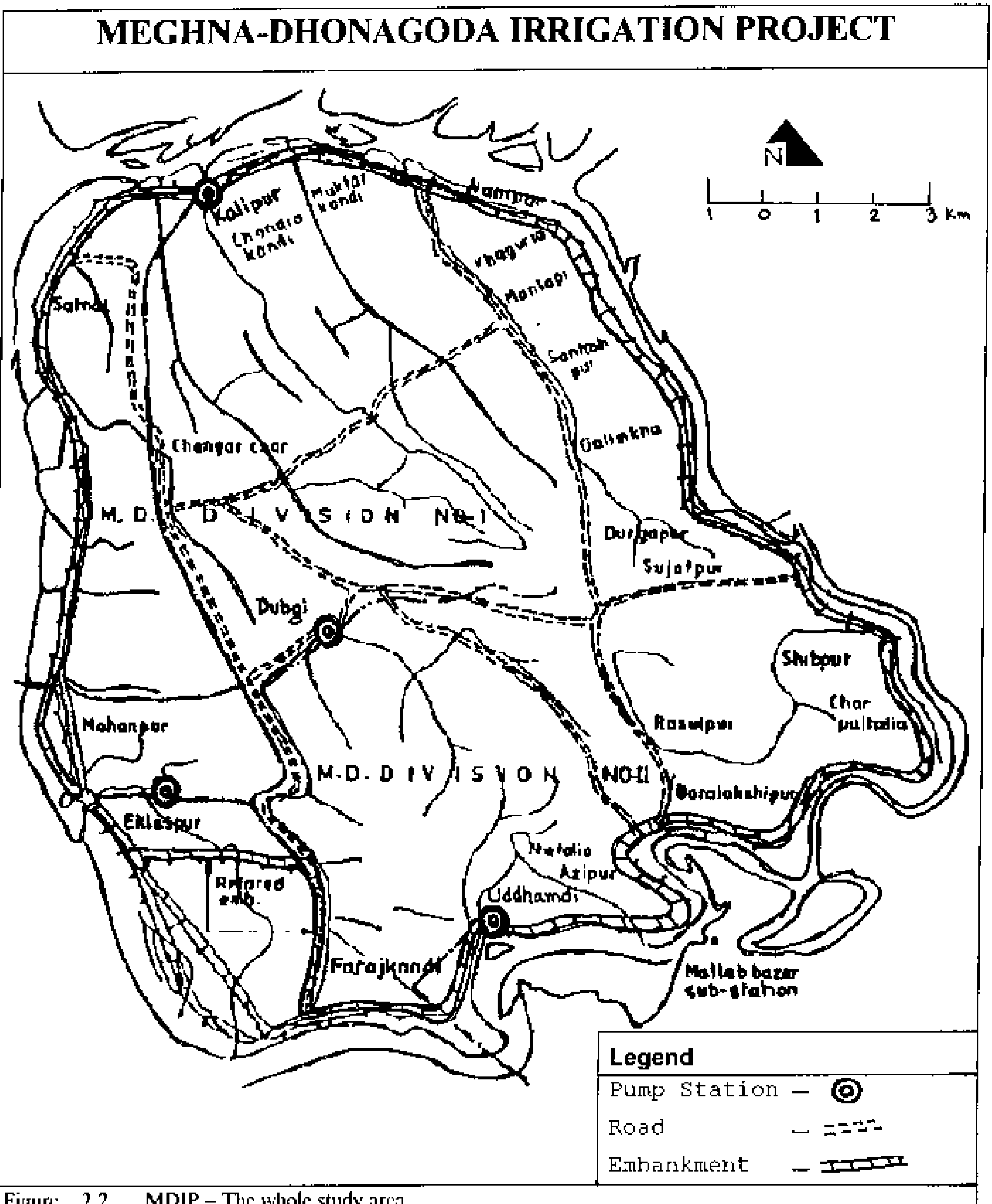


Figure 2.2 MDIP – The whole study area
Source IFCDR, 1995

Table 2.3 Distribution of soil texture in different land types in Matlab Thana (in ha)

Land type	Soil type				Total
	Sandy	loamy	Silty	Clayey	
Highland	-	13	-	-	13
Mediumland	-	405	-	-	405
Medium low	-	20,972	-	-	20,972
Low land	-	3,082	-	1,811	4,893
Total	-	24,472	-	1,811	26,282

Source: IFCDR, 1992, p-7.3

In the pre-project period, the soils were annually inundated and renewed by river alluvium deposits every year. Due to water logging condition during rainy season, sub-soil layers show brown spots, yellowish brown strips and mottling, which are presumably due to leaching of the ferruginous compounds from the upper layers Occasionally, dark spots of manganese and iron salts are found in some places of the soil matrix.

Soils are well drained in the dry season, but have impeded drainage during monsoon up to Autumn season Top soils are acidic when dry but become near neutral when flooded Lower layers are mainly neutral to moderately alkaline in reaction According to results of auger borings, carried out in May to July, 1977 the subsoil upto 30m deep consists of two layers: Brown sandy silt (top layer) and gray silty sand. The thickness of the top layer ranges from 1.2m to 2.7m, and the bottom of the lower was not seen in the boring logs (IFCDR, 1992)

2.2 PROJECT HISTORY

BWDB and the Asian Development Bank identified the project in 1975. Feasibility studies were conducted with ADB funding in 1976-77, and the project was appraised by ADB in 1977. Construction by BWDB commenced in 1978 and the embankment was completed in 1987, four years after the scheduled completion date of 1983. Breaches of the embankment on the eastern (Dhonagoda) side of the project occurred in both 1987 and 1988, with deep and rapid flooding of the project interior, major damage to the irrigation canal system and much sand deposition in the vicinity of the branches. A rehabilitation programme is being implemented by BWDB, but at the time of the FAP 12 RRA in March 1991 over 3,000 ha. of the irrigable area remained without direct canal supply due to unprepared flood damage (FAP, 1992a)

Prior to the MDIP there was no flood protection and irrigation in the project area was virtually absent. There appear to have been no local initiatives to prevent flooding by bunds; instead, agriculture was adjusted to the normal range of monsoon flooding and homesteads were on higher land such as the ridges In between the lower troughs and depressions there was limited private irrigation for example by LLP from the large khals in the area Hence, there was no wide spread experience of public involvement in water management on which the project could be built.

2.3 PROJECT DESIGN AND OBJECTIVES

The overall objective of MDIP was to bring about a transformation in the hydrology of the area favourable to introduction of MV paddy in both the monsoon and dry seasons. The monsoon objective required both exclusion of the deep river flood and provision of drainage to prevent congestion of the high volume of rainfall while the dry season objective required provision of irrigation facilities.

MDIP is therefore a combined flood control, drainage and irrigation (FCDI) project. The main design features were a ring embankment around the perimeter for flood protection, and an internal network of gravity flow canals for dry season irrigation, and a network of drainage channels (mostly linked pre-existing khals) for drainage of excess rainwater in the monsoon Evacuation of drainage water is by two pump stations, one at Kalipur at the northern end of the project , and the other at Uddhamdi at the southern end. The main pump stations are reversible and can be used to lift water into the irrigation canals in the dry seasons The drainage volume is however much larger than that required for irrigation and the pumps were sized to handle the monsoon drainage requirement Part of the area can not be commanded by gravity flow from the main pump stations, and there are therefore two booster pump stations, at Dubgi, and Eklaspur, to command the higher areas The canal system is designed to command a total of 14,367 ha., the remainder of the gross area being too high to command economically (FAP-12, 1992a).

MDIP was to avoid sacrificing the internal navigation access provided by khals in achieving the project objectives in flood control. Navigation locks at the outfalls of the main khals were therefore planned In addition to maintaining the pre-project water transport system, the project also had an objective of improving the land transport system by constructing or upgrading of village roads

2.4 PROJECT STRUCTURES

The structures planned and actually constructed to achieve MDIP's objectives are summarised in Table 2.4. The design 100-year high water level of the embankment was set at 6 7m. above PWD datum, which agrees well with the 100-year flood The actual crest height of 7.6m. PWD datum includes a freeboard of 0.9m. The embankment was in no danger of overtopping in 1987 or 1988 (FAP-12, 1992a).

As can be seen from Table 2.4, there was significant variation between the structures originally planned and those actually built. The erosion problems, which affected the embankment and resulted in it being retired to a shorter alignment, need to be discussed Of the irrigation components, the third booster pump station envisaged for the eastern side of the Project was removed from the detail design as it was not economically justified by the additional command area, but the length of canals constructed by BWDB was almost three times that originally planned, due to BWDB assuming responsibility for the tertiary network. The originally planned envisaged provision of navigation locks and of an improved road network, was constructed The navigation locks ware downgraded transhipment points during detailed design, and even these were not actually constructed. None of the road network was built, although the planned number of bridges was constructed. Neither the BWDB nor the ADB PCR give the underlying reasons for these changes, but it seems highly likely that they were forced by the serious cost over-run of the project (FAP-12, 1992a).

Table: 2.4 Summary of main project features

Items	No/Length(km)		No./Length(km)	No./Length (km)		Remarks
	As Planned	As Implemented	Damaged 1987and 1988	Repaired/ Modified	Need repair/Nodi fication	
A. Flood embankment	65 km.	60 km.	46.78 km	46078 km.	-	-
B Pumping stations			-	-	-	-
Main	2 Nos	2 Nos	-	-	-	-
Booster	3 Nos.	2 Nos	-	-	-	-
C. Irrigation canal						
Main & secondary		97.5 km.	-	-	-	-
Tertiary		120 5 km	-	-	-	-
Total	75 km.	218 km.	162.28km.	74.70 km.	18.50 km.	-
D. Irrigation						
Regulator	69 Nos	69 Nos.	-	-	-	-
Irrigation conduit	14 Nos.	14 Nos.	2 Nos	2 Nos.	-	-
Check gate	42 Nos.	42 Nos	-	-	-	-
Turn out	387 Nos	387 Nos.	358 Nos.	358 Nos.	-	-
Escape	17 Nos	17 Nos.	1 Nos	1 Nos	-	-
Aqueduct	3 Nos	3 Nos.	-	-	-	-
E. Drainage canal	160 km.	125.5 km	38.25 km.	-	-	-
F. Drainage Structure						
Drainage conduit	39 Nos.	39 Nos.	7 Nos.	7 Nos.	-	-
Combined strictures	14 Nos.	14 Nos.	-	-	-	-
Water control strc	9 Nos.	9 Nos.	-	-	-	-
G. Bridges	72 Nos	72 Nos	6 Nos.	6 Nos	-	20 new bridges const-ructed
H. Roads	70 km.	Nil	-	-	-	-
I Navigation locks	2 Nos.	Nil	-	-	-	-

Sources.FAP 12. RRA survey, 1992a, p – 2 9

2.5 ORGANIZATION AND MANAGEMENT

BWDB is the principal executing agency of the project, and it was also responsible for the whole of the project implementation except agricultural extension, agricultural research, fisheries development, marketing and credit. Although at present there is an extension component of water development Board working in the project area, it is likely that in future this component will be abolished and the full load of extension works will be done by the extension people of Ministry of Agriculture. Other agencies involved are Ministry of local Government, Rural Development and Co-operatives, Ministry of Fisheries and Livestock (IFCDR, 1992).

2.6 . PRESENT OPERATION AND MANAGEMENT PROCEDURE

In general an operation service of an irrigation project has, as its chief objective, the timely delivery of the irrigation water necessary to satisfy crop water requirements. At the same time the fundamental requirement for successful operation is proper maintenance. Some important aspects of operation and maintenance of Meghna-Dhonagoda project are given below

Manpower and Training: The project has required number of officials as per the O&M manual. Some of them received training but due to transfer process some officials trained specifically for this project have already left the project There is no formal in house training program in existence at present in the project. The manpower of the project is given below

1	Superintending Engineer	1 no.
2	Executive Engineer	2 no
3	Sub-divisional Engineer	5 no
4.	Section Officer	14 no.
5.	Other Staffs	87 no

Equipment

The project has bulldozer, crane, dumptruck, shoveldozer, jeeps, speedboats and other kinds of equipment although many of them are not in running condition

Decision Making Process

The project officials take most of the decisions concerning operation and maintenance of the project. The Superintending Engineer (SE) has the ultimate responsibility of the project O&M and thus he takes all the important decisions. Executive and sub-divisional engineers can also take decisions in less important matters or in case of emergency. Decisions like starting and stopping of main pumps, operation of drainage pumps, closing or opening of the gates etc. are taken by project officials. Beneficiary involvement is mostly through representation of officials through their representatives and outlet committees. This project is not a big one. As such, problems can be identified and brought to the notice of officials quickly and decisions can accordingly be made. Farmers can draw attention of the officials regarding drainage congestion within hours and pumps are then operated until the problem is solved. Need for maintenance work is assessed through observation, surveying, and inspection or by observing the unsatisfactory performance of the structures. Officials complained that lack of fund and facilities sometimes result in unsatisfactory maintenance works (IFCDR, 1992)

2.7 PERFORMANCE AND CONDITION OF PROJECT STRUCTURES

Project Performance before 1988 Flood

During the 1987 flood a portion of the embankment on the Dhonagoda, near Durgapur on the eastern side of the project, was breached, and another portion at Rishikandi near Durgapur was breached by 1988 flood. From river gauging at Chandpur on the lower Meghna, the 1988 flood was only about a 1-in-19 event, and the 1987 a 1-in-2 event, whereas the embankment crest level was designed for a 1-in-100 year event. This confirms the evidence of BWDB reports and local residents that the breaches were due to embankment and/or subsoil failure, not to overtopping. Both the 1987 and 1988 floods caused widespread damages to the recently completed irrigation system, and an area of several thousand acres inside the breaches was badly affected by sand carried by the resulting high-velocity flows (FAP-12, 1992a).

Performance since 1988

Since 1988 two of the three major engineering components of the project - the embankment and the pumping stations- have functioned effectively. The repaired embankment has successfully withstood the 1989, 1990 and 1991 floods, and on this evidence now seems adequate to withstand the normal yearly floods caused by the Meghna and Dhonagoda rivers in the project area There is still cause for serious concern, however, over the erosion threat to the main embankment This remains severe both in the region of the 1987-1988 breaches on the eastern side of the project, and in the south-western corner and on the western side, where continued erosion by the Meghna is likely. Extensive and expensive programs are in hand for armouring the most vulnerable stretches on the side.

Discussion with BWDB staff on the operation of Uddhamdi and Eklaspur pumping stations gave no evidence of serious drainage congestion in the project area. This situation is possible because the two primary pumping stations were designed to satisfy major drainage requirements, and have so far operated without problems The pumping stations have also been able to meet the dry season water supply requirement, leading to dramatic increase in irrigated cropping in the Boro and Aus seasons.

Third main component - the irrigation canal system - remains extensively damaged, although a rehabilitation program is gradually bringing it back into full operation This has not in fact prevented the appearance of the expected dry-season agricultural benefits The pump stations have been able to assume the required water supply, and a mixture of ad hoc operation of the damaged parts of the system and private initiative in providing low-lift pumps has been able to deliver it to farmers' fields.

Due to lack of proper compaction, randomly scattered rat holes, cattle grazing along the slope of irrigation canal dykes and local people using sides of these canals for bathing and washing clothes, severe damage is being caused to the interior sides of the irrigation canal dykes

The as-built 14 ft crest width in most parts of the flood embankment seems to be adequate for road traffic although this width is hardly sufficient for passing of two standard vehicles At present mini-taxi services have been well established from the ferry ghat opposite Matlab Bazar to Kalipur Bazar. Passenger road transport has been found quite attractive to local people, compared with the previous water transport system, due to reduced travel time. However, the road network in the project interior remains rudimentary. Consequently, in the absence of the pre-project internal water transport system, farmers are facing additional unit transport costs At the same time their transport requirements for both inputs and outputs have risen dramatically due to agricultural intensification (FAP-12, 1992a).

Project Performance during the 1998 Flood

The 1998 flood is the severest flood on record at Chandpur. Being subject to the combined flow of the Padma, which flows south and joins the Meghna, the project by default is at its most vulnerable state. Since the second week of July when the water level was flowing above the danger level, the project started experiencing multifarious problems The damages inflicted on the project embankment are summarized in table 2.5

Table 2.5 Damage assessment of MDIP during 1998 flood

Types of damages	Seepage	Boiling	Piping due to rat hole	Sliding	
				c/s slope	r/s slope
Extent of damage	250 nos	322 nos	83 nos	3611 m	2525 m

Source: IFCDR. 1998

The main reason for such damage may well be attributed to the persistently long high water level beyond the designed level and the head difference between the inside and outside water levels, the weak soil properties of the embankment, and the inadequate design of the embankment. The most parts of the embankments were constructed with sandy soils that are favourable for creating piping and seepage problems. The embankment has been re-sectioned for 12 km (width of 20 feet, as recommended in the feasibility report, has been developed and the r/s slope has been re-sectioned to 1:3) These rehabilitated sections did not suffer much except some boiling problems The main problem beset the old portion of the embankment, especially in areas adjacent to the launch ghats where people's movement on the embankment is more and in areas where there are borrow pits on the c/s.

Owing to very weak foundation materials, water seeped through the foundation soil and caused boiling in the c/s floodplains at numerous places Two areas, severely affected by sliding at Sepaikandi and Beltoli, where the head difference between the inside and outside water level were 18 feet and 15 feet respectively during the flood and there are low depressions at the c/s

2.8 SUMMARY

In this chapter, physical situation of MDIP has been discussed From the above discussion it is found that MDIP have so many drawbacks, which also has impact on environment. The construction was affected by persistent problems, some of which reflect shortcomings in planning and design, while other relate to the standard of construction and the quality of its supervision

CHAPTER – 3

THE EXISTING ENVIRONMENT OF THE MDIP AREA

3.1 INTRODUCTION

In this chapter, most of the environmental components that are affected by the Meghna-Dhonagoda Irrigation Project have been discussed Secondary data and finally the author's judgement have been the basis upon which the existing environmental condition of MDIP has been portrayed.

3.2 ECOLOGICAL ENVIRONMENT

3.2.1 FISHERIES

The entire Meghna-Dhonagoda area was a flood plain that used to remain under water upto a depth of 2-3 meters from June to October. The area used to be rich fish breeding ground especially for sweet water prawn. This fish breeding ground is now lost Actually no attempt was made to study the capture fisheries production situation and the social and economic roles such fisheries production play in the lives of the people, compared to pre-embankment situation The fish production and the number of fishermen has declined in the post project period due to embankment construction, closure of khals and drainage development.

The CIRDAP benchmark survey report, conducted in 1986, provided information on the number and areas of different water bodies, types of fishing and fish output within MDIP for the pre-project period. The total number of fishermen now has been estimated at about 3000 in the project area (FAP 12 , 1992a). The average daily catch and fishing days per year per fisherman are shown in Tables 3 1 and 3.2.

Table 3.1 Average capture fish catch per Fishermen per day(kg.)

Items	Fish catch per Fishermen per day
Now	2 7
Before project	4.4

Source : FAP 12 PIE survey, 1992, p-7 1

Table 3.2 Average number of fishing days per fishermen per year

Items	Peak period	Lean period	Total
Now	126	150	276
Before project	118	134	252

Source : FAP 12 PIE survey, 1992, p-7.1

The sharp difference of present average catch from that pre-project indicates rapid decline of fish production in MDIP. The average daily catch has declined by about 39 percent in MDIP The RRA team (FAP, 1992a) also reported a 75 percent loss of fish catch in the interior water bodies. The average number of fishing days per fishermen per year has increased slightly between now and the pre-project situation. The average fishing days per year are relatively high in this project as a result of the timing and duration of flood and the scope for fishing in different types of water body. The peak fishing season extends from April to November in the impacted area and the lean fishing season varies from December to March (FAP 12, 1992a).

The main causes of the decline in capture fish stock and catches as reported by the fishermen are presented in Table 3.3.

Table 3.3 Fishermen's Views on Causes of Project Impact

Causes of Impact	Percentages
Fish access blocked by embankment	43%
Drying of water bodies	17%
Decreases in fishing area	30%
Less fish	4%
Gods will	4%

Source FAP 12 PIE survey, 1992, p-7 2

Table 3.3 shows that the majority of fishermen in the impacted area (43%) are of the opinion that blockage of migratory routes is the main reason for reduction of catch and fish stock in the impacted area. The next most important reasons as stated by the fishermen are decrease in fishing area and drying of water bodies These findings are quite similar to the findings of the RRA which found that the obvious cause for decline is the prevention of fish migration into the previous flooded areas by the embankment and loss of spawning areas in the shallow and slow-moving flood waters. This project has most effectively controlled the annual flooding and thereby resulted in a sharp reduction on the areas of regularly inundated plains. Moreover, irrigation and drainage channels have greatly reduced the beel areas, rendering a vast area of water bodies seasonally if, not permanently, dry.

It is emphasised that natural capture fisheries production, cannot be replaced, from either biological, social or economic points of view, by other measures such as fish culture in ponds, irrigation canals etc. Recently, an understanding between the Ministry of irrigation, Water Development and Flood Control and the Ministry of Fisheries and Livestock of the Government has taken place to the effect that the water bodies in and around FCD/I will be handed over to Department of Fisheries (DOF) to develop them for fish culture programs. In the MDIP area, the DOF has undertaken construction of a series of fish ponds on the BWDB borrow pits immediately outside of the embankment through re-excavation of the borrow pits (BETS, 1994).

Although the Department of Fisheries is encouraging aquaculture within the project area, it is doubtful whether the loss in fish resources due to interference in the flood plain can be recovered Moreover, the culture fisheries will never be able to compensate the loss in the diversity of fish species due to loss of flood plain (IFCDR, 1994).

The project has provided a good opportunity for pond fish culture and restocking of water bodies within the project with quality fish seeds due to their protection from annual flooding. Unfortunately, little attempt has been made by the DOF extension officials to develop fish culture, only local landowners were found to have benefited instead of the displaced fishermen and landless labourers who were targeted in the Feasibility Report (FAP-12, 1992a)

As reported by MDIP authority, several programs have been taken to develop the fish culture in the project. 300 acre of ponds are developed and 300 acre of ponds are under processing for fish culture. 30% of 173km-drainage canal was taken for fish culture Now they are trying to extend their program – provide another 30% of drainage canal, developed borrow pit, ditches etc. and to utilize the irrigation canal during lean period for short time fish culture.

3.2.2 TREE PLANTATION

Tree plantation play an important role in the environmental balance and economic life of the people in terms of providing food and nutrition, construction materials, biomass fuel, fodder, shelter and shade, windbreaks, organic matter, erosion control and the balance between flood and drought

The embankment have given rise to the opportunity to tree plantation. A portion of the embankment has already been brought under babla plantation. Moreover, protection from the yearly flood has given rise to the diversity in tree species. Many species which are tolerent to flood such as jackfruit, lemon, banana are now abundant in the project area. The diversity in species always bears well for environment (IFCDR, 1994)

Though the tree plantation is more benefited for National and Environmental points of view, but during the 1998, the project was additionally endangered by trees on the embankments. There are thousands of large trees along the r/s slopes of the embankment and in some parts also on the c/s slope, which are now threats to the embankment When wave action dislodged trees, they created holes, which ultimately lead to piping in the embankment. Even the shaking of trees owing to wind caused gaps along the tree roots through which water seeped It was taken care of by cutting the branches and placing them on the slope. Cutting the soil during the low water and performing good compaction of the soil prevented the leakage of water through the gaps of tree roots (weakened by the wind action). So although trees are environment friendly, they are obviously not embankment friendly. Cutting trees seems to be the only option. However, trees on the c/s may be protected and alternative species may be planted to balance the concern of environment and embankment.

3.3 PHYSICAL ENVIRONMENT

3.3.1 FLOOD CONTROL AND DRAINAGE

The MDIP was designed to provide complete river flood control and drainage The Project has been very successful in providing flood control and drainage benefit to the project area. The entire project area is now flood free providing better security to crops and infrastructure. The main parameters here are the level, timing, and rate of rise, duration and extent of floods. In the Project Area flooding continues to result from heavy monsoon and sometimes pre-monsoon rains, but since 1988 the Project has achieved its objective of complete river flood control. However, the environmental assessment must address what has actually happened. Reality is that in two of the five project years, the project area, was devastated by the Dhonagoda breaches In the south west, over 1,000 ha of land had to be permanently sacrificed to the Meghna (FAP 12, 1992a)

An important point is that the 1987 and 1988 breaches were structural failures, despite the exceptional river levels, the embankment was not topped. Even the most casual inspection of the Dhonagoda bund between Nandalalpur and Durgapur indicates that the next time if seriously attracked by the river, another major breach will occur. The embankment is riven with gullies and riddled with incipient piping, possibly related to rat-holes. Thus the risk factor in impact assessment is considerable in this area

Similarly, over a much longer timeframe but even more inexorably, the Meghna embankment in the west will always be threatened The cost of maintaining it near Eklaspur is plain to see, as concrete block defences are hastily being established.

It is apparent, therefore, that despite what may be temporary success in flood control, the long-term technical sustainability of this project is seriously in doubt, except at yet more exorbitant cost. Even with funds available, a very much higher standard of inspection, maintenance and emergency flood response will be required than has been seen to date.

Part of the problem is that MDIP is located in what is still a very dynamic landscape, where in comparatively recent geomorphic time a huge river once flowed. The natural fluvial and sedimentary activities in the area since then have yet to establish fixed pattern for themselves. An understanding of these geomorphologic uncertainties during project preparation might have led to a sounder project concept, in both environmental and economic terms.

This situation, therefore, poses problems for both environmental and economic evaluation, but especially for the former, since flooding is the most important primary environmental issue. On this basis, moderate positive impacts are assessed, with only minor negative impacts These assessments reflect the great success of flood control (post-1988), the damage and loss of land in other years, the considerable risk factor, and also a degree of local dissatisfaction everywhere with the efficiency of drainage. The breach floods, it must be noted, caused loss of crops, property and even life through out much of the Project Area, as reported at Byasdi in the north, at Sataki and Subandi in the north west, and at Machua and near Thetalia in the south (FAP 12, 1992a).

The 1998 flood is the severest flood, the project started experienced multifarious problems which are discussed in the previous chapter. As reported by BWDB, there was very little drainage congestion problem inside the project area during the flood. The water level inside the project was only slightly higher than the design water level of the 2.56m and maintained almost a constant level The higher than designed water level was purposefully maintained. Water was pumped from the surrounding rivers to the irrigation canals to minimize the head difference between the inside and outside of the project Pumps could not be operated for 5-6 days as the river water level was exorbitantly high. But it did not cause much harm except some temporary problems in the lower pockets.

3.3.2 SOIL EROSION

The soil erosion to occur, from the riverbank erosion of some parts of the embankment is under threat. The less immediately threatened western bund is suffering some erosion but it is on the more critical eastern side, especially between Nandalalpur and Durgapur, that the situation is most serious. Gullying and piping are pronounced. The overall impact remains major because of the very high risk factor involved (FAP 12, 1992a).

During the flood of 1998, bank erosion assumed a serious turn in the western part of the project at Mohanpur and Dashani. The river progressed about 170m inward in three months in this part, and the project's life was at stake if protection measures were not taken immediately. Around 3km of such embankment reach along the Meghna were under threat. Around 1.5-2 km of the Dhonagoda side were also under threat from erosion problem in the east-southern part of the project at Gazipur, Shibpur, Amirabad and Torki. River protection measures in Mohanpur have been largely damaged by 1998 flood (IFCDR, 1998)

Southern part of flood embankment is being severely affected by wave action causing the soil erosion in the riverside slope of the embankment. Soil erosion is also occurring and reducing the design section due to rainfall.

The MDIP is totally surrounded by the river Meghna and Dhonagoda, so that the meandering phenomenon is also the another cause of soil erosion in the river bank.

3.3.3 WATER LOGGING AND DRAINAGE CONGESTION

Some patches of the project area do suffer from water logging. Water logging in drainage channel create water pollution at the point of Udamdi and Kalipur pump house However the problem may be considered as of very low impact in nature (IFCDR, 1994).

Drainage congestion is increasing day to day due to power failure, mechanical problem in the pump, lacking of efficiency to operate the pump by operator The drainage congestion also create to use the drainage canal for fishing purpose making cross bundh across the canal by local people. The catchment area of the drainage canals is also blocked due to unplanned road, bridge, culvert constructed by different organization. The drainage canals are being closed due to domestic use by the local people like construction of washing place, latrine etc.

3.3.4 SOIL FERTILITY

The land in the project area is a newly formed low flat alluvial delta. The land is mainly medium low to low having no well-defined ground slope. The soil analysis suggests the soil type to be as sandy loam and slightly acidic. The organic matter content is low and Nitrogen content is also near the critical level. Phosphate content is however above the critical range (IFCDR, 1995) Due to absence of yearly flooding, the project area is now deprived of yearly nourishment As a result, it can be expected that nutrition level will go down which has actually happened. Organic nitrogen level now stands at 0.75%, which is much below the critical level of 1.1% (IFCDR, 1994). Now farmers' are used to apply high doses of chemical fertilizers to make up the nutrient deficit for reasonable crop productions.

From the soil test results, undertaken in collaboration with SRDI Laboratory, it is evident that the Organic Matter (OM) contents of the soil have deteriorated to an alarming stage In terms of other nutrients contents also, particularly of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc, the fertility status is poor. This situation has been created by replenishment of floodwaters by the embankment. Farmers were bound to apply high doses of chemical fertilizers to make up the nutrient deficit for reasonable crop productions.

3.4 HUMAN INTEREST

3.4.1 EMPLOYMENT OPPORTUNITY

The continuous embankment rehabilitation and drainage/irrigation canal re-excavation work generate considerable employment opportunities. Moreover increased agricultural activity has also generated farming opportunities (IFCDR, 1994).These have all received very positive impacts from the Project since 1988, but during the first two years the breach floods prevented any marked initial improvement. Thompson (1990) notes the negative impacts of the 1987 floods on employment and incomes in the MDIP area

It was observed during the discussion with the local people and MDIP officials, employment opportunity has been created for the following reasons –agriculture sector developed for the whole year, developing scientific fishing policy, communication development in transport sector, Home stead farming, developing Livestock and Dairy farm, small trade like Handy craft, increasing the working facilities of NGO, LGD, R&H, Public Health, DAE etc All of these opportunities have been possible due to flood free environment created by MDIP.

3.4.2 COMMUNICATION (NAVIGATION/TRANSPORT)

Project Planning orignally included the somewhat contradictory elements of navigation locks in the embankment to maintain pre-project boat transport and a comprehensive internal road network to accompany the embankment road, Neither were built, which has created some problems for bulk transport within the area. The village roads are suitable only for pedal rickshaws, since 1988 they have probably been usable during the wet season to a much greater extent than pre-project, although the 1987/88 breach floods caused them damage.

The embankment road is usually motorable throughout, although subject to the risk hazards. However, there seem to be only two vehicles (both belonging to BWDB) in the area, which still has no vehicle ferry links with the outside world. Mini-taxis ply the eastern embankment, but generally only as far as Nabipur or Beltali, even though the Dhaka river launches come to Kalipur Large steamers and river launches still dominate peripheral transport, although the embankment road serves both the external riverine areas, in addition to the project area (FAP 12, 1992a).

3.4.3 IRRIGATION FACILITY

Within the project area irrigation water distribution is mainly by gravity flow, but there are also two internal booster pump stations to lift water to higher water The canal system commands a total of 14,367 ha. The remainder being excluded as it was considered to be too high to be irrigated economically During the non-monsoon half-year the project area was flood-free, and moisture deficit for paddy production occurs on most land from January onwards

There was a little development of irrigation during pre-project period, only a relatively small number of LLPs were used to raise water from the tidal khals and small area was irrigated by traditional manual lifting methods. Ground water irrigation by DTW is possible in the area, but the depth of flooding in the monsoon would have made fixed pump installations vulnerable except on the highest land

As reported by BWDB, about 7,500 ha area have been achieved for irrigation facility out of targeted 13,600 ha (which is now reduced to 80% due to creating new Homestead)

A number of defects were identified in design and construction level. In many cases local people have constructed unauthorised pipe turnouts from the irrigation canals, indicating that the turnouts originally provided were insufficient in number and inappropriately placed. Some turnout locations have been found to be useless due to borrow pits dug on the outlet side Pipes used in turnouts are inadequate in size in many places and in some cases the beds of turnout pipes are inconsistent in level with the canal bed Due to poor workmanship, water leakage has been found in some aqueducts and drainage conduits In a few cases levelling of the structures both with respect to each other and with respect to the canal bed was not maintained. The crest level of one escape was found to have a higher level than the check gate and regulator on the downstream side (FAP 12, 1992a).

3.5 SUMMARY

From the above discussion, it is cleared that the project has effectively prevented the annual flooding and greatly reduced flood of the project areas. But it has inflicted adverse impacts on some environmental components like fish culture, soil-ferrility and drainage congestion. Other environmental components although not affected seriously at present but these may be affected in the future. Therefore, an integrated approach to environmental management directed towards minimising adverse environmental effects is essential for sustainability of MDIP.

CHAPTER 4

MITIGATION OF ENVIRONMENTAL IMPACTS OF MDIP THROUGH THE APPLICATION OF AHP MODEL

4.1 INTRODUCTION

FCD/I project such as MDIP has generated several environmental impacts and these need to be further analysed to find out the significantly affected environmental components. From the discussion of previous chapter, four environmental components that are more affected by MDIP have been identified In this chapter, an attempt is made to find out the mitigation measures to minimize the adverse impacts of these four environmental components of MDIP and also to find out the side affects caused by the mitigation measures. Detail concept of AHP model, it's calibration procedure and analysis process of experts' (Appendix A) opinion by the AHP model that has been discussed in this chapter

4.2 AHP MODEL DESCRIPTION

Complex problems of choice are often so tangled that human minds are not capable of considering all the factors and their effects simultaneously To solve complex problems they do not need a more complicated way of thinking Rather, they need to view their problems in an organized frame work, elaborated in a new way that makes it possible for decision makers to capitalize on their valuable personal knowledge. Individual attitudes towards different choices were analysed by Analytic Hierarchy Process (AHP). Decision making with AHP, it's principles and axioms, it's causes of inconsistency in the sample, it's model structure, also it's scale of ranking the individual's opinion, and it's calibration procedures were discussed in the following sub sections.

4.2.1 AHP EVALUTION

Thomas I. Saaty developed AHP in 1977 for military contingency planning to allocate scare resources, and for political participation in negotiated disarmament agreement. Vargas referred that it is a multiple criterion evaluation methodology that is both descriptive and prescriptive.

Saaty (1987) discussed how the rank of a set of alternatives changes when a new, criterion intrudes into the old set of criteria or when the importance of the criteria depends on the number of alternatives and on the strength of their ranking. Thus even inclusion of an alternative can change the ranking order of the previous set. In a complex structure when the importance of the criteria are not well established this can be done by making paired comparison of alternatives with respective of criteria. In case when the importance of the alternatives are well established, they are scored according to the weights of the criteria and a new alternative would not change the relative ranking of the old ones. Again, in 1990 Saaty explained the AHP as a structured process consisting of a goal, criteria, sub-criteria, and alternatives (options) and a set of judgements to establish a relationship amongst them. The ultimate objective is to obtain a scale of relative importance for the alternatives

Wind and Saaty (1980) pointed out the potential applications marketing arena viz. the portfolio decision of a firm, determination of the direction of new product development and generation and evaluation of marketing mix strategies. Zahedi checked the validity of the AHP results in 1987 with that of the theory of utility. He compared the results of AHP with that of the utility function of several types: uni-attribute, multi-attribute, non-additive & additive For uni-additive it was found to be unconditionally consistent. But to again consistency for the additive utility function it requires additional assumptions regarding the underlying utility functions or the careful interpretations of the relative weights of the attributes Where as in case of multiplicative utility functions the results are always consistent with that of AHP when the local weight are aggregated into a global weight. Same year in 1987, Harker suggested a method to reduce the process of questioning substantially. In a standard mode of questioning method of AHP the respondent need to fill up a positive reciprocal matrix by answering n(n-1)/2 questions for each element in the previous level where each number is an approximation of the ratio of the 'n' items being compared. An extension of the Eigen vector approach of AHP has been proposed which allows – the decision maker to respond "I don't know" or "I'm not sure" to some of the questions so as to shorten the questioning process.

Forman (1988) stated that it does not prescribe that the judgement be perfectly consistent rather allows the decision-maker to decide how mach inconsistency is allowable. According to Forman, the main characteristics of AHP are: structuring complexity in a hierarchy, making pair-wise relative comparison, and using redundancy of judgements to improve accuracy and deal with fuzziness

4.2.2 DECISION MAKING WITH EXPERT CHOICE

Expert Choice (EC) treats a decision as a whole system and not as isolated parts It does this in part by performing mathematical calculations, which immediately show the relationships among various perceptions. EC goes beyond conventional decision analysis techniques by not restricting the judgement process to quantifiable attributes but it can make judgements that are subjective as well as objective. The logic of EC has a sound theoretical basis, yet it is capable of accommodating apparent inconsistencies that often exist in the real world. For example, logic says that if A is preferred over B, and B is preferred over C, then A must be preferred over C. this is not necessarily so, and EC can accommodate such situations. Another advantage of EC is that new knowledge can be integrated, as it becomes available.

Complex decisions consisting of intricate network of factors which otherwise are not easily identified, broken down into less complicated component parts, arranged in a hierarchical order, subjective fundaments trade-offs quantified and the judgements are synthesized to determine the best decision The overall objective of the decision tree lies in the top of the hierarchical arrangement and the criteria; sub-criteria and decision alternatives are arranged in descending order in the hierarchy. The hierarchy need not be a complete one, i.e. an element at any level need not be connected to all the elements in the level below.

The AHP model abides by three basic principles of logical analysis. First one is principal of decomposition of hierarchy the elements in a level is independent from those in succeeding levels. Second one is, principles of comparative judgement: pairwise comparison of the elements in some level is done with respect to a shared criteria in the level above. Third one is, principles of logical consistency the priorities are synthesized from the second level down by multiplying local priorities by the priority of their corresponding criterion in the level above, and adding for each element in a level according to the criteria it effects Saaty, Haker and Vargas stated the axioms of AHP. These are i) Reciprocal condition Axiom – it postulates that if A is 'n' times preferred to B, B is 1/n times as preferred as A. ii) Homogeneity – comparison is meaningful only when the elements are comparable. As for example, apples are not comparable to automobiles. iii) Dependence – comparison at the lower level depends on the higher level. iv) Expectation – any change in the hierarchical tree will require new evaluation of references for the new hierarchy

4.2.3 CAUSES OF INCONSISTENCY

Result may be inconsistent for a number of reasons. These are – a) Clerical error: while entering the values into the computer. Wrong value may cause inconsistency. b) Lack of information: can cause the judgement to appear random resulting in a high consistent ratio. c) Lack of concentration or of interest: is often found when the respondent is fatigued or in a hurry or not in a mood to fill up the questionnaire. d) Lack of consistency in the decision being modelled: the real world situations are rarely consistent by nature. The interesting example is when one has to compare three professional sports team. The results of the games played by them are sometimes random like team 'A' defeats team 'B' and is defeated by team 'C' where as team 'B' might have defeated team 'C'. e) Inadequate model structure. Ideally the complex decision process is structured in a way that the elements in a level are comparable within an order of magnitude for different factors in the level above Though it may sometimes be felt that the scale range is only from 1 to 9, because the priorities are based on the order of dominance, the AHP can resultantly produce a scale of higher magnitude The extreme judgements often need a higher in consistency ratio than the popular allowable ten percent:

4.2.4 STRUCTURE OF THE MODEL

An expert choice model organizes the various elements (factors) of a problem into a hierarcby similar to a family type structure (an upside down tree structure). Each element in a tree called is called node. The top level contains the GOAL node (the tree branches downward from the GOAL) Intermediate levels represent the FACTORS, OBJECTIVES, of CRITERIA of the problem. At the bottom of the tree are the LEAVES, which represent the ALTERNATIVES of the choice.

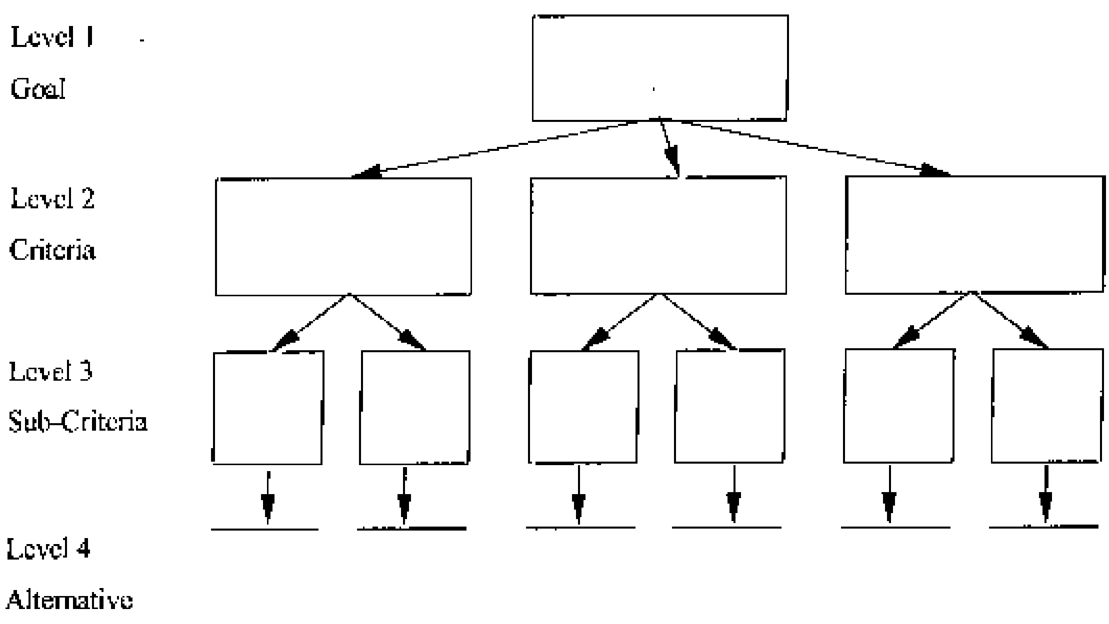


Figure: 4.1 Structure of an AHP model

Simple models typically have criterion nodes below the goals, and alternative nodes below each criterion node. More complex models may have additional nodes to represent further breakdowns of the main criteria into sub-criteria

Once the EC model is built as shown in the figure 4 1, the judgement process starts. First COMPARE, the main criteria in pairs with respect to the goal. Here personal judgements have to be entered. After the main CRITERIA are compared with the respect of the GOAL, the alternatives are COMPARED in pairs with respect to each criterion. One can express the relative importance of one element over another with respect to a given criterion either verbally or numerically. Table 4.1 explains both scales and their relationship

Table: 4.1 The comparative Scaling . Used in the AHP method

Numerical scale	Verbal Scale	Explanation
1.0	Equal importance of both elements	Two elements contribute equally
3 0	Moderate importance of one elements over another	Experience and judgement favour of one element over another
5.0	Strong importance of one element over another	An element is strongly favoured
7 0	Very strong importance of one elements over another	An element is very strongly dominant.
9 0	Extreme importance of one above the other	An element is favoured by at least an order of magnitude of difference
2.0,4.0,6.0,8.0	Intermediate value between two adjacent judgements	Used for compromise between two judgements.
Increments of 1 0	Intermediate value in Increments of 0.1(eg. 6.3 is a permissible entry)	Used for even finer gradations of judgements

4.2.5 AHP MODEL

The choice process is to be structured in hierarchical order, in different levels such that the elements in each level is related to least one element each preceding and the succeeding levels. Here in the search for best policy choice, the selection process has been divided into three levels as follows:

Level 1. Goal of the structure.

Level 2: Criteria - the factors on which the selection of the possible alternatives depends are numerous.

Level 3: Alternatives- the elements in the third level of the choice hierarchy are the possible alternatives.

4.2.6 HIRARCHICAL LEVELS OF CHOICE PROCESS

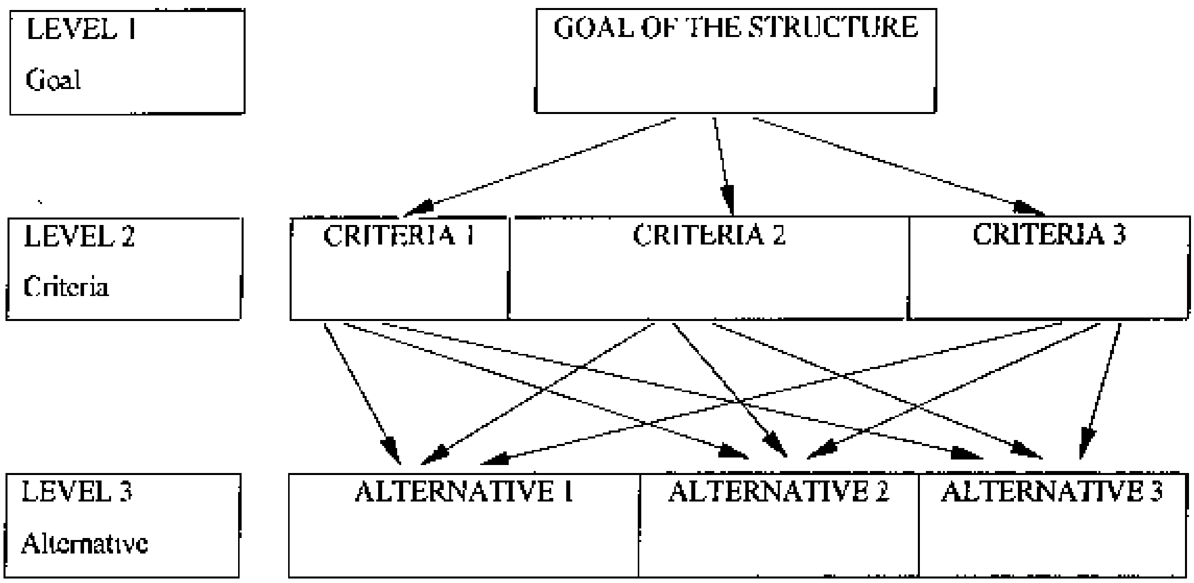


Figure 4.2 Hierarchical structure of the model

4.2.7 AHP MODEL: STRUCTURE and CALCULATION

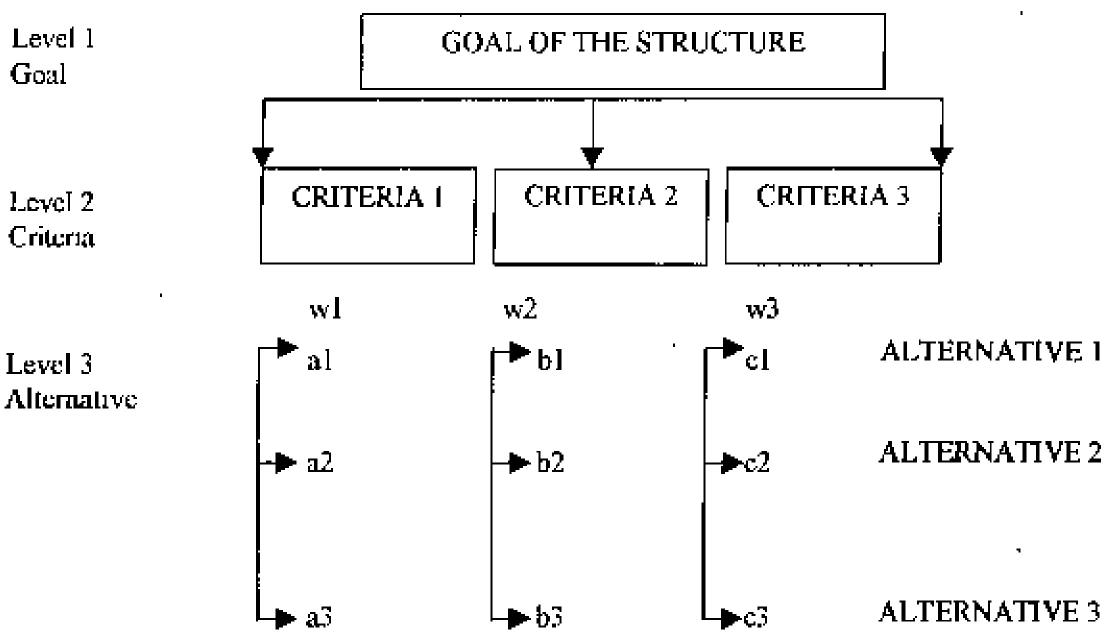


Figure: 4.3 Calculation procedure of the AHP Model

Preference weights of the policies:

Weight of ALTERNATIVE 1	=	a1w1+b1w2+c1w3
Weight of ALTERNATIVE 2	=	a2w1+b2w2+c2w3
Weight of ALTERNATIVE 3	=	a3w1+b3w2+c3w3

4.2.8 AGGREGATION TECHNIQUES IN AHP ANALYSIS

The individual respondent's preference weights were considered separately. The normalized weights and the corresponding consistency ratios were obtained from each matrix developed on the basis of their filled up questionnaires. Only cases where consistency ratio is less than 10 percent have been selected for further analysis.

To arrive at a consensus preference weight different methods have been suggested regarding the mode of aggregation of the responses. These varying consensus methods have different advantages and disadvantages. No single method is universally recommended and they have been judged based on the requirement of the task.

4.3 APPLICATION OF THE AHP MODEL

The AHP approach was used by Banani-Kashani (1989) to estimate the multimodal urban corridor travel demand. In this paper it has been shown that AHP has also an interface with the discrete, behavioral choice model. The Partovi and Burton (1992) made a constructive model, based on AHP for assigning the departments optimally in a facility based on both quantitative and qualitative criteria. Hoque (1997) analyzed the factors like travel cost, safty, time saving ability, accessibility of the mode, and comport affecting the modal choice with Analytical Hierarchy Process (AHP) technique.

The AHP model has been applied to deal with the mitigation options for the identified environmental components of MDIP. Integrated Environmental Management of MDIP is very complex because to mitigate the adverse impact of any components will affect other environmental components Based on the questionnaire of experts' opinion, the components are identified individually at three levels within the framework of AHP model. The first level, sets-up the ultimate goal of the individual component. In the second level as criteria of the model, identified the environmental components, which will be affected by achieving the goal of the individual component. In the third level, alternative choices are selected to find out the best policy for achieving the goal

4.4 FISHERIES

For the environmental component of fisheries, the main objective is to mitigate the loss of fisheries in MDIP. For that three mitigation measures which are treated as alternative policies with the consideration of four impacted components which are treated as criteria of the model have identified. The three alternative policies are – '*increase the fish culture in ponds and closed water bodies*', '*increase the fish culture in the open* water' such as khal, river or agricultural land, *and 'no policies over present condition'*. Four impacted components, which are also influenced by taken policies, these are – increase of water pollution, increasing of employment opportunity, increasing of income, and improvement of overall social life.

4.4.1 AHP MODEL AND FISHERIES OF MDIP

According to AHP model choice process is to be structured in hierarchical order, in different levels such that the elements in each level is related to least one element each preceding and the succeeding levels. Here in the best policy choice method, the selection process has been divided into three levels as follows:

Level 1 Goal of the structure is to find out the policy to *"Mitigation of adverse environmental impacts on fisheries"*.

Level 2 Criteria - the factors on which the selection of the mitigation measures depends are numerous. However based on the human capability in comparing the factors in the paired comparison method, only four most important criteria in selecting the policies have been considered These are – income, employment, water pollution and social life (Figure 4.4).

Income: Before the project, a large number of people were involved with fishing and this was their main source of income After the project most of them became unemployed or earning low income Development of fisheries can redress fishermen by creating source of income

Employment: Development of fisheries will help to generate more employment.

Water pollution. Close water fish culture in ponds, canals, and ditches would create water logging, thereby contribute to water pollution.

Social life Any policy taken to develop fish culture can have impact positive or negative on the society.

Level 3: Alternatives- the elements in the third level of the choice hierarchy are the possible alternatives in the mitigation measure in MDIP In AHP analysis, three policies have been selected for the comparison. A large numbers of policies in the level increase the complexity of the questionnaire Three policies are – '*close water fish culture*', '*open water fish culture*' *and 'no intervention on present condition'*.

'*Close water fish culture*' fish culture on ponds, ditches, and reservoir water etc. where the fishes are developed under artificial care.

'*Open water fish culture*'. it means fish culture on khal, beel, open field, river etc. where the fishes are developed under natural care.

'*No intervention*' present situation to remain as it is now.

4.4.2 HIRARCHICAL LEVELS OF CHOICE PROCESS

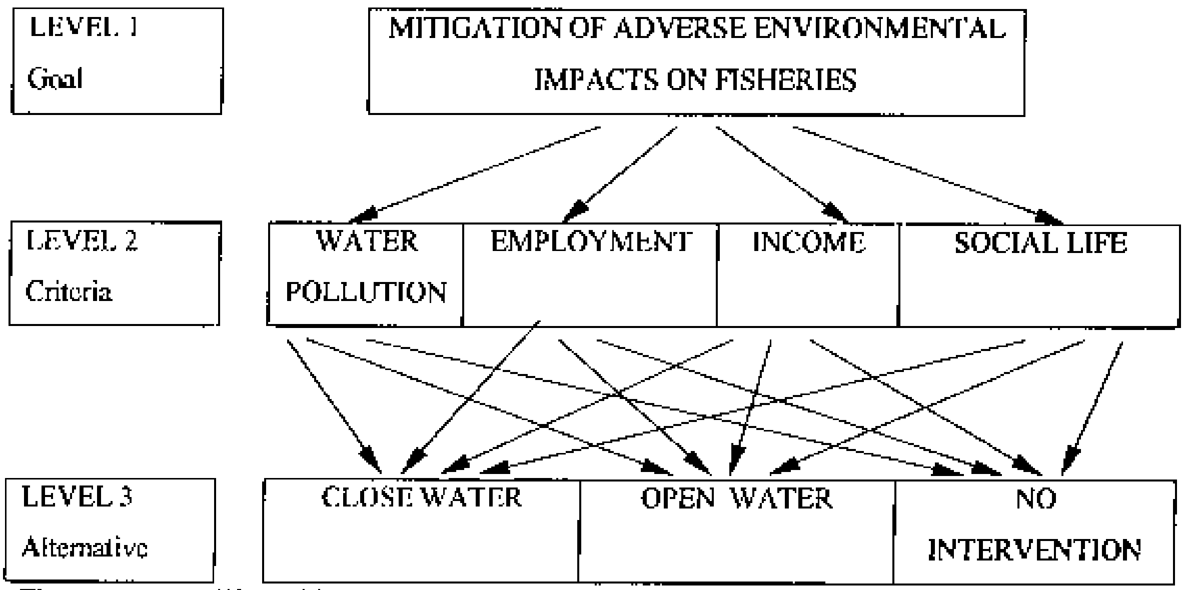


Figure : 4.4 Hierarchical structure of the model (fisheries)

4.4.3 AHP MODEL: STRUCTURE and CALCULATION

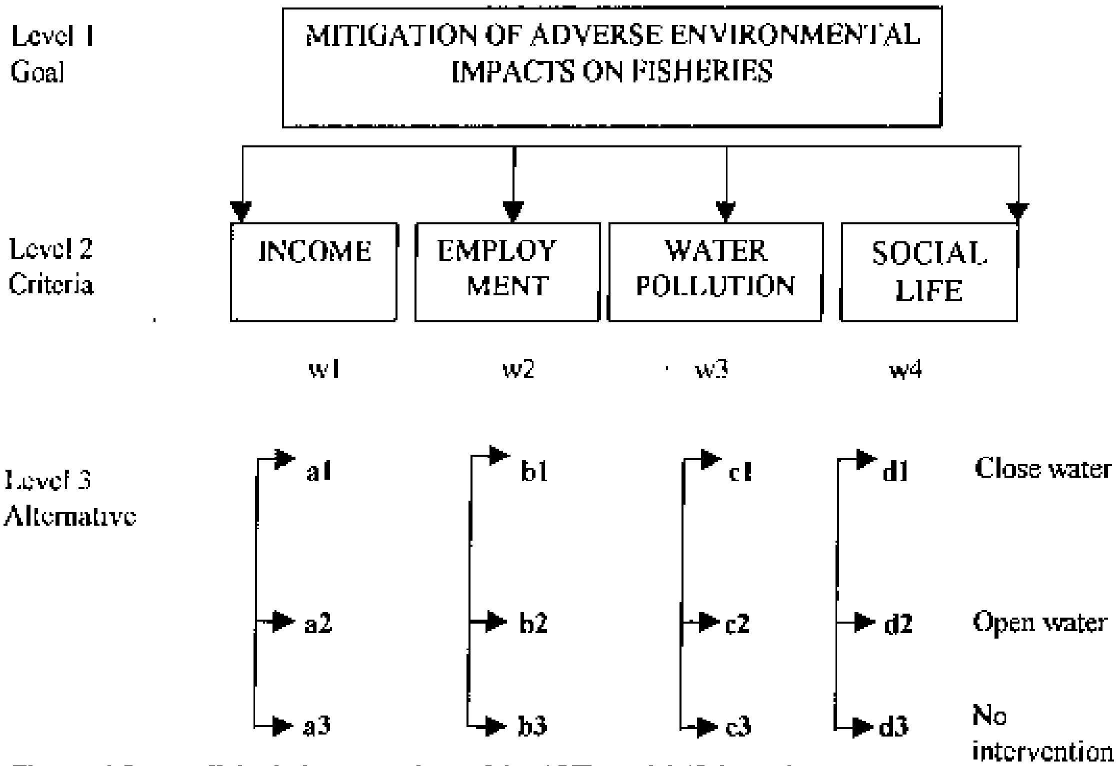


Figure: 4.5 Calculation procedure of the AHP model (fisheries)

Preference weights of the policies:

Weight of close water = a1w1+b1w2+c1w3+d1w4

Weight of open water = a2w1+b2w2+c2w3+d2w4

Weight of no intervention = a3w1+b3w2+c3w3+d3w4

4.5 SOIL FERTILITY

For the environmental component of soil fertility, the main objective is to mitigate the loss of soil fertility in MDIP For that four mitigation measures were treated as alternative policies with the consideration of three impacted components have been identified. The four alternative policies are – *'reduce the use of chemical fertiliser'*, *'reduction of crop cultivation season'*, *'increase the use of modern machinery'*, and *'increase the culture of green manure'*. Three impacted components, which are also influenced by taken policies, these are - increase of crop production, increase of technical training, and improvement of social life.

4.5.1 AHP MODEL AND SOIL FERTILITY OF MDIP

According to AHP model the choice process is to be structured in hierarchical order, in different levels such that the elements in each level is related to least one element each preceding and the succeeding levels Here in the search for best policy choice, the selection process has been divided into three levels as follows

Level 1: Goal of the structure is to find out the policy to *"Mitigation of adverse environmental impacts on soil fertility"*

Level 2: Criteria - the factors on which the selection of the mitigation measures depends are numerous However, based on the human capability in comparing the factors in the paired comparison method, only four most important criteria in selecting the policies have been considered These are - increase of crop production, increase of technical training, improvement of social life (Figure 4.6)

Increase of crop production: Crop production is directly related to soil fertility. So the development of soil fertility is the cause of increase crop production

Increase of technical training: Actually the loss and development of soil fertility depends on so many causes To mitigate the loss of soil fertility, technical training is essential in order to enhance the awareness of people

Social life: Any policy taken to improve soil fertility can have impact positive or negative on the society.

Level 3: Alternatives- the elements in the third level of the choice hierarchy are the possible alternatives in the mitigation measure in MDIP. In AHP analysis, three policies have been selected for the comparison These are – *'increase the use of modern machinery', 'increase the green manure cultivation', 'reduce the use of chemical fertiliser' and 'reduction of crop cultivation season'.*

'Increase the use of modern machinery'. Ploughing technique changes from old machinery to modern machinery (like tractor, Power tiller etc.) can help to improve the soil fertility

'Increase the green manure cultivation': The cultivation of green manure like Daincha in the off season can also help improve the soil fertility

'Reduce the use of chemical fertiliser' Chemical fertilizers always decrease soil fertility. So controlled use of chemical fertilizer can increase soil fertility.

'Reduction of crop cultivation season'. Reduction of crop cultivation from three seasons to two seasons can help increase soil fertility.

4.5.2 HIRARCHICAL LEVELS OF CHOICE PROCESS

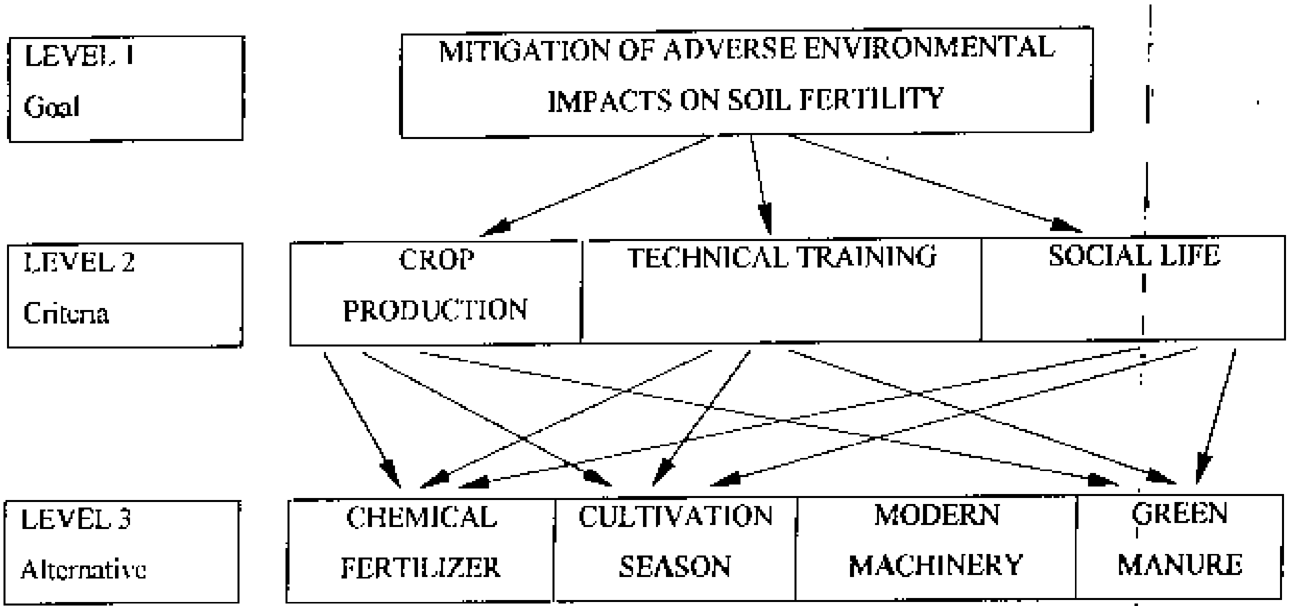


Figure : 4.6 Hierarchical structure of the model (Soil fertility)

4.5.3 AHP MODEL: STRUCTURE and CALCULATION

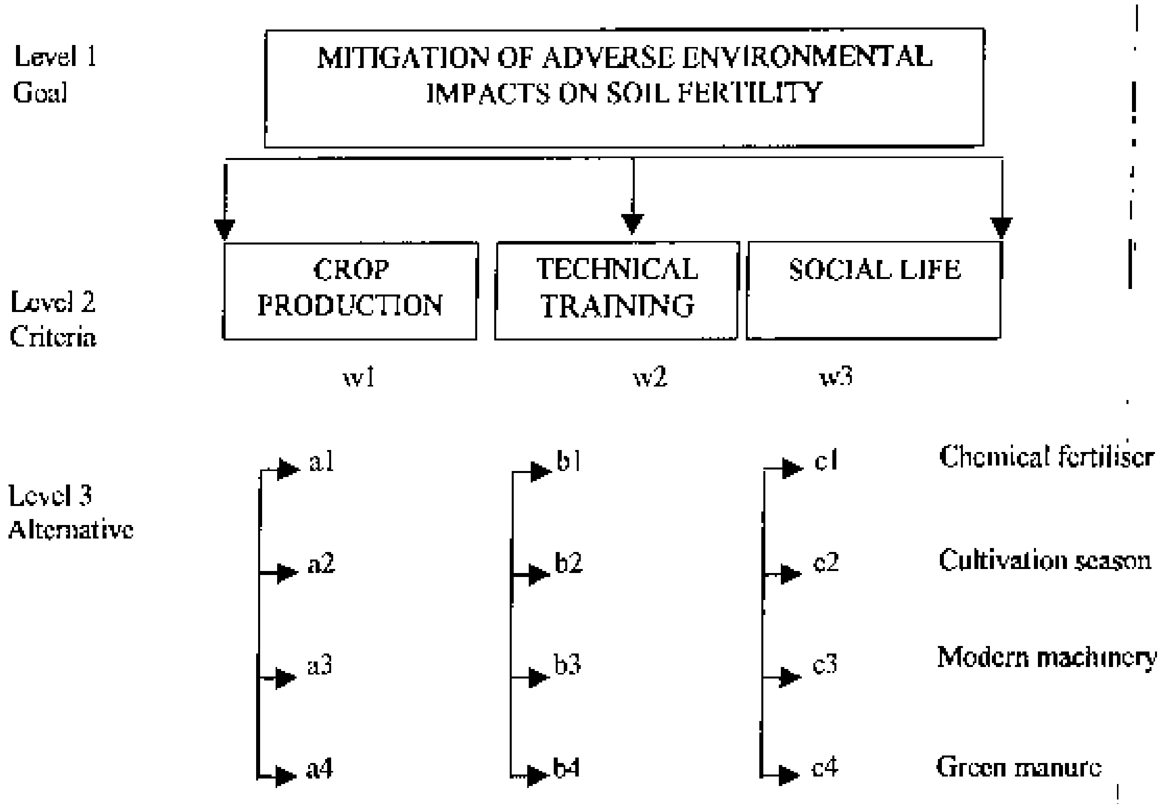


Figure: 4.7 Calculation procedure of the AHP model (Soil fertility)

Preference weights of the policies:

Weight of chemical fertiliser = a1w1+b1w2+c1w3

Weight of cultivation season = a2w1+b2w2+c2w3

Weight of modern machinery = a3w1+b3w2+c3w3

Weight of green manure = a4w1+b4w2+c4w3

4.6 DRAINAGE CONGESTION

For the environmental component of drainage congestion the main objective is to mitigate the adverse environmental impact on drainage congestion in MDIP. For this purpose three mitigation measures which are treated as alternative policies with the considerations of three impacted components have been considered. The three alternative policies are – *'remove local stocking program in drainage canal'*, *'provide appropriate slope in drainage canal'*, and *'no policies over present condition'*. Three impacted components, which are also influenced by the taken policies, are - water pollution, fish culture, and social life.

4.6.1 AHP MODEL AND DRAINAGE CONGESTION OF MDIP

According to AHP model the choice process is to be structured in hierarchical order, in different levels such that the elements in each level is related to least one element each preceding and the succeeding levels. Here in the search for best policy choice, the selection process has been divided into three levels as follows:

Level 1 Goal of the structure is to find out the policy to "*Mitigation of adverse environmental impacts on drainage congestion*"

Level 2: Criteria - the factors on which the selection of the mitigation measures depends are numerous However, based on the human capability in comparing the factors in the paired comparison method, only three most important criteria in selecting the policies have been considered They are – increase of water pollution, decrease of fish culture, social life (Figure 4 8)

Increase of water pollution. Drainage congestion creates water pollution Any policy to remove drainage congestion, will contribute to decrease the water pollution

Decease of fish culture. Removal of the drainage congestion can hamper the fish culture.

Social Life: Any policy taken to remove drainage congestion can have impact positive or negative on the society

Level 3. Alternatives- the elements in the third level of the choice hierarchy are the possible alternatives in the mitigation measure in MDIP. In AHP analysis, three policies have been selected for the comparison. These are '*remove local stocking programs in drainage canal*', '*provide appropriate slope determination in drainage canal*', '*no intervention on the present condition*'

'*Remove local stocking program in drainage canal*': local stocking program on drainage canal creates drainage congestion So by removal of local stocking will contribute to improve drainage congestion

'*Provide appropriate slope in drainage canal*': Appropriately designed drainage canal can carry more water. So this policy will also improve drainage congestion.

'*No intervention*': Present situation to remain as it is now

4.6.2 HIRARCHICAL LEVELS OF CHOICE PROCESS

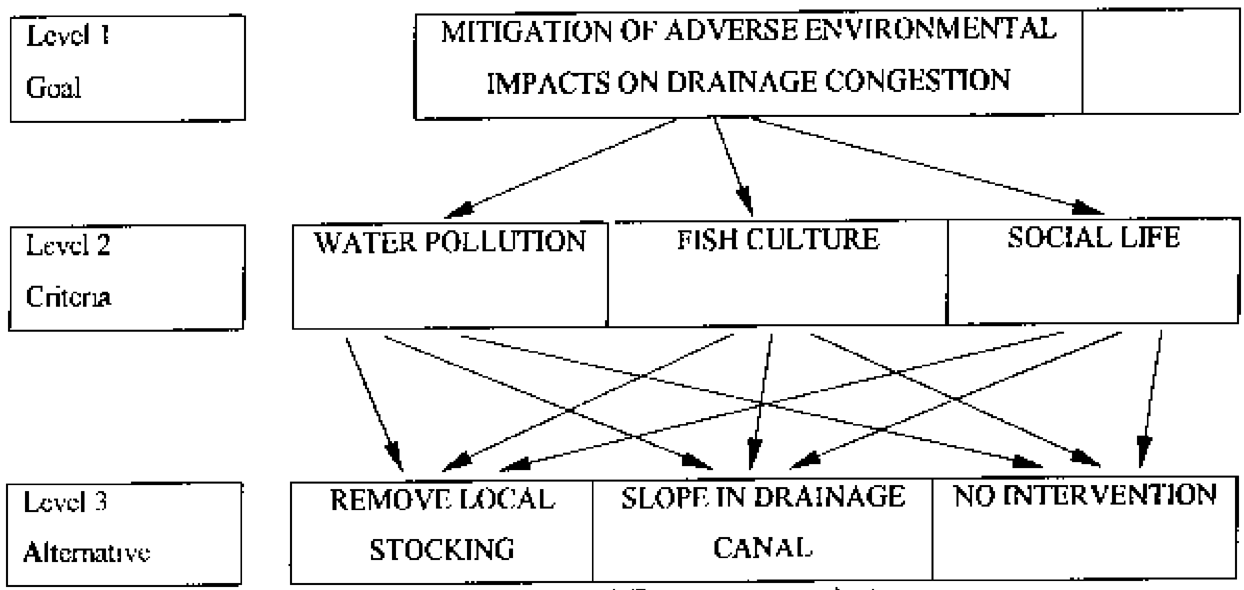


Figure . 4.8 Hierarchical structure of the model (Drainage congestion)

4.6.3 AHP MODEL: STRUCTURE and CALCULATION

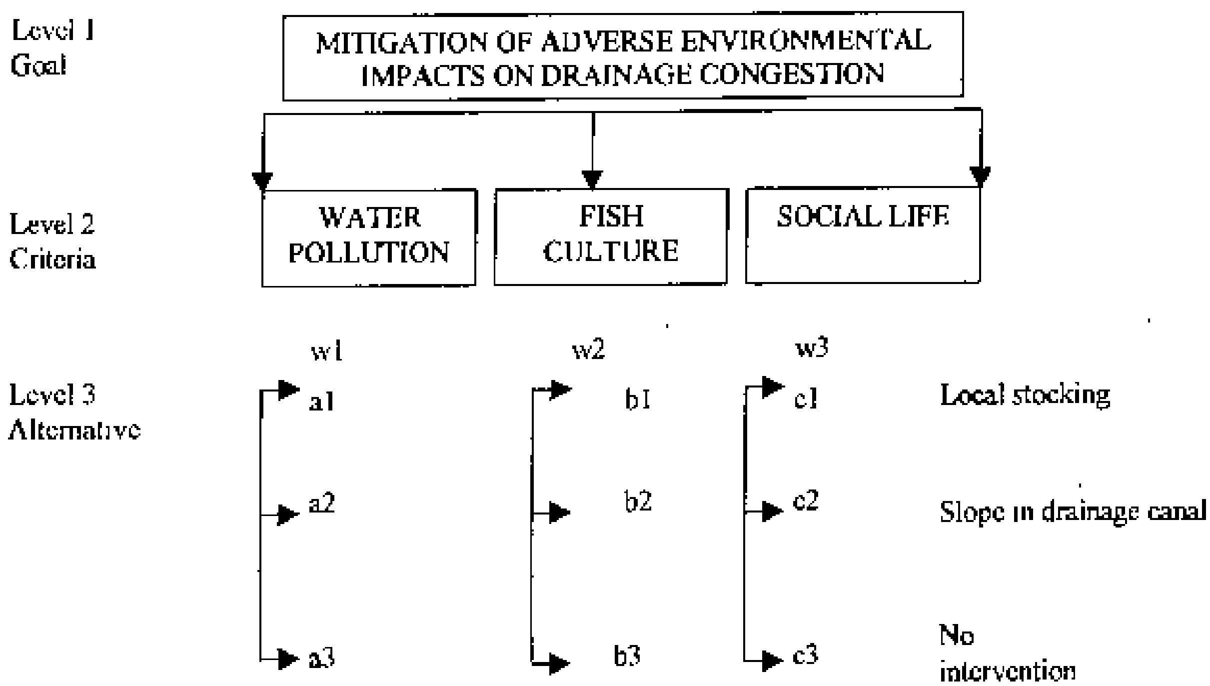


Figure. 4 9 Calculation procedure of the AHP model (Drainage congestion)

Preference weights of the policies:

Weight of local stocking	=	a1w1+b1w2+c1w3
Weight of slope in drainage canal	=	a2w1+b2w2+c2w3
Weight of no intervention	=	a3w1+b3w2+c3w3

4.7 IRRIGATION FACILITY

For the environmental component of irrigation, the main objective is to increase the facility of irrigation in MDIP For that three improvement measures which are treated as alternative policies with the consideration of three impacted components have been identified. The three alternative policies are – '*provide appropriate slope in irrigation canal*', '*use of ground water*', and '*no policies over present condition*'. Three impacted components, which are also influenced by taken policies, are – project expenses, and water pollution and social life.

4.7.1 AHP MODEL AND IRRIGATION FACILITY

According to the AHP model the choice process is to be structured in hierarchical order, in different levels such that the elements in each level is related to least one element each preceding and the succeeding levels. Here in the search for best policy choice, the selection process has been divided into three levels as follows:

Level 1: Goal of the structure is to find out the policy to "*Improve the irrigation facility.*"

Level 2: Criteria - the factors on which the selection of the mitigation measures depends are numerous. However, based on the human capability in comparing the factors in the paired comparison method, only three most important criteria in selecting the policies have been considered. They are - project expenses, water pollution, social life (Figure 4.10)

Project expenses: At present, about 75% area of MDIP have get the irrigation facility. Now to extend the irrigation coverage will take more expense.

Increase of water pollution: More coverage of irrigation can create more water pollution.

Social life: Any policy taken to improve irrigation facility can have impact positive or negative on the society.

Level 3: Alternatives- the elements in the third level of the choice hierarchy are the possible alternatives in the mitigation measure in MDIP. In AHP analysis, three policies have been selected for the comparison. These are – *'provide appropriate slope in irrigation canal', 'use of ground water', 'no intervention'.*

'Provide appropriate slope in irrigation canal': Appropriately designed irrigation canal can help to increase irrigation facility.

'Use of ground water'. Use of ground water (like pumping) may alternative policy for the improvement of irrigation facility.

'No intervention': Present situation to remain as it is now.

4.7.2 HIRARCHICAL LEVELS OF CHOICE PROCESS

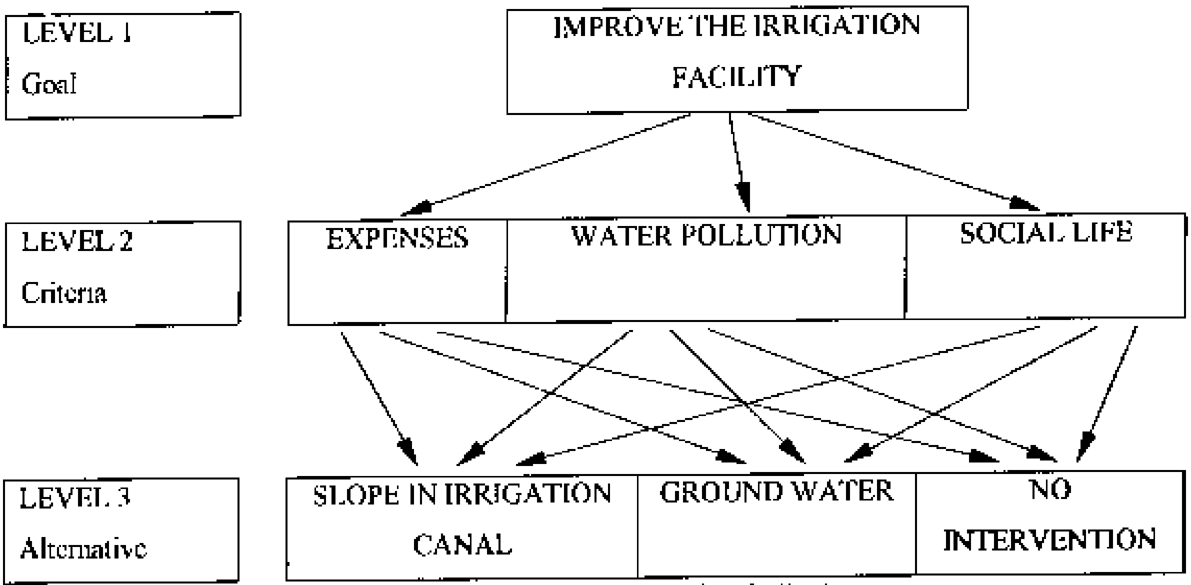


Figure 4.10 Hierarchical structure of the model (irrigation facility)

4.7.3 AHP MODEL: STRUCTURE and CALCULATION

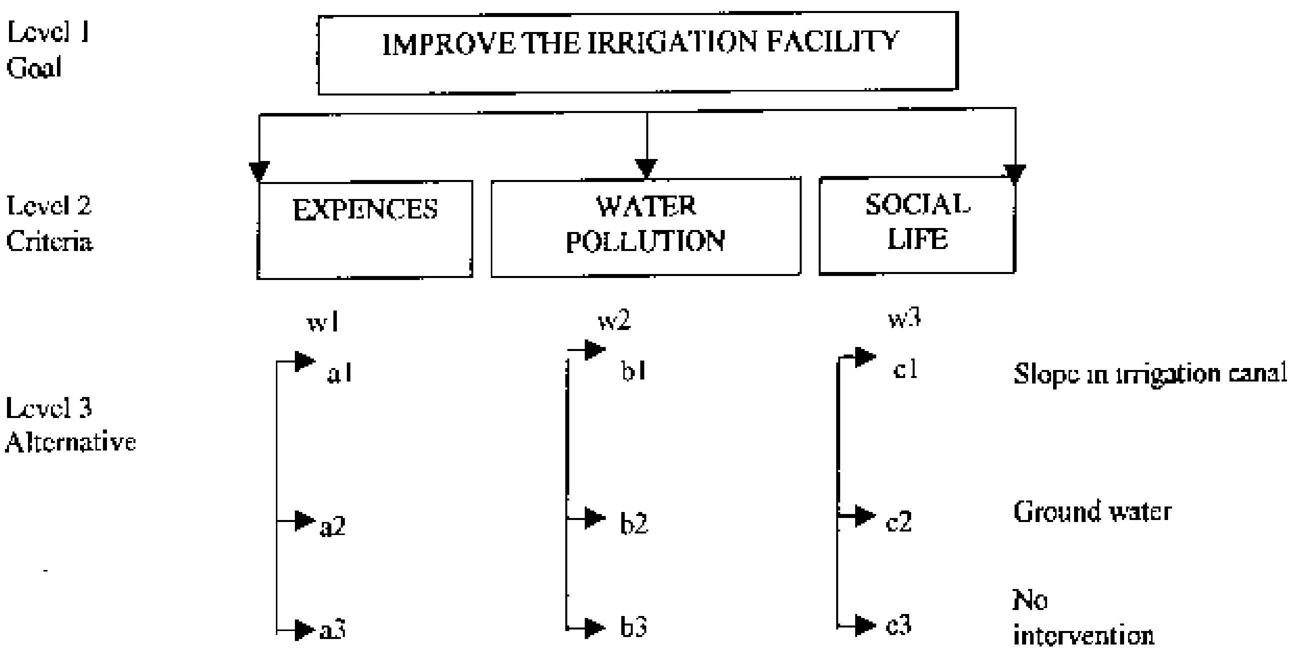


Figure 4.11 Calculation procedure of the AHP model

Preference weights of the policies

Weight of expenses	=	a1w1+b1w2+c1w3
Weight of ground water	=	a2w1+b2w2+c2w3
Weight of no intervention	=	a3w1+b3w2+c3w3

4.8 SUMMARY

From the opinion of experts, mitigation policies and their side effects of adverse environmental impact on four components have been discussed. The result of expert opinion survey was useful to determine users' opinion. For analysing the users' survey, it was discussed in an organized framework in the model AHP, where the mitigation measures are treated as alternatives and the side effects or the impacted components are treated as criteria of the model. This analysis helped to arrive at integrated environmental management policies for MDIP.

CHAPTER 5

FINDINGS OF THE AHP MODEL

5.1 INTRODUCTION

In chapter three, four environmental components of MDIP were identified and in chapter four, experts' opinion on their mitigation measures and side affects have been discussed. In this chapter, to find out the best alternative policies from the user's point of view, the result of the AHP model has been discussed

5.2 OUTCOME OF THE AHP MODEL

For every identified environmental component, two types of results have been obtained. First, the ranking of best policy for the mitigation of adverse environmental impact on specific component and Second, the ranking of influencing factors by the taken policies on the same component.

5.3 FISHERIES

For the environmental component of fisheries, the main objective is to mitigate the loss of fisheries in MDIP. For that three alternative policies with the consideration of four different aspects have been identified. The three alternative policies are – '*increase the fish culture in ponds and closed water bodies*', '*increase the fish culture in the open* water' such as khal, river or agricultural land, *and 'no policies over present condition'*. Four different aspects, which are also influenced by the adopted policies are – increase of water pollution, increase of employment opportunity, increase of income, and improvement of overall social life.

5.3.1 IMPORTANT CONSIDERATION FOR FISH CULTURE (criteria)

From the findings of AHP model, employment opportunity is the most important factor, which has to be considered for increasing fisheries in MDIP. Income generation through fish culture is the second priority and the consideration of social life is third. But an interesting fact is that people of MDIP are not so afraid for the increase of water pollution by fish culture.

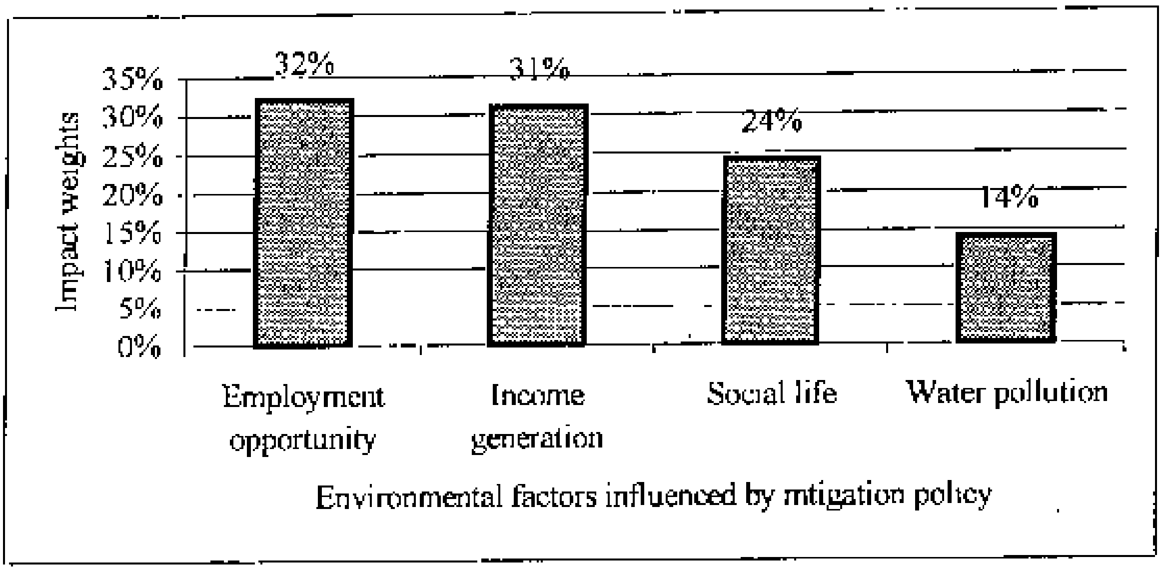


Figure: 5.1 Comparison of affected environmental components with improvement of fish culture

5.3.2 PREFERENCE WEIGHTS ON DIFFERENT POLICIES (alternative policies)

When the policies are compared considering the important factors (employment, income, water pollution and social life) in the first level of the AHP hierarchy, the result becomes - higher the value higher the policy is preferred among the alternatives considering the choice factors (Table 5.1).

It is revealed from the figures contained in Table 5.1 that in terms of water pollution, *'fish culture in closed water'* is the most preferred policy and *'fish culture in open water'* is second and the value of no intervention is the lowest.

Table: 5.1 Comparison of the policies for improvement of fish culture with respect to affected components.

	Water pollution	Employment opportunity	Income generation	Social life	Total
Close water fish culture	**0.073**	**0.167**	**0.145**	**0.115**	**0.502**
Open water fish culture	0 042	0.111	0.122	0.094	0 371
No intervention	0 02	0 038	0.040	0.026	0.126

Source : Field survey, 1998

Considering employment opportunity 'fish culture in closed water' has got the highest preference, 'fish culture in open water' is second and no intervention is the lowest. Again for the consideration of income generation *'closed water fish culture'* get most preferred policy, *'open water fish culture'* get second preferred policy

5.3.3 PREFERRED POLICY ACCORDING TO AHP MODEL FINDINGS

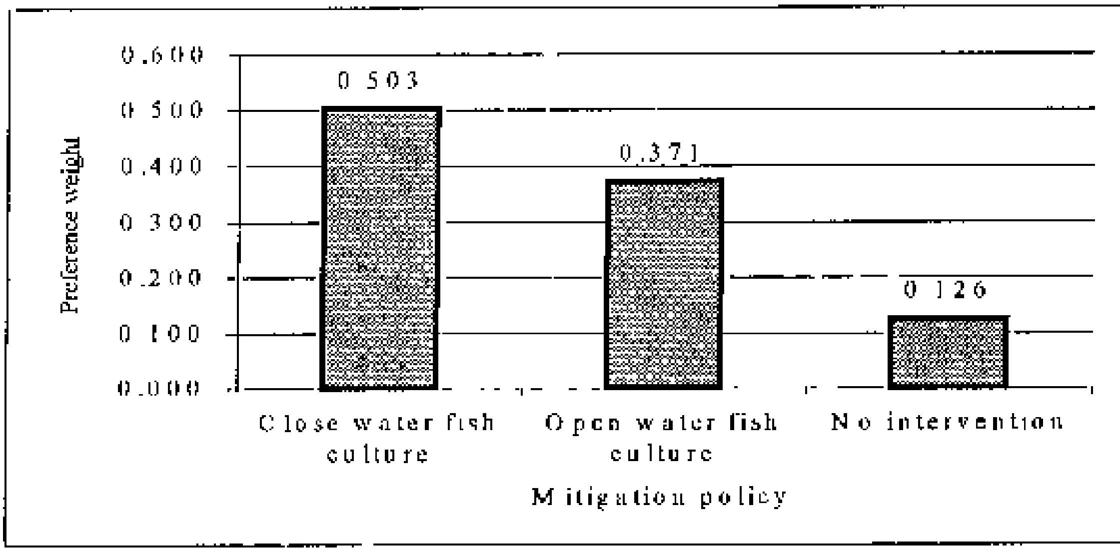


Figure 5.2 Comparison of the policies for improvement of fish culture.

After synthesising the data by Analytic Hierarchy Process (AHP), considering four different factors, the final result is presented in Figure 5.2. The most preferred policy becomes '*closed water fish culture*' with a value of 0.503 '*Open water fish culture*' and '*no intervention*' each had a value of 0.371, 0.126, respectively Therefore, close water fish culture appears to be the most preferred policy option in MDIP by using the AHP model.

5.4 SOIL FERTILITY

For the environmental component of soil fertility, the main objective is to mitigate the loss of soil fertility in MDIP. For that four alternative policies with the consideration of three different aspects have been identified The four alternative policies are – *'reduce the use of chemical fertiliser', 'reduction of crop cultivation season', 'increase the use of modern machinery', and 'increase the culture of green manure'.* Three different aspects, which are also influenced by adopted policies are - increase of crop production, increase of technical training, and improvement of social life

5.4.1 IMPORTANT CONSIDERATION FOR SOIL FERTILITY (criteria)

From the findings of AHP model, crop cultivation is the most important factor, which has to be considered for increasing soil fertility of MDIP Social life is the second priority and the consideration of technical training is the third.

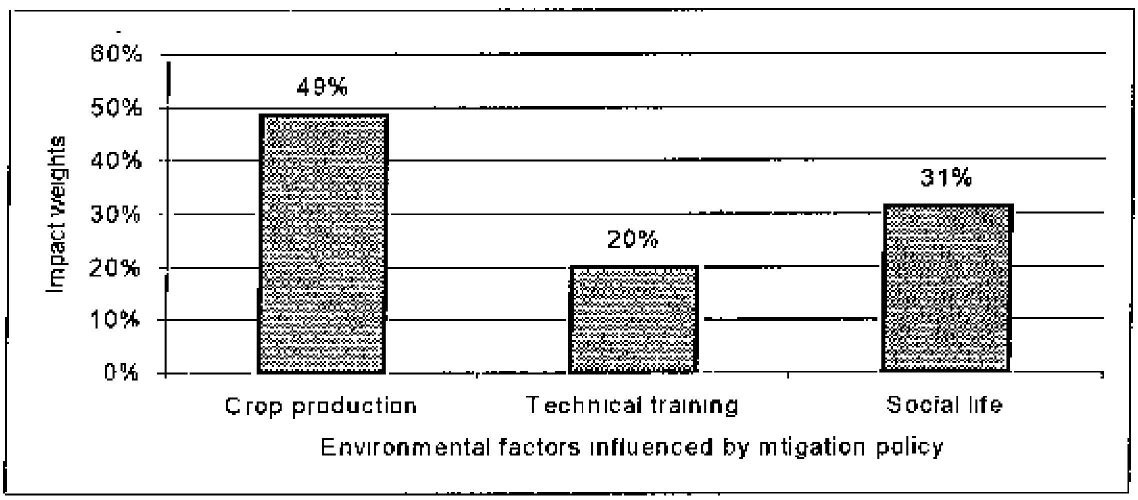


Figure 5.3 Comparison of affected environmental components with improvement in the soil fertility

5.4.2 PREFERENCE WEIGHTS ON DIFFERENT POLICIES (Altenative policies)

In the first level of the AHP hierarchy, the policies are compared considering the important factors (crop cultivation, technical training and social life). The results, which refer to higher the value higher the policy is preferred among the alternatives considering the choice factors, are presented in Table 5.2.

It can be seen from Table 5.2 that in terms of increase of crop production, '*use of modern machinery*' is the most preferred policy, '*increase of green manure cultivation*' is second and '*reduction of crop cultivation season*' is the lowest

Table 5.2 Comparison of the policies for improvement of the soil fertility with respect to affected components.

	Increase crop production	Increase technical training	Social life	Total
Reduction of the use of fertiliser	0.077	0.037	0.058	0.173
Reduction of crop cultivation season	0.047	0.021	0.024	0.092
Use of modern machinery	**0.228**	**0.09**	**0.144**	**0.464**
Increase green manure cultivation	0.132	0.05	0.085	0.269

Source: Field survey, 1998

In considering the increase of technical training, '*use of modern machinery*' has the highest preference, followed by '*increase of green manure cultivation*' and '*reduction of crop cultivation season*', which is of lowest priority

However, due considering to social life, '*reduction the crop cultivation season*' get highest preference followed by '*increase of green manure cultivation*' which is the second preferred policy

5.4.3 PREFERRED POLICY ACCORDING TO AHP MODEL FINDINGS

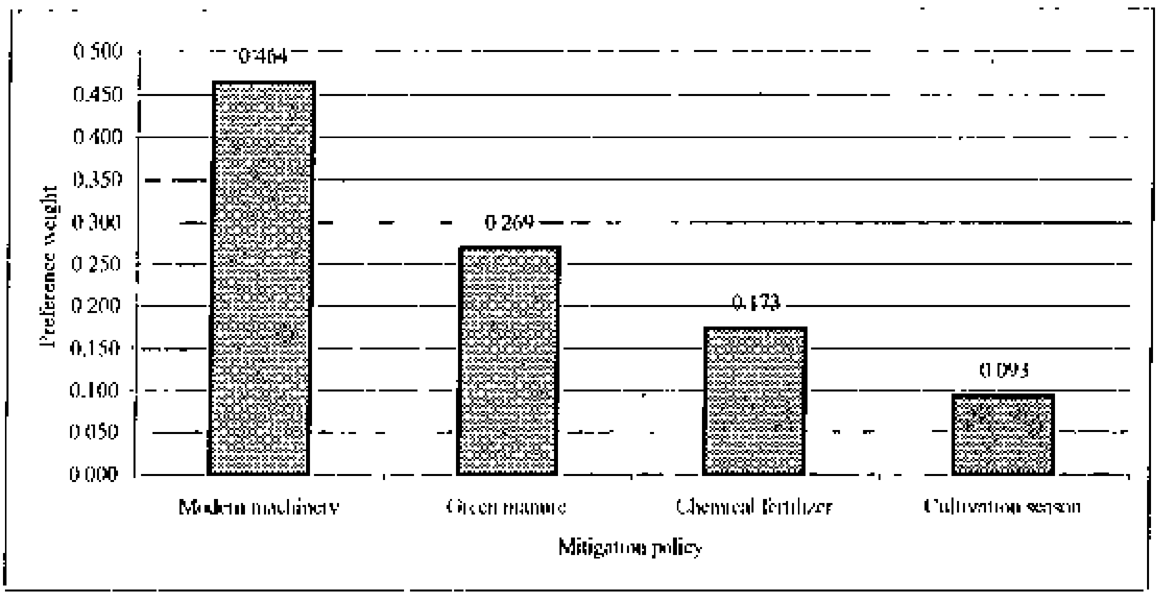


Figure: 5.4 Comparison of the policies for improvement of soil fertility

After synthesising the data by Analytic Hierarchy Process (AHP) model, considering four different factors, the final result is presented in Figure 5.4. It appears from the chart that the most preferred policy becomes '*increase the use of modern machinery*' with a value of 0.464 followed by the '*increase of green manure cultivation*' which occupies second position with a value of 0 269

'*Reduce the use of chemical fertiliser*' and '*reduction of crop cultivation season*' each had values of 0.173 and 0.092, respectively, reflecting their weaker positions in the policy preference arena. Therefore, '*increase the use of modern machinery*' appears to be the most preferred policy option to mitigate the adverse impact on soil fertility in MDIP by using the AHP model

5.5 DRAINAGE CONGESTION

For the environmental component of drainage congestion the main objective is to mitigate the adverse environmental impact on drainage congestion in MDIP For this purpose three alternative policies with the considerations of three different aspects have been considered. The three alternative policies are – '*remove local stocking program in drainage canal*', '*provide appropriate slope in drainage canal*', and '*no policies over present condition*'. Three different aspects, which are also influenced by the adopted policies are - water pollution, fish culture, and social life

5.5.1 IMPORTANT CONSIDERATION FOR DRAINAGE CONGESTION (criteria)

From the findings of AHP model, fish culture and social life are equally important factor, which has to be considered for decreasing the water logging in MDIP. And water pollution is lower important factor But an interesting factor is that people of MDIP are not so afraid for water pollution against the increase of fish which seems to have popular support.

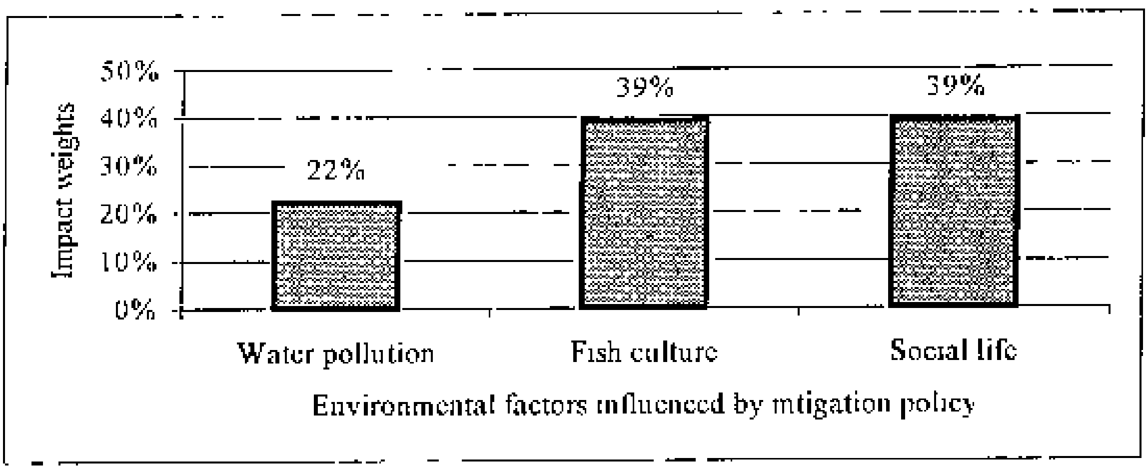


Figure: 5.5 Comparison of affected environmental components with improvement of the drainage congestion

5.5.2 PREFERENCE WEIGHTS ON DIFFERENT POLICIES (Alternative policies)

In the first level of the AHP hierarchy, the policies are compared considering the important factors (water pollution, fish culture and social life). The results, which refers to higher the policy is preferred among the alternatives considering the choice factors, are presented in Table 5.3.

Table 5 3 Comparison of policies for improvement of the drainage congestion with respect to affected components

	Water pollution	Decrease fish culture	Social life	Total
Local stocking	0 088	0 135	0.13	0.354
Slope in drainage	**0.092**	**0.202**	**0.204**	**0.5**
No intervention	0.035	0 052	0.057	0 145

Source : Field survey, 1998

It can be seen from Table 5 3 that in terms of water pollution '*provide appropriate slope in drainage canal*' is the most preferred policy and '*removal of local stocking program*' is second and the value of '*no intervention*' is the lowest.

In considering fish culture, '*provide appropriate slope in drainage canal*' is the most preferred policy followed by the '*removal local stocking program*' and the value of '*no intervention*' which is of lowest priority. However, with due consideration to social life, the result is the same as above.

5.5.3 PREFERRED POLICY ACCORDING TO AHP MODEL FINDINGS

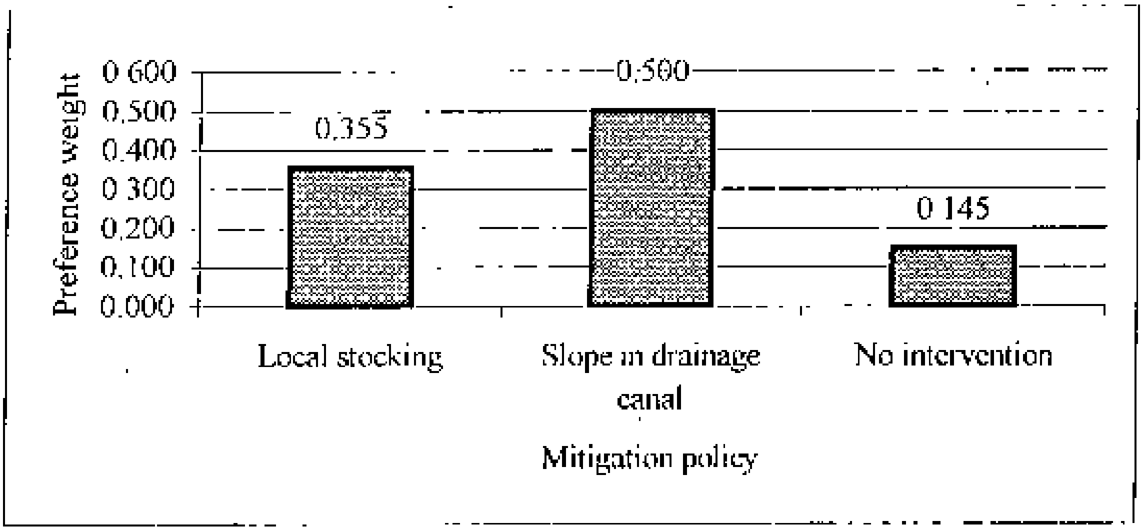


Figure 5.6 Comparison of the policies for improvement of the drainage congestion.

After synthesising the data by Analytic Hierarchy Process (AHP) model, considering four different factors, the final result is presented in figure 5.6. It appears from the chart that the most preferred policy becomes '*provide appropriate slope in drainage canal*' with a value of 0.5 followed by '*removal local stocking program*' and '*no intervention*' each had a value of 0.354 and 0.145, respectively. Therefore, 'provide appropriate slope in drainage canal' appears to be the most preferred policy option to remove the drainage congestion in MDIP by using the AHP model.

5.6 IRRIGATION FACILITY

For the environmental component of irrigation, the main objective is to increase the facility of irrigation in MDIP. For that three alternative policies with the consideration of three different aspects have been identified. The three alternative policies are – *'provide appropriate slope in irrigation canal'*, *'use of ground water'*, and *'no policies over present condition'* Three different aspects, which are also influenced by adopted policies, are – project expenses, water pollution and social life.

5.6.1 IMPORTANT CONSIDERATION FOR IRRIGATION (criteria)

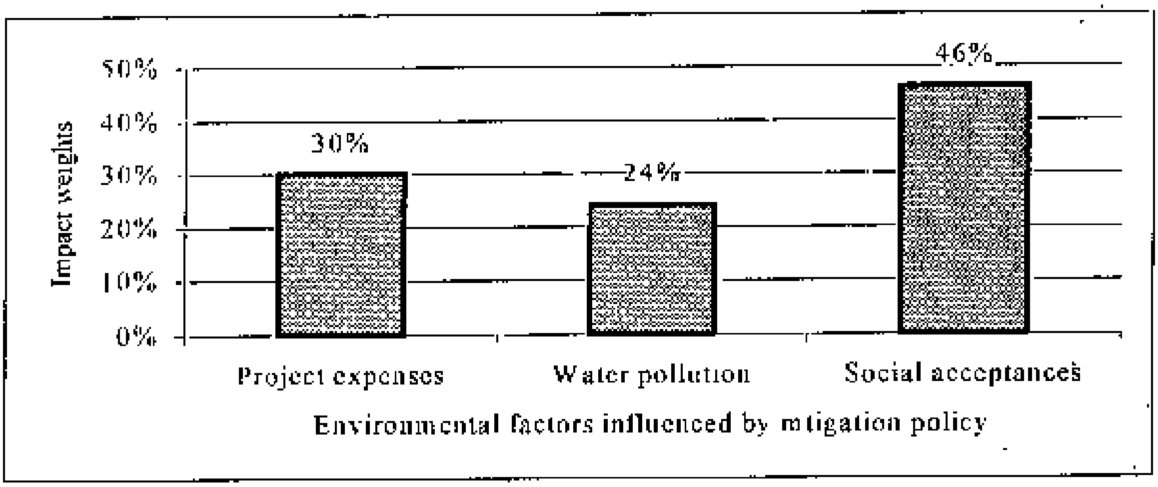


Figure 5.7 Comparison of affected environmental components by improvement of irrigation facility

From the findings of AHP model, social life is the most important factor, which has to be considered for increasing the irrigation facility in MDIP. Project expenses to increase due to the irrigation facility are the second priority and the consideration of water pollution is the third But an interesting factor is that people of MDIP are keen to get more irrigation facility for increasing their crop production

5.6.2 PREFERENCE WEIGHTS ON DIFFERENT POLICIES (alternative policies)

In the first level of the AHP hierarchy, the policies are compared considering the important factors (employment, income, water pollution and social life), the results of which refers to higher the policy is preferred among the alternative considering the choice factors, are presented in the Table 5.4. It can be seen from Table 5.4 that in terms of increase of project expenses, '*provide appropriate slope in irrigation canal*' is the most preferred policy and '*use ground water* 'is second and the value of '*no intervention*' is the lowest

Table: 5.4 Comparison of policies for improvement of irrigation facility with respect to affected components

	Expenses	Water pollution	Social life	Total
Slope in irrigation canal	**0.155**	**0.108**	**0.247**	**0.512**
Ground water	0 104	0.102	0.16	0.367
No intervention	0.043	0 025	0.051	0 119

Source Field survey, 1998

In the considering of water pollution and the consideration of social life '*provide appropriate slope in irrigation canal*' is also the most preferred policy

5.6.3 PREFERRED POLICY ACCORDING TO AHP MODEL FINDINGS

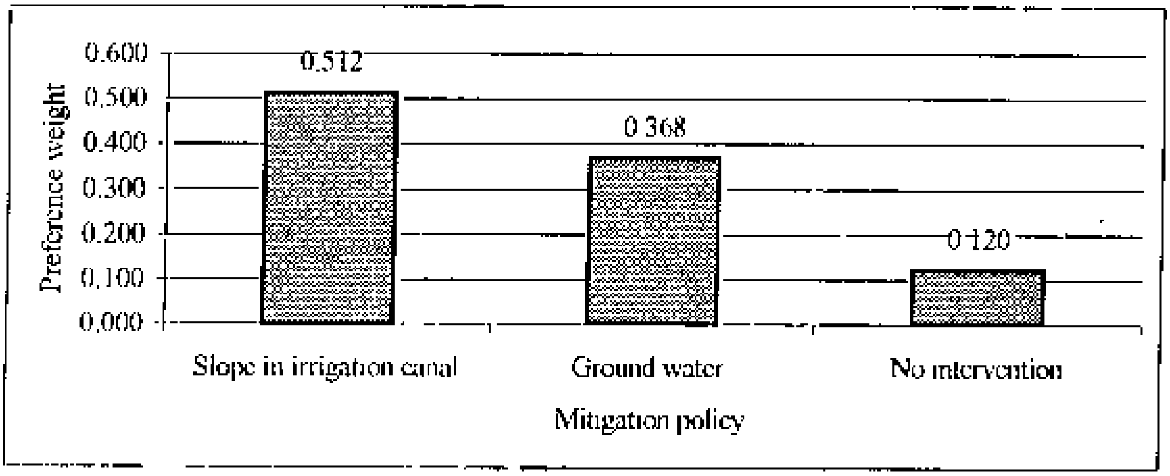


Figure: 5.8 Comparison of the policies for improvement of the irrigation facility.

After synthesising the data by Analytic Hierarchy Process (AHP) model, considering four different factors, the final result is presented in figure 5 8 It appears from the chart that the most preferred policy becomes '*provide appropriate slope in irrigation*' canal with a value of 0.512 followed by the '*use ground water*' and '*no intervention*' each had a value of 0 367 and 0,119, respectively Therefore, '*provide appropriate slope in irrigation canal*' appears to be the most preferred policy option to improve the irrigation facility in MDIP by using the AHP model.

5.7 INTEGRATED ENVIRONMENTAL MANAGEMENT POLICIES FOR MDIP:

AHP is a decision making tool From the forgoing discussion it appears that to mitigate the adverse impact of different environmental components, some policies have been set within the preference scale. Now, it is necessary to put them together and this has been attempted in Table 5.5.

Table: 5.5 Component wise policy preferences for mitigation of environmental impacts of MDIP

To mitigate the adverse environmental impact on the components MDIP	1st preference	2nd preference	3rd preference	4th preference
Fisheries	Fish culture in closed water	Fish culture in open water	No intervention	
Soil fertility	Increase the use of modern machinery	Increase green manure cultivation	Reduce the use of chemical fertiliser	Reduction of crop cultivation season
Drainage congestion	Provide appropriate slope in drainage canal	Removal of local stocking program	No intervention	
Irrigation facility	Provide appropriate slope in irrigation canal	Use ground water	No intervention	

Source: Field survey, 1998

It appears from the Table 5.5 that 1st preference of all the individual components should be implemented to mitigate the adverse impact on environment by MDIP. If, for any reason, 1st preference could not be adopted the other preferences could be tried

Also it is evident from Table 5.5 that the alternative mitigation policies assume higher preferential positions over '*no intervention*' option. Adopting of either or all of these may well be considered as development from the present situation

5.8 SUMMARY

From the analysis of users' survey using the technique AHP, component wise policy preferences for mitigation of environmental impacts of MDIP have been found In this chapter, a package of policies is identified with their preferential positions Therefore, '*close water fish culture*, for fisheries, '*increase the use of modern machinery*' for soil fertility, '*provide appropriate slope in drainage*' for drainage congestion *and '**provide appropriate slope in irrigation canal*' for irrigation facility appears to be the 1st preferred policy option in MDIP by using the AHP model Through this, the preferential positions of potential mitigation policies are found out

CHAPTER – 6

CONCLUSION

6.1 INTRODUCTION

The main objective of the study is to find out the alternative mitigation measures to minimize the adverse impacts on environmental components of MDIP The Analytic Hierarchy Process (AHP) has been applied to deal with the mitigation options for identified environmental components of MDIP By using the technique, all the problems were described at some specific level and the whole decision was defined in an organized framework. In this chapter, the findings of the study have been analysed to draw policy guidelines.

6.2 SUMMARY OF THE FINDINGS

The study found that the construction of MDIP has inflicted adverse impacts on some environmental components such as fish culture, soil-fertility and drainage congestion Other environmental components, though not affected seriously at present, may be affected in the future.

Expert opinions gathered to determine essential components of the integrated environmental management policies for MDIP, are briefly discussed in the following manners.

Fisheries:
General observation from the Experts to develop the fish culture is that 'closed water fish culture', is accepted by the society. If this policy is organised at the village and community

level, people's income will be enhanced. If the 'open water fish culture' (control flooding) is developed then the authority of MDIP has to strictly control the system Because crop production and agricultural land can be damaged by applying the policy. Some experts have supported for control flooding after 5 year's interval. Another opinion is to remove local stocking program in drainage canal, which is used for fish culture, approved by thana parishad but this is contrary to the concept of the project.

Soil Fertility:

Improvement of soil fertility through policies, such as – 'reducing in the use of chemical fertiliser ',' reduction of crop cultivation season ',' increased use of modern machinery 'and' increase of the culture of green manure, are effective and accepted by the society But the implementation of the policies would require technical training and financial support, which may be organised by involving NGO's in different development work of the MDIP

Water Logging and Drainage Congestion:

Water logging problem is actually present in some areas of the project like Udamdi and Kalipur. The problem has occurred since these areas lie below the mean water datum of the project The Experts defer to change the project plan at the present situation and they suggest that in areas where the water logging occur, people may take advantage to develop seasonal fish culture. This type of fish culture can increase water pollution, which can be removed by control flooding after 5 years interval. Drainage congestion is increasing day by day due to operating efficiency. unplanned structure and local stocking program. Since the comparative expensive policy of 'appropriate slope in drainage canal' could not be implement at present, experts suggest to 'remove local stocking program' immediately for improving drainage congestion problem.

Irrigation facility:

Most of the project area (about 75% area) has irrigation facility. To extend this facility to other areas, new planning is required which is also time taking and expensive But the design and implementation of 'appropriate slope in irrigation canal' can increase irrigation facility

6.3 USERS OBSERVATIONS

Users are the ultimate beneficiaries of the MDIP. Their opinion is always based on grass root observation. It must, therefore, be considered with due weightage to ensure sustainable development. Their opinions were formally collected through structured questionnaire and were also analysed through AHP technique. In the research, users' observations are based on experts' opinion and actually these opinions have been set within the preferred scale, thereby became the policies to mitigate the adverse environmental impact of MDIP.

Fisheries:

Adopting alternative policy option can compensate the loss of fisheries by the MDIP In this regard, users opinion '*closed water fish culture*' as the most preferable policy. To implement the policy they need knowledge and training.

Soil Fertility:

People are not that aware about the impact on soil fertility due to MDIP. They are mostly interested about the increase of crop production. Through analysis using AHP model the most preferred policy came out to be 'increase the use of modern machinery' because it contributes to increase the crop production and decrease labour and cost

Drainage congestion:

Small parts of MDIP are very much affected by drainage congestion, which are also the causes of many diseases like diarrhoea '*provide appropriate slope in drainage canal*' which is the preferred policy option by the users, can improve the drainage congestion problem of MDIP.

Irrigation facility:

Part of the area of MDIP are still out of irrigation facility and some of the area get irrigation irregularly because of the project planning, as identified by the users' So to '*provide appropriate slope in irrigation canal*' can solve the problem At present, they prefer to 'use ground water' by pumping, as an alternative.

6.4 RECOMMENDATIONS FOR POLICY GUIDE LINES

From the study it becomes clear that users' observations with their preferred options would be the policy guidelines and therefore the following policies might be considered to mitigate the adverse impact on environmental components of MDIP

1. *'Close water fish culture'* is the best policy to mitigate the adverse impact on fisheries. For the sustenance of the policy, it should be implemented by village and community level.
2. To implement the most preferred policy for mitigation of the adverse impact on soil fertility, the policy option, *'increase the use of modern machinery'*, would require technical training and financial support, which can be organised by the different NGOs and financial agencies. People should be encouraged adopt other policies like *'green manure cultivation', 'reduce the use of chemical fertiliser for increasing the soil fertility.*
3. To remove the drainage congestion and to improve the irrigation facility *'provide appropriate slope in drainage and irrigation canal'* is the best policy. This implies the existing irrigation and drainage design has to be revised considering the whole project area.
4. Continuos' monitoring of the environment is necessary to keep a project sustainable. It allows early detection of any undesirable developments and allows timely intervention before the project deteriorates to such an extent that the damage becomes irreversible An ideal monitoring plan uses the fewest possible variables without losing the perspective of the whole environment and the interdependency of its components. For the adoptions of integrated environmental policy, the monitoring needs to be done by an umbrella organization, covering all the environmental components

The above policies will help the Government and the concerned agencies such as BWDB, DOE, and DAE to ensure sustainable development in implementing their projects as well as other FCD/I projects in Bangladesh. Depending on the success of computing the best alternative policies using AHP, other projects may adopt the same technique to arrive at their own environmental management policies.

6.5 RECOMMENDATIONS FOR FURTHER RESEARCH WORK

The study has arrived at some policy for sustainable development, which needs to be implemented to yield its positive impact. Since it is a collective responsibility of various line agencies of the Govt. as well as international donor agencies like ADB, World Bank etc. Also, in the community level, there is room for various NGOs to play their role. All such forces must be brought to an integrated management system with done respective weightage and interrelations to ensure desired result Such a delicate balance calls for further research.

APPENDIX - A

LIST OF MDIP EXPERTS

1 Mr Dawan Md. Hasan Sayed, SDE, Water Development Board, Dhaka.

2. Mr Sarfaraj Wahed, SDE, Water Development Board, Dhaka.

3 Mr. Dilip Kumar Sha. Extension officer, MDIP.

4 Dr Salimul Haque, BCAS, Dhaka

5. Mr. Mozibur Rahman, Environmental Directorate, Dhaka.

6. Md. Abdul Majid Mollah, SDE, Water Development Board, Dhaka.

7. Md Mizanur Rahman, SDE, Water Development Board, MDIP

8 Md Siddiqur Rahaman, SDE, Water Development Board, Dhaka

9. Mr. Abdul Malek Mia, Ex -EE of MDIP.

10. Mr. Abu Taher Chawdhury, SE, Chandpur O&M circle, Dhaka.

11. Mr. AFM Mahbubul Alam, Ex -EE of MDIP

12 Mr. Azhar Ali, Director of Planning. FAP-16, Dhaka.

13. Prof. Dr Mohammad Abdul Mohit. BUET, Dhaka.

14. Prof. Dr. Rezaur Rahman, IFCDR, BUET, Dhaka

15. Dr. Bilkis, ICDDRB, Dhaka.

16. Dr. Salahuddin, CIRDAP, Dhaka.

17 Mr. Emaduddin, Director, SWMC, Dhaka

18 Mr Faruq, Water Development Board, Dhaka.

19. Mr Habibur Rahman, Water Development Board, Dhaka.

20 Mr Moshiur Rahman, Water Development Board, Dhaka

21 Mr Motin Bhauyan, EE, MDIP.

22. Mr. Mujibur Rahman, Ex -EE of MDIP.

23. Mr. Muklesuzzaman, SE, Design circle II, Green Road, Dhaka

24. Mr Poul Thomson, consultant.

25. Mr Rafiqul Qadar, EE, MDIP.

26. Prof Dr. Aminul Haque, BUET, Dhaka

27. Prof. Dr. Firoz Ahmed, BUET, Dhaka.

28. Prof. Dr Inunnishat, BUET, Dhaka.

29. Prof Dr. Mozannal, BUET, Dhaka.

30. Prof Dr. Samsul Alam, Jahangirnagr University, Dhaka

31. Mr Raquib, ISPAN, Dhaka

32. Mr Shafiqur Rahman, CIRDAP, Dhaka

33 Mr. Syed Ismail Ali, SDE, Water Development Board, Dhaka.

34. Mr. Tareq Chowdhury, ICDDRB, Dhaka

35. Mr Tom Widgveld, Consultant, CAD Programme, MDIP

36. Mr. Yousuf, BCAS, Dhaka.

37. Mr. Md Abul Kasem, Ex -EE of MDIP.

38. Mr. Md Shajahan Ahmed, Ex -EE of MDIP.

39. Mr Monoar Kamal, ISPAN, Dhaka.

APPENDIX - B

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APPENDIX - C

Name of the Thesis: Developing Integrated Environmental Management Policies for Meghna-Dhonagoda Irrigation Project in Bangladesh.

Department of Urban & Regional Planning
Bangladesh University of Engineering & Technology

Questionnaire Format for Expertise

(To find out the list of mitigation policies for adverse environmental impacts and also their possible affected aspects)

Sir/Medam,
I, from the Department of Urban & Regional Planning Bangladesh University of Engineering and Technology, am doing a research on "Developing Integrated Environmental Management Policies for Meghna-Dhonagoda Irrigation Project in Bangladesh." In this regard I am seeking for same general information and valuable opinions about a few vital factors. Your kind Co-operation will be very useful for my research, You need not to mention your name The data will be only for research purpose and will be kept secret.

Name of the Interviewers & Designation ____________________ Serial no. _____

Name of the organization ____________________

Date _________ Time _______

☐ Have you any experiences of working (or any study) in MDIP?
☐ If Yes, How long? __________ years

Notes :

1. Please tick in your choices (✓).
2. You may select one or more choices, which are mention in the below, But recommended choices are three to five nos.
3. You may also add more choices, comments, what you think.
4. MDIP means Meghna-Dhonagoda Irrigation Project

QUESTIONNAIRE OF FISHERIES

Recommended policies to mitigate the adverse impact on fisheries in MDIP	Potential environmental impacts due to the recommended policies
☐ Compensate the loss of fish culture by 'fish culture in closed water' (Fish culture on ponds, ditches, and reservoir water etc. where the fishes are developed under artificial care)	☐ Water pollution ☐ Employment of fisherman. ☐ Social acceptance. ☐ Income ☐ Fish diseases ☐ Please specify, if any. ☐
☐ Compensate the loss of fish culture by 'Open water fish culture' (it means fish culture on khal, beel, open field, river etc. where the fishes are developed under natural care)	☐ Water pollution ☐ Sources of water supply(for irrigation). ☐ Crop damage and loss of agricultural lands ☐ Increase drainage congestion and water logging. ☐ Improve navigation and communication ☐ Social acceptance. ☐ Please specify, if any. ☐
☐ Allow control flooding (Provide adequate opening in roads and embankments along routes of fish mitigation).	☐ Water pollution ☐ Crop damage and loss of agricultural land ☐ Increase drainage congestion. ☐ Social acceptance ☐ Please specify, if any. ☐
☐ Fisheries passes all main canals on MDIP (irrigation canals).	☐ Please specify, if any. ☐ ☐ ☐
☐ Allow local stocking programs on canals in MDIP (irrigation canals).	☐ Water pollution ☐ Increase drainage congestion ☐ Social acceptance. ☐ Please specify, if any ☐
☐ No intervention (no other policies should be required).	☐ Please specify, if any. ☐ ☐ ☐
☐ Please specify, if any	☐ Social acceptance. ☐ Please specify, if any. ☐ ☐

Comments:

QUESTIONNAIRE OF SOIL FERTILITY

Recommended policies to mitigate the adverse impact on Soil fertility in MDIP	Potential environmental impacts due to the recommended policies
☐ Reduce the use of chemical fertilizer.	☐ Decrease crop production ☐ Social acceptance ☐ Please specify, if any. ☐ ☐ ☐
☐ Reduction crop cultivation season (from three to one/two season)	☐ Decrease crop production. ☐ Social acceptance ☐ Please specify, if any. ☐ ☐ ☐ ☐
☐ Use of modern Machinery	☐ Increase crop production. ☐ Technical training. ☐ Please specify, if any. ☐ ☐
☐ Increase the cultivation of Green Manure like Daincha.	☐ Social acceptance ☐ Increase crop production. ☐ Please specify, if any. ☐ ☐
☐ No intervention (no other policies should be required).	☐ Social acceptance ☐ Please specify, if any. ☐ ☐
☐ Alternative cropping patterns have been suggested entailing crop-rotation (shallow and deep-rooted crops)	☐ Please specify, if any ☐
☐ Please specify if any.	☐

Comments:

QUESTIONNAIRE OF DRAINAGE CONGESTION

Recommended policies to mitigate the adverse impact on Drainage congestion in MDIP	Potential environmental impacts due to the recommended policies
☐ Provide appropriate slope in Drainage canal for surface drainage	☐ Water pollution ☐ Please specify, if any ☐ Social acceptance ☐ ☐
☐ Local Stocking program in drainage canal (through thana Parisad Approval, but which is not under project plan) must be removed.	☐ Social acceptance. ☐ Water pollution ☐ Fish culture
☐ Change project planning, to decrease the water level	☐ Social acceptance. ☐
☐ No intervention (no other policies should be required)	☐ Please specify, if any. ☐

Comments:

QUESTIONNAIRE OF IRRIGATION FACILITY

Recommended policies to improve the Irrigation facilities in MDIP	Potential environmental impacts due to the recommended policies
☐ Provide appropriate slope in Irrigation canal for surface irrigation	☐ Social acceptance ☐ Project expenses. ☐ Please specify, if any. ☐ Water pollution ☐ ☐
☐ Use surface water where available.	☐ Soil fertility. ☐ Social acceptance. ☐ Please specify, if any. ☐ Water pollution ☐
☐ Use of ground water, select a aquifer producing good quality water.	☐ Please specify, if any. ☐ Water pollution ☐
☐ No intervention (no other policies should be required).	☐ Social acceptance. ☐ Please specify, if any.
☐ Please specify, if any	☐

Comments:

APPENDIX - D

Name of the Thesis: Developing integrated Environmental Management policies for Meghna-Dhonagoda Irrigation Project in Bangladesh.

Department of Urban and Regional Planning
Bangladesh University of Engineering and Technology

Sir/Medam,
I, from the Department of Urban & Regional Planning Bangladesh University of Engineering and Technology, am doing a research on "Developing Integrated Environmental Management Policies for Meghna-Dhonagoda Irrigation Project in Bangladesh " In this regard I am seeking for same general information and valuable opinions about a few vital factors Your kind Co-operation will be very useful for my research, You need not to mention your name The data will be only for research purpose and will be kept secret.

A) General Information of People

Name of the Interviewers & Addresee ____________________ Serial no. _____

____

Name : Pumping area : A. Kalipur Pumping station
B Udamdi Pumping Station
C. Ekhlaspur Pumping station
D Dubgi Pumping station

Age	Sex	Education	Occupation	Resident
1 = 0 - 19	1=Man	1=Illiterate	1= Service	1=Permanent
2 = 20 - 29	2=Woman	2=Primary level	2= Business	2=Temporary
3 = 30 - 44		3=Secondary level	3= Labor/Worker	
4 = 45 - 59		4=S S C. level	4= Student/Teacher	
5 = 60+		5=Graduate or more	5= Others	
		6=Technical training		
		7=Others		

DIFFERENT POLICIES TO INCREASE THE SOIL FERTILITY

Impacted Environmental Components by the increasing soil fertility

Soil fertility is hampered by MDIP. Different policies have been taken to mitigate the loss of soil fertility, which may also, impact on other environmental components. In the followings 3 environmental components are shown in 3 pair. You have to tick (✓) one component from the pair and also give another tick (✓) to mark the degree of impact.

	Equal	Little more	More	Lot more	Extremely more	
Increase crop production	1	2	3	4	5	Increase technical training
Increase crop production	1	2	3	4	5	Social acceptance
Increase technical training	1	2	3	4	5	Social acceptance

Considering Crop Production

Fish culture has been hampered by MDIP. If different policies have been taken to mitigate the loss of soil fertility, assumed that crop production will be increased. In the followings 4 policies are shown in 6 pair. With the consideration of crop production, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference.

	Equal	Fairly preferable	Prefer -able	Highly preferable	Most preferable	
Decrease the use of chemical fertilizer	1	2	3	4	5	Decrease the crop cultivation season
Decrease the use of chemical fertilizer	1	2	3	4	5	Use modern machinery
Decrease the use of chemical fertilizer	1	2	3	4	5	Increase Daincha cultivation
Decrease the crop cultivation season	1	2	3	4	5	Use modern machinery
Decrease the crop cultivation season	1	2	3	4	5	Increase Daincha cultivation
Use modern machinery	1	2	3	4	5	Increase Daincha cultivation

Considering Technical Training

Fish culture has been hampered by MDIP. If different policies have been taken to mitigate the loss of soil fertility, assumed technical training will be increased. In the followings 4 policies are shown in 6 pair. With the consideration of technical training, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference

	Equal	Fairly preferable	Prefer -able	Highly preferable	Most preferable	
Decrease the use of chemical fertilizer	1	2	3	4	5	Decrease the crop cultivation season
Decrease the use of chemical fertilizer	1	2	3	4	5	Use modern machinery
Decrease the use of chemical fertilizer	1	2	3	4	5	Increase Daincha cultivation
Decrease the crop cultivation season	1	2	3	4	5	Use modern machinery
Decrease the crop cultivation season	1	2	3	4	5	Increase Daincha cultivation
Use modern machinery	1	2	3	4	5	Increase Daincha cultivation

Considering Social Acceptance

Soil fertility has been hampered by MDIP. If different policies have been taken to mitigate the loss of soil fertility, should also be accepted by society. In the followings 4 policies are shown in 6 pair. With the consideration of social acceptances. , you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference

	Equal	Fairly preferable	Prefer -able	Highly preferable	Most preferable	
Decrease the use of chemical fertilizer	1	2	3	4	5	Decrease the crop cultivation season
Decrease the use of chemical fertilizer	1	2	3	4	5	Use modern machinery
Decrease the use of chemical fertilizer	1	2	3	4	5	Increase Daincha cultivation
Decrease the crop cultivation season	1	2	3	4	5	Use modern machinery
Decrease the crop cultivation season	1	2	3	4	5	Increase Daincha cultivation
Use modern machinery	1	2	3	4	5	Increase Daincha cultivation

Different policies to mitigate the adverse impact of drainage congestion

Impacted Environmental Components by the mitigation of drainage congestion

Drainage congestion is increased by MDIP. Different policies have been taken to mitigate the loss of fish culture, which may also, impact on other environmental components. In the followings 3 environmental components are shown in 3 pair. You have to tick (✓) one component from the pair and also give another tick (✓) to mark the degree of impact

	Equal	Little more	More	Lot more	Extremely more	
Increase water pollution	1	2	3	4	5	Increase the loss of fish culture
Increase water pollution	1	2	3	4	5	Social acceptance
Increase the loss of fish culture	1	2	3	4	5	Social acceptance

Considering water pollution

Drainage congestion has been increased by MDIP. If different policies have been taken to mitigate Drainage congestion, assumed that water pollution will be decreased. In the followings 3 policies are shown in 3 pair. With the consideration of Water pollution, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference

	Equal	Fairly preferable	Preferable	Highly preferable	Most preferable	
Removal of local stocking in drainage channel	1	2	3	4	5	Provide appropriate slope in drainage canal
Removal of local stocking in drainage channel	1	2	3	4	5	No intervention
Provide appropriate slope in drainage canal	1	2	3	4	5	No intervention

Considering fish culture

Drainage congestion has been increased by MDIP. If different policies have been taken to mitigate Drainage congestion, assumed that fish culture will decreased. In the followings 3 policies are shown in 3 pair. With the consideration of fish culture, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference.

	Equal	Fairly preferable	Preferable	Highly preferable	Most preferable	
Removal of local stocking in drainage channel	1	2	3	4	5	Provide appropriate slope in drainage canal
Removal of local stocking in drainage channel	1	2	3	4	5	No intervention
Provide appropriate slope in drainage canal	1	2	3	4	5	No intervention

Considering Social acceptance

Drainage congestion has been increased by MDIP. If different policies have been taken to mitigate Drainage congestion, should accepted by society. In the followings 3 policies are shown in 3 pair. With the consideration of social acceptances, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference

	Equal	Fairly preferable	Preferable	Highly preferable	Most preferable	
Removal of the local stocking in drainage channel	1	2	3	4	5	Provide appropriate slope in drainage canal
Removal of local stocking in drainage channel	1	2	3	4	5	No intervention
Provide appropriate slope in drainage canal	1	2	3	4	5	No intervention

Different policies to increase the irrigation facility

Impacted Environmental Components by the developing of irrigation facility

Irrigation facility is the main objective of MDIP But till today it could not fulfill the people expectance If different policies have been taken to develop the irrigation facility, which may also, impact on other environmental components In the followings 3 environmental components are shown in 3 pair You have to tick (✓) one component from the pair and also give another tick (✓) to mark the degree of impact.

	Equal	Little more	More	Lot more	Extremely more	
Increase expenses	1	2	3	4	5	Increase water pollution
Increase expenses	1	2	3	4	5	Social acceptance
Increase water pollution	1	2	3	4	5	Social acceptance

Considering Expenses

Irrigation facility is the main objective of MDIP But till today it could not fulfill the people expectance. If different policies have been taken to develop the irrigation facility, assumed that the expenses will be increased In the followings 3 policies are shown in 3 pair. With the consideration of expenses, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference.

	Equal	Fairly preferable	Preferable	Highly preferable	Most preferable	
Provide appropriate slope in irrigation canal	1	2	3	4	5	Use of ground water
Provide appropriate slope in irrigation canal	1	2	3	4	5	No intervention
Use of ground water	1	2	3	4	5	No intervention

Considering water pollution

Irrigation facility is the main objective of MDIP But till today it could not fulfill the people expectance. If different policies have been taken to develop the irrigation facility, assumed that water pollution will be increased In the followings 3 policies are shown in 3 pair. With the consideration of water pollution, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference

	Equal	Fairly preferable	Preferable	Highly preferable	Most preferable	
Provide appropriate slope in irrigation canal	1	2	3	4	5	Use of ground water
Provide appropriate slope in irrigation canal	1	2	3	4	5	No intervention
Use of ground water	1	2	3	4	5	No intervention

Considering social acceptance

Irrigation facility is the main objective of MDIP. But till today it could not fulfill the people expectance If different policies have been taken to develop the irrigation facility, should also be accepted by society In the followings 3 policies are shown in 3 pair. With the consideration of social acceptance, you have to tick (✓) one policy from the pair and also give another tick (✓) to mark the degree of preference

	Equal	Fairly preferable	Preferable	Highly preferable	Most preferable	
Provide appropriate slope in irrigation canal	1	2	3	4	5	Use of ground water
Provide appropriate slope in irrigation canal	1	2	3	4	5	No intervention
Use of ground water	1	2	3	4	5	No intervention