ECONOMIC CONSIDERATIONS FOR ZONING AS A PROCESS OF FLOOD PROTECTION IN BANGLADESH

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ABSTRACT

Bangladesh, a predominately agricultural country in the Third World, with 110 million people and only 9 million hectares of cultivable land, is known worldwide for its frequency of severe floods and other natural hazards like cyclones, tornadoes and epidemics. Increased pressure on the scarce land resources for food and habitation of the growing population is the main consideration for any agricultural project formulation. Successive development plans of Bangladesh have tried to address different socioeconomic problems by spreading limited available resources thinly over different sectors, although self sufficiency in food grain production has been targeted by politicians as well as researchers. Recently, the agricultural sector has planned for growth through the development of water resources management, in particular flood protection, as this is the primary source of all development activities in the country.

The decision making processes of farmer is taken as the main focus of this dissertation. Farming in Bangladesh, mostly for subsistence, may be a profitable or a losing concern, depending on the selection of the crop mix. In other words, farming depends on the decision making process of the farmers. The farm environment in a flood protected project area is described along with its agro-socio-ecological linkages. Flood mitigation literatures describing optimising crop mix technologies are reviewed. Theoretical details of different quantitative methods were brought together for the purpose of selection of an appropriate analytical model to capture the diversified nature of farming. The selection process utilised concepts, data and theories from relevant academic disciplines to find a model that could address a set of problems related to decision making at the grass roots level.

The empirical work of this dissertation is mainly based upon a survey of production relations in agriculture. The survey comprises randomly but purposively chosen farmer respondents within groups in order to capture a general picture of some agrarian relations for a specific flood control project - the Meghna Dhonagoda Irrigation Project.

A linear programming model was formulated. The coefficients of the model were estimated from the survey data. Given average resource endowments possessed by different groups of farmers, optimal cropping patterns for various situation were found. The model was run for five groups of farmers, under both with and without project conditions.

The results obtained from the model runs show that rice production in all farms increases by 140 to 383 percent. At the same time production of other crops diminishes significantly. The net year ending savings of group A (small) farmers decreases by 7 percent although their living standard is improved (indicated by increased family rice consumption and expenses). Group B (middle) farmers are in a slightly improved position, with a 1.5 percent increase in net year ending savings whereas the net year ending savings of groups C and D (large farmers) is doubled. The achievements of groups C and D compared to those of groups A and B shows the anomaly in welfare distribution of the public investments.

The impact on net return due to changes in resource endowments or crop coefficients is obtained from sensitivity and range analysis. It indicates the profitability or shadow cost for individual constraints.

Before implementation of the project, farmers often mixed different crops in the same field to reduce the risk if a particular crop failed. They grew a variety of staple crops and vegetables to meet family food needs and they rarely purchased artificial chemical fertilisers or pesticides. In other words, they were diversified and less susceptible to the natural disasters. After the project, farmers were much less diversified and used more artificial inputs.

Three significant features of the public investment in flood protection and irrigation arose:

a) Rapid economic growth, though with significant evidence of diminishing returns

b) Increased rice production at the expense of other crops

c) Unequal welfare distribution between rich and poor.

The results obtained through model runs conform to general trends. All available evidence indicates that past improvements to flood control and irrigation contributed significantly to the growth in agricultural production in Bangladesh. The complementarity between proven yield-increasing technologies and water application points out the importance of water resources development. Thus there should be no question about the desirability of flood control projects. But equitable distribution of facilities, or at least betterment of the majority of population, may not be achieved at the desired rate.

CHAPTER I

MOTIVATION FOR THE STUDY

1.1 Introduction

Bangladesh, a predominantly agricultural country in the Third World, with 110 million people and only 9.03 million hectares of cultivable land, is known worldwide for its frequency of severe floods. Construction of flood embankments and polders has been adopted as a measure of flood protection since the 1960s. This consumes a considerable portion of the development budget and affects a large percentage of cultivable lands.

Increasing pressure on scarce land resources for food and habitation of the growing population is a crucial consideration for any economic activities of the country. Haphazard dwelling of the small farm families and their endeavours for the production of subsistence crops, mainly cereals, makes the development project formulation a difficult task which has become more complex by the frequent visit of the devastating floods. Past strides of the country have been analysed by a joint Government of Bangladesh - United Nations Development Programme team as follows:-

> "Many of the FCD (Flood Control and Drainage) and FCDI (Flood Control, Drainage and Irrigation) projects constructed so far are incomplete, often concentrating on the construction of flood embankments only, without due regard to the creation of conditions in the embanked area that favour agricultural development. Experience in Bangladesh shows that unless flood protection is integrated with a coherent package of measures and works, the expected benefits will not accrue. Both polder and embankment projects require an integrated approach with physical and non-physical dimensions....The non-physical dimension relates to assistance to the farmers in adapting their practices to the changed conditions thus helping them to fully exploit the potential of the changed conditions."
>
> (Bangladesh Flood Policy Study, 1989)

The study suggested that "Integrated development is one of the basic assumptions underlining the plan and compartmentalisation is one of the main instruments in this respect.....Benefits of flood protection in Bangladesh will have to accrue mainly from agriculture, the realisation of these benefits will be realised earlier if agricultural development is implemented in small units. Water management can also be brought down to the level of compartments."

Successive development plans of Bangladesh have tried to address different socio-economic problems through multiple objectives like: reduction of population growth, creating opportunities for productive employment, food self sufficiency, accelerating economic growth, equity in the distribution of development benefits, technological development, structural change, etc. As a result of diversified emphasis, the food grain production rate could not commensurate the population growth rate. The Planning Commission analysed the situation like this " With continuation of current trends, Bangladesh can expect an increasing food gap rather than a declining or disappearing one" (Planning Commission, 1988).

To describe prioritisation, Warton expressed his concern about the urgent need to accelerate food production and his conviction that the limited available resources must not be spread too thinly to be effective. The goal will be "not balanced growth nor unbalanced growth, but selective growth." (Warton, 1985) Bangladesh Government recently has chosen the agriculture sector for selective growth. As agriculture and water resources are closely related, planners in both these sectors have given flood control top priority.

The success of any flood control project will come through the farmers of the project area who will be using the created facilities to change or develop their cultivation practices. If the return from their changed practices is high enough to cover their costs, they could rationally be taxed to contribute to the operation and maintenance cost as well as capital recovery of the project. Different studies show that the medium and large farmers of Bangladesh are price sensitive in selecting the cropping pattern when they have irrigation or similar facilities available to them (MPO Technical Paper No.23, 1986). Flood control project planning for overall economic enhancement of the country should therefore include information on the optimal cropping pattern for a particular zone within the prevailing technical as well as socio-economic restrictions of that zone which will ensure the maximum benefit for the farmers. At the same time the project should at least be worthwhile to fulfil the minimum standard of internal rate of returns and benefit cost ratio set by the Government.

The optimal cropping pattern within a flood protected zone can be identified through analysing the on-farm budget and resource data in a linear programming model. The feasibility of the project can be judged by analysing the costs and benefits of the optimal cropping pattern through with and without situations. The purpose of this dissertation is to develop a representative model of farming for a flood control project in Bangladesh - the Meghna Dhonagoda Irrigation Project. Using actual survey data the model will give an indication of the ability of the project to fulfil the objective function of maximising the farmers' benefit. The model can also be used to calculate the level of agricultural resources used in flood control projects.

1.2 Organisation of the dissertation

In Chapter II detailed background of the flood control area is given. It includes physical, geographical and climatological significance of the country. The resource position (their availability or scarcity), institutional strength for project implementation, and the interaction between the two are described. Chapter III summarises the literature on flood protection decision variables and application of optimisation models to agricultural development in Bangladesh. The theoretical overview of the quantitative methods, especially of mathematical programming, is incorporated in Chapter IV. Merits and demerits of different approaches have been compiled from different authors. Special attention is given to identifying the issues important to constructing a representative farm model which reflects the situation in Bangladesh. Model formulation for the study is summarised in Chapter V. Chapter VI describes the field survey and its findings. Results obtained by running the formulated model with the data obtained from field survey are discussed in Chapter VII. Chapter VIII concludes the findings of the study and suggests areas for further study and actions for betterment.

CHAPTER II

FLOODS AND FLOOD CONTROL IN BANGLADESH

2.1 Floods in Bangladesh

This chapter will provide background on Bangladesh situation by highlighting the short history of past development and facilities available for implementation of agricultural and flood control projects.

2.1.1 Frequency of floods

Floods are a general natural calamity in Bangladesh. Every year around 30 percent of the country is flooded to a depth up to one metre. The people of that area are adapted to live with floods. The farmers developed their own skills and tenaciously stick to their farming. But the number of dependents per acre of cultivable land is increasing with population growth. Farmers are being compelled to increase their investments in agricultural inputs for High Yielding Varieties (HYV) under the risks of floods. History shows that severe floods occurred in Bangladesh during 1954, 1955, 1963, 1969, 1970, 1974, 1987 and 1988. The approximate area flooded to a depth of more than one metre was as follows:

YEAR	AREA FLOODED (in '000 sq.km)	% OF TOTAL AREA (143,998 sq.km)
1955	50.68	35
1963	43.14	31
1974	52.70	37
1987	57.47	40
1988	77.97	55

Source : Adapted from Khan,A.H 1988

2.1.2 Causes of floods

The geographical location of Bangladesh is the cause of floods. It is situated in the confluence of three mighty rivers, namely the Ganges, the Brahmaputra and the Meghna. The three rivers drain a total catchment area of about 1.5 million square kilometres of which only 7 percent lies within Bangladesh (UNDP, 1989).

In brief, the causes of floods in Bangladesh may be summarised as follows:

(i) Southwest monsoon winds.

(ii) Confluence of three mighty rivers.

(iii) Most of the catchment area of the rivers (93%) are outside of the country.

(iv) The elevation of most land from mean sea level is low.

(v) The influence of tides extend to a large part of the country due to flat topography.

(vi) Silt carried by different rivers settles on the bed of the rivers,raising the river, increasing flood probability and reducing the drainage capacity of the rivers.

(Adapted from Khan,A.H 1988)

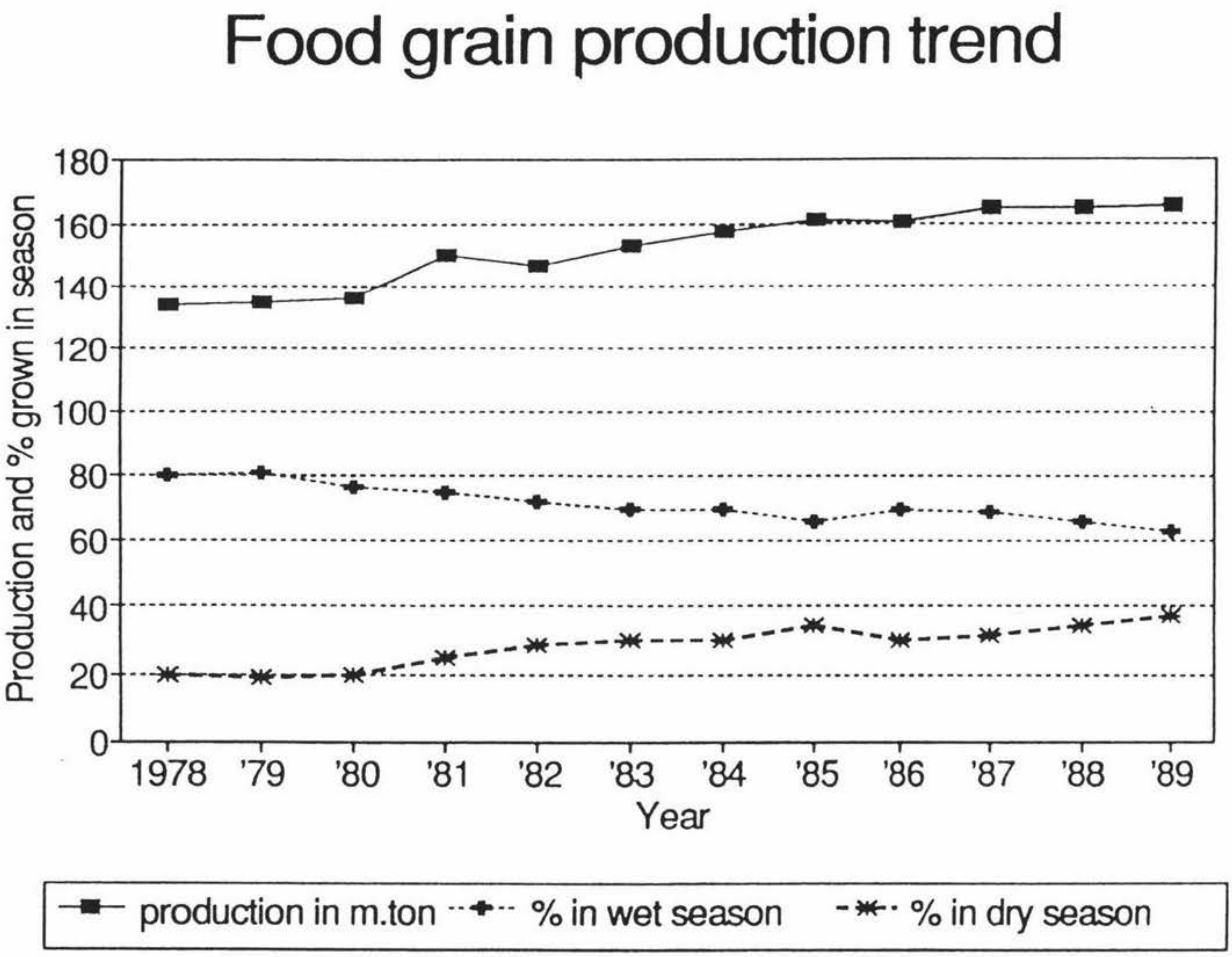

Figure 2.1 Food gain production trend in Bangladesh

(Source : Planning Commission, 1990)

2.1.3 Types of floods

Bangladesh experiences various types of floods:

- flash floods characterised by a sharp rise and drop in water levels, causing high velocity flows that damage crops and property,
- rain floods due to high intensity of rainfall over and outside of the country,
- monsoon floods from the overspilling of major rivers which usually rise slowly. Extensive damage occurs when the three major rivers rise simultaneously.
- floods arising from storm surges in the coastal area.

The normal sequence of floods starts with flash floods in the eastern and northern hill streams (April-May) before the monsoon. Onset of the monsoon generally occurs in June and the Meghna and the Brahmaputra reach flood peaks during July and August, whereas the Ganges normally peaks during August and September (UNDP, 1989).

2.1.4 Extent of flood damage

Assessment of flood damage is difficult because of the diversity of its nature. Schools, houses, livestock, telecommunications, roads, railways, and bridges are damaged or destroyed. Standing crops and raw materials are lost and works in progress are interrupted. Millions are driven from their homes. It takes away the lives of hundreds of people. The environmental damage due to flood causes the outbreak of epidemic diseases for humans and livestock.

The 1988 flood was the worst on record with widespread sufferings and loss of life. A joint United Nations Development Program (UNDP) and Government of the Peoples Republic of Bangladesh (GOB) team estimated the cost of reconstruction and rehabilitation program at US $ 1.1 billion.

2.1.5 Flood protection measures taken to date

Though the role of water for agricultural production increased during the 1960s and the first half of the 1980s, flood control and drainage remained an essential component of water resources management programs. In recent years, flood control and drainage have acquired greater importance because of the unprecedented floods of 1987 and 1988.

In spite of limited resources, an area of 3.36 million hectares is expected to be protected from flood by the end of the Third Five Year Plan (TFYP), through construction of an estimated 7024 kilometres of embankment, 3017 kilometres of drainage channel, 6884 hydraulic structures, 3888 bridges and culverts, and 1064 river closures (MIWDFC Task Force Report, 1990).

Embankments and flood control structures are designed on the basis of previous flood level records and the limited resource availability of the country. If heights of the embankments and dimensions of the structures are increased to protect abnormal floods, the costs will increase proportionately. As a result, less area could be given minimal protection with the limited funds. On the other hand, when the flood depth exceeds the designed height, the embankment is topped and acts as a hindrance to quick recession of flood water. Due to flat topography of the country, gravity drainage systems have limited applicability. Intensive rainfall within a short duration makes pump drainage a costly affair due to initial cost and operation cost.

Most of the flood control and irrigation projects completed so far considered increased agricultural production as the main benefit of the projects and expected post project benefit was calculated to outweigh the implementation cost of the projects. The proposed production levels could hardly be achieved due to the gap between farmers' practices and calculated cropping intensities. After post project evaluation of the completed Flood Control and Drainage projects, most of the multinational donor agencies recommended complementary agricultural development projects and provided funds for those projects. For instance, the World Bank's agricultural development projects in Chenchury Beel and Barnal Salimpur Kolabashukhali were completed during the Second Five Year Plan (SFYP) period.

The country by this time has gathered some practical experiences in dealing with floods. It is the intent of the government to utilise these experiences through undertaking a massive flood control program which will not only change the flood dynamics but also call for a new configuration of agricultural productive forces including institutional management in a changed environment.

2.2 Agriculture

The economy of Bangladesh is predominantly agricultural, contributing about 50 percent to the Gross Domestic Production (GDP) and 80 percent of the export earnings of the country. Agriculture also provides employment opportunities to the vast majority of the people.

Bangladesh has followed the course of planned development since independence in 1971. Although successive plans had multiple objectives, there was some confusion between opposing objectives, particularly those for the agricultural sector. There was no clear cut statement about exactly what the agricultural sector was going to maximise - food production or employment opportunity. As can be seen from a review of Third Five Year Plan, "The plan aimed at attaining a food grain production level of 20.7 million metric tones(mmt) by 1990. It envisaged diversification of agriculture with greater emphasis on minor cash crops, livestock, and forestry with a view to accelerating absorption of the growing labour force in productive employment and thereby raising the income level of the common people. The production program was backed by an input package, extension work, incentive prices and strengthening of agricultural support institutions" (Planning Commission, 1988).

Over the years, wide swings were experienced in yield, growth and production and the food grain production level has stagnated at around 16.5 mmt since 1986 (Fig. 2.1). Some commentators remarked that this was due to natural calamities, mainly floods. Actually the trend was difficult to predict. Several experts noted in a seminar on October 1988 that "Bangladesh has the lowest growth rate in agricultural production among low and middle income countries of Asia" (Ahmed, R., 1988).

2.2.1 Crops

Though hundreds of crops are grown in Bangladesh, cereals, mainly rice, cover about 80 percent of the total cropped area (BBS,1986). In Bangladesh the two cropping seasons experience two extreme conditions of flood and drought. Farmers have historically been compelled to produce crops in the kharif (rainy) season to take advantage of the natural rainfall as source of water, although they must design their cropping pattern and/or crop variety to avoid flood damage. With the increase of flood control, drainage, and irrigation facilities, cropping intensity is expanding in the rabi (drought) season. Now it is essential to determine the optimal crop variety for a particular flood protected area to suit the availability of water and giving maximum benefit to the farmers.

2.2.2 Fisheries

The fisheries sector contributes about 6 percent to Gross Domestic Production and about 12 percent of the total export earnings of the country. Fisheries of Bangladesh are broadly categorised as inland and marine fisheries. The inland fishery provides about 80 percent of the animal protein in the national diet, employs about two million landless fishermen and small fish traders. Subsistence fishing in the flood plain is the major source of free animal protein supply to over 10 million rural people. In 1986-87, actual fish production was 0.815 mmt of which 0.597 mmt came from inland source and 0.218 mmt came from marine sources (Planning Commission, 1988).

National Water Plan Report suggested that "it should be considered for planning that fish is a crop having an economic value and fish resources in open inland waters are common property, natural renewable resources. They should be sustained and optimised" (MPO ,1986).

Floods cause severe damages to the fisheries sector. Embankments of the ponds, dikes of the shrimp culture farms, and some permanent structures like boundary walls, drains, etc. of fish seed multiplication farms are destroyed. Also most of the broad fish fingerlings escape from ponds due to flooding.

2.2.3 Forestry

In Bangladesh, forest resources account for about 16 percent of the total traditional energy volume. By 1987-88 12.5 million cubic feet of timber and 25.0 million cubic feet of fire wood was produced (Planning Commission, 1988). Bamboo production contributes to the pulp industry and local housing. Rubber plantations are in the experimental stage. The hilly area of Chittagong district (southeast Bangladesh) is mainly suited for forestry, which accounts for only 12 percent of the total land resources of the country (MPO,1985b). With the increased pressure of population growth forest lands are being utilised for housing and cereal production.

Forest now covers about 2.11 million hectares as against 2.19 million hectares in 1981. The most significant environmental threat in Bangladesh is the rapid decline of forests. Deforestation has direct impact on floods and soil erosion. Due to deforestation, the land mass suffers from erosion in the rainy season and dry conditions during the winter season. This vulnerability of topsoil to the weather is detrimental to agricultural productivity.

2.2.4 Livestock

Livestock contributes to the national economy in the form of essential draft power, valuable protein food, manure, fuel, rural transportation and industrial products. The supply of milk, meat, and eggs in the country during 1987-88 was only 1.27 mmt, 0.415 mmt, and 1800 million respectively, which was very low in respect of national requirements.

Bangladesh produces several forms of milk and milk products, the most available of which is fluid milk, which consists over 92 percent (by weight). The next popular products are curd (2.6%), chhana (2.6%), ghee (2.3%). Butter and cheese are also produced but in very small quantity. Out of the total supply of meat, beef accounts for about 70 percent, poultry (mainly chicken) about 16 percent, mutton 12 percent and buffalo 2 percent (Planning Commission, 1987b).

During the flood of 1988, about 37000 head of large and small animals and 0.206 million poultry birds died, causing a shortage of supply of livestock. Flood causes both the shortage of animal food and outbreaks of different epidemic diseases of livestock.

2.3 Agricultural Inputs

Agricultural production depends on the level and quality of inputs. Input production/acquisition, storage, and distribution carry a direct bearing on availability at the farm level and utilisation. Demand of one input is related to availability of the other. So maintenance of uniform flows and price levels within the reach of general farmer has been one of the goals of planning for increased production.

2.3.1 Land

Agricultural output can only grow by increasing land intensity (such as through improving yields), since there is little scope for increasing the amount of cropped land. Most land suitable for cultivation is already in use. Out of the total area of 14.40 million hectares in Bangladesh, 9.03 million hectares is cultivable (BBS, 1986). The landscape of Bangladesh is characterised by 36 physiographic units which may broadly be grouped into three land forms. These are -

(i) hill areas accounting for 12 percent of the total area,

(ii) terrace areas covering 8 percent and

(iii) active and inactive flood plan areas covering 80 percent (MPO, 1985a)

2.3.2 Labour

In Bangladesh, about 85 percent of the total population lives in villages, of which 59 percent are farmers and 25 percent are agricultural labourers. The agricultural labour force is those who are available to work in agriculture and, therefore, must not be confused with the rural work force which also consist of workers in non-agricultural activities in rural areas (Ahmad, K.U., 1982). The rural work force has been growing by at least 2 percent per annum. The agricultural labour hire has been growing rapidly and has grown up to 4 percent (BBS, 1986). The growing tide of landlessness and low production in below subsistence holding sizes are forcing a greater proportion of the population into rural labour markets.

2.3.3 Credit

Farm credit in agricultural production has been described in a report as "one of the most important needs of the majority of farmers in all developing countries". In most cases the availability or lack of farm credit influences the productive capacity and income level of farmers, particularly the small ones. Often they have limited access to institutional credit owing to their lack of collateral and low level of education and are, therefore, unable to avail themselves of such important inputs as fertiliser, farm chemicals and machinery. In fact the absence of farm credit on the part of the small farmers denies them the benefits of farm technology and innovations. On the other hand, they often develop dependency on credit for subsistence between planting and harvesting periods" (APO, 1984).

There are mainly two types of agricultural credit available in Bangladesh.

(i) Institutional credit disbursed through multiple agencies like banks and cooperative societies and;

(ii) Non-institutional credit available from friends, relatives, village well-to-do people and money lenders.

During 1982, out of the total credit supplied by the different institutional sources, the proportion of agricultural credit was 20 percent, which was only 8 percent of the requirement and could cover 15 percent of the rural families (Ahmed, J.U 1984).

In later years, the loan disbursement procedure has been modified for better utilisation of the agricultural credits. Originally, only land was accepted as security for agricultural loans. Now loans are extended to the farmers by simple crop hypothecation so those farmers who lease land can get credit. Co-operative societies become the guarantor of the credit when it is processed through Bangladesh Rural Development Board (BRDB). Farmers groups can acquire agricultural machinery on credit for common utilisation by forming a registered society. Bangladesh Bank has established credit norms which allows borrowing for cropped area between 0.33 acre and 2.0 acres. In spite of the above facilities, agricultural credit per farm was only about Tk 907 where Tk 5473 million was disbursed during 1985-86 (Planning Commission, 1987a).

2.3.4 Water

Water is the conduit from soil to the plant for most of the nutrients. It converts plant nutrients into acceptable form and maintains favourable environment for plant growth. So availability of water is one of the considerations for any high yielding technology. The damage (potential yield loss) from shortages of water in Bangladesh is many times higher than the damage from flood. This is because farmers know the location of his land in respect of flood depth and can select the cropping pattern to avoid normal floods of that area, but he cannot predict the drought. The result obtained from farm trials in different regional research stations and adjusted BBS data showed that average yield reduction from drought for high yielding varieties of aus is 23 percent, for high yielding varieties of aman is 31 percent and for wheat is 50 percent (MPO, 1985c).

Average annual water availability for agricultural use was calculated by the National Water Plan (NWP) project in 1985. It revealed that annual peak discharges of the Ganges, the Brahmaputra and the Meghna are 60000, 85000 and 14000 cubic metres per second (cms) whereas the dry season flows are 1500, 5700 and 85 cms respectively. The total potential sustainable withdrawal of ground water available for agricultural development may be taken as 45800 million cubic metres per year (MPO, 1986).

2.3.5 Irrigation

Irrigation is the key element in the spread of HYVs technology in flood protected areas. Out of 9.03 million hectares (mha) cultivable land 7.56 mha are suitable for irrigation. It was estimated by the National Water Plan that with the ultimate development of all water supplies (ground water and surface water including barrages) only 6.9 mha could be developed for irrigation. Up to June 1988, the total area irrigated by different methods of irrigation was 2.95 mha, which was about 32 percent of the total cultivable area. The contribution of different methods were-

Shallow tube well 0.8 mha (27.12% of total),Low lift pump 0.79 mha (26.78%), Deep tube well 0.63 mha (21.36%), manual/traditional methods 0.41 mha (13.9%), gravity canal 0.22 mha (7.46%) and local bodies through command area development (CAD) 0.1 mha (3.38%0). It is expected that at the end of TFYP the coverage would be 3.47 mha (Planning Commission, 1989).

2.3.6 Flood control

The importance of flood control for agricultural production can not be ignored as a more secure environment is required to foster the institutional and individual confidence necessary for investment in this sector. Out of the different options for flood protection, like upstream storage dams, channel improvements, under ground storage, shallow storage reservoir in plains, embankments, etc., the last one suits well in the context of Bangladesh.

According to an analysis made by Master Plan Organisation (MPO), the total flood vulnerable area in Bangladesh is 5.76 mha which is about 64 percent of the net cultivable area. There is partial overlapping of irrigation and drainage area but not all irrigable land requires flood protection or drainage and not all flood protected land is irrigable. The net benefited flood control and drainage area by the end of the Third Five Year Plan is estimated to be about 1.78 mha. The remaining potential for development is therefore 3.96 mha (MPO, 1990).

2.3.7 Fertiliser

Chemical fertilisers are necessary to replenish the essential nutrients which crops remove from the soil, in varying amounts. Farmers' demand for fertiliser is determined not only by price level but also by other factors such as the availability of irrigation facilities. With irrigation more area will be devoted to high yielding varieties and fertiliser demand will increase proportionately.

In Bangladesh the intensity of fertiliser use is low and poorly balanced compared with other Asian countries. During 1985-86 the chemical fertiliser used per acre was 21.6 kg compared to 114 kg in South Korea. Fertiliser sales in 1985-86 totalled 0.973 mmt; 0.657 mmt of urea, 0.259 mmt of TSP, and 0.052 mmt of potash. In addition 3869 mt of gypsum (containing sulpher) and 744 mt of zinc sulphate were distributed (Planning Commission, 1988).

2.3.8 Seed

Farmers are the main sources of their own seeds. Bangladesh Agricultural Development Corporation (BADC) supplies imported seed as well as own produced seeds but this is very small in comparison to the need. BADC considers that it met 5.9 percent of the requirement of paddy seeds and 23.75 percent of the requirement of wheat seeds in 1986-87 (BADC 1988).

2.3.9 Pesticide

Plant protection coverage grew slowly, at 2 percent per annum over the Third Five Year Plan period. Coverage for rice increased from 7.7 percent of area planted to 8.7 percent (Planning Commission, 1990).

2.3.10 Draft power

Animals supply virtually all of the draft power in Bangladesh - for ploughing, harrowing, leveling, making drainage ditches, threshing and transportation. According to Planning Commission figures the number of animals used for draft purposes increased by 15.5 percent but because of the poor quality of the stock, acute shortage of feed and fodder, the majority of draft animals are small, poorly fed and in poor health.

The average national draft power energy requirement has been estimated at 0.373 kw/ha where as the average available draft was estimated at 0.271 kw/ha. Therefore the current stock of draft animals is 73 percent of its proper level (Planning Commission, 1988).

2.4 Socioeconomic conditions

The noneconomic variables associated with agricultural development makes agricultural planning a difficult task. The types and size of the land holding, food habit and customary pattern of consumption, sociocultural values of the farmers, types of subsistence or surplus farming, etc. should also be considered in depth for preparation of a pragmatic plan.

Reynolds considered four major types of potential changes causing uncertainty in project planning. Those are:

(i) natural uncertainty,
(ii) social uncertainty,
(iii) institutional uncertainty and
(iv) economic uncertainty.

He noted that the analytical capabilities for natural uncertainties (such as hydrologic and economic evaluation) far exceeded the capability to analyse social and institutional problems. Analytical problems in the latter areas are compounded by both lack of data and lack of conceptual basis for dealing with questions of equity and other socially significant factors (Reynolds, 1979).
So socioeconomic considerations greatly influence the success of any agricultural project.

2.4.1 Land tenure system

In Bangladesh, there exists private ownership of land. The Land Reform Committee in 1983 observed that the farmers occupying 43 percent of net cultivable area were share croppers. The terms of share cropping are set by the landlords and go in favour of them. In most areas, landlords claim 50 percent of the product without sharing any input costs. As a result, share croppers lose their incentive to invest for high yielding varieties inputs because their share of increased return cannot meet up the additional inputs cost for cultivation. In the areas under any or Flood Control, Drainage and Irrigation Projects, the terms of share cropping are intervened by the project authorities. Here the product is shared 50 - 50 after reimbursement of the input costs.

2.4.2 Farm size

Farm structure in Bangladesh is quite unstable and skewed. 35 percent of the farm families are landless, 46 percent of the farm families have 0.05 to 2.49 acres of cultivable land and they possess 29 percent of the net cultivable area. Sixteen percent of the farm families possess 45 percent of net cultivable land. Their individual holdings range between 2.5 to 7.49 acres and average holding is 4.12 acres. The remaining 3 percent farm families possess 26 percent of the net cultivable land. Their average farm size is 11.85 acres. The average farm size of Bangladesh can be derived from the following table:

Table 2.1 Farm size of Bangladesh

Group	Range of holding in acres	No. of farms in millions (% of total)	Total area owned by the group in million acres (% of net cultivable area)	Average farm size in acres
a	0 - .04	5.409 (35)	0.071 (-)	0.013
b	.05-2.49	7.066 (46)	6.502 (29)	0.91
c	2.50-7.49	2.483 (16)	10.226 (45)	4.12
d	7.50- <	0.496 (3)	5.879 (26)	11.85
total		15.454	22.678	1.47
c + d	2.5 - <	2.979 (19)	16.105 (71)	5.41
b+c+d	.05 - <	10.045 (65)	22.607 (100)	2.25

Source :- BBS 1983 - 84 Farm and Livestock Survey, 1986

Ahmed, R. showed that 71 percent of the net cultivable area in Bangladesh is held by farmer groups who have more than 2.5 acres of land (group c+d) and they provide 91 percent of the marketable rice. They produce a marketable surplus in good as well as in bad harvest years (Ahmed,R. 1989).

For planning purposes, a reasonable assumption is that 65 percent of the rural families have farms of which 46 percent (that is 71 percent of the farms) have less than 2.49 acres (say 1 hectare) of cultivable land each. Some of those are deficit farms (which are less than 1 acre in size. Ahmed Raisuddin mentioned their proportion to be 40 percent.) and some of those are marginally self-sufficient (having cultivable land in between 1 - 2.49 acres, their proportion is 31 percent). The remaining 29 percent of the farms may be classified in two groups as medium farms (having cultivable land of the range of 2.5 - 7.49 acres each, say 1 - 3 hectares. Their proportion is 24.5 percent and they possess 45 percent of the net cultivable land.) and large farms (having cultivable land of above 7.5 acres, say above 3 hectares. They occupy 26 percent of the net cultivable land and their proportion is 4.5 percent.).

In a nutshell, the farms in Bangladesh can be classified the following types-

(i) Deficit (40% of the total, size less than 1 acre each),

(ii) Marginal (31% , size 1-2.49 acres),

(iii) Medium (24.5% , size 2.5-7.49 acres, occupying 45% of the net cultivable area) and

(iv) Large (4.5% , size above 7.5 acres, occupying 26% of the net cultivable area).

2.4.3 Farm families

A BBS sample survey during 1982 showed that out of 87.1 million population, 13.2 million live in town in 2.2 million households, whereas remaining 73.9 million live in rural areas in 12.8 million households. The above statistics reveal that the average number of family members of a rural household is 5.77. Table 2.1 shows that only 19 percent of the farm families are self sufficient, possessing 71 percent of net cultivable land, and 46 percent of farmers hire some land from that 19 percent group as their own land is not sufficient for farming. Thirty-five percent of the landless families either rent land for share cropping or work as hired labour or in combination of both the activities. Some of the landlords manage their farms through hired labour whereas some rent out all the land under share cropping and involve themselves in business. This class generally stays in town but actively participates in rural politics to maintain their social power.

2.4.4 Food habits

Zaman,H (1984) described very nicely the food habits of Bangalies. They will always propose, "Let us eat rice" instead of saying, "Let us take food or let us have lunch or dinner". In rural areas all the three meals consist mostly of rice with a little vegetables, pulse and chilies. There is general feeling that those who cannot afford rice will take alternative food such as bread or potatoes.

The average daily per capita worldwide intake in 1983 - 85 was 2666 calories. At 1859 calories, Bangladesh had the lowest daily intake in Asia (average 2437 calories) and the sixth lowest in the world. While per capita daily consumption increased world wide by 15 percent from 1961 to 1985, per capita consumption in Bangladesh fell. Nutrition intake studies in Bangladesh confirmed that the situation worsened over the last two decades. Caloric intake exhibited a steady downward trend, of 23 percent over the 1962 to 1985 period from 2301 calories in 1961 to 1773 calories in 1985 (Planning Commission, 1988).

One solution to increase the caloric intake is to increase the availability of alternative food supplies. Thus, crop diversification programs have been given top priority.

2.4.5 Farm budget

Cost of production for different crops with irrigation projects and without projects were estimated by MPO in 1985 prices. The purpose of the estimate was to compare the projects' cost with the increased benefits created by the projects through irrigation or flood control. For that reason, proportion of capital costs for irrigation or flood control projects were not included in the estimates but increased input and operational costs for the farmers were included. Rough idea of expected cost or benefit can be achieved from that calculation. Summary of the estimates are given below:

Table 2.2 Farm budget for different crops in one hectare of land (figures in Taka US$ 1 = Tk 20 approximately)

Crop	With project condition			Without project condition		
	gross income	production cost	net income	gross income	production cost	net income
B.AUS	8013	6318	1695	8013	6318	1695
T.AUS(H)	25349	9871	15478	19501	8523	11078
B.AMAN	10632	5073	5559	10632	5073	5559
T.AMAN	12558	5609	5948	11828	5361	6466
HYV.AMAN	24109	8337	15772	17239	6987	10253
BORO (L)	16119	6210	9908	13873	5899	7873
BORO (H)	23375	9002	14374	19864	9002	10844
HYV.WHEAT	15413	7379	8033	9987	5836	4151
POTATO	42284	16357	29927	29556	13994	15562
JUTE	11746	7715	4031	11746	7715	4031
SUGARCANE	34251	15408	18843	29253	14508	14745
PULSES	8336	2586	5750	8336	2586	5750
OIL SEED	8607	3930	4616	8607	3930	4676
ONION	18595	8511	10184	18595	8511	10184
VEGETABLE	28785	13987	14798	25694	12839	12855
TOBACCO	11947	9698	2249	8107	8245	-138

Source : MPO FFYP Project proposal, 1990.

Based on the above assumptions, an approximate budget for one season for different types of farms in Bangladesh may be estimated as follows:

Table 2.3 Approximate farm budget for a season

Type of Farm (% of total)	Appr. size (ha)	Hired labour (man-day)	Capital requir- (Tk)	Bullock power (pair-day)	Share of NCA (%)	% used for sub-sistance
Deficit(40)	.40	-	4000	15		200
Self-sf(31)	1.00	80	10000	50/1pa	29	100
Medium(24.5)	2.00	240	25000	100/2pa	45	50
Large (4.5)	5.00	720	65000	300/6pa	26	20

2.4.6 Agencies involved in agricultural development

Different institutions are involved for the supply of credit, inputs and extension services to the farmers. Bangladesh Agricultural Development Corporation is responsible for seed, fertiliser and minor irrigation equipment, Bangladesh Rural Development Board forms the co-operative groups among the farmers and thereby helps in credit availability, Bangladesh Water Development Board provides flood protection and irrigation through large projects, Local Government and Engineering Bureau executes small scale Flood Control, Drainage and Irrigation Projects through local bodies. Different commercial banks and cooperatives provide credit facilities. Directorate of Agricultural Extension provides the extension services. Bangladesh Agricultural Research Institute and Bangladesh Rice Research Institute are involved in research activities in relation to the improvement of the varieties as well as practices. Bangladesh Agricultural Research Council (BARC) is entrusted with the coordination of different agricultural research. Universities are involved in different research through BARC.

2.5 Agroecological conditions

Agricultural production is highly dependent upon location, soil type, weather conditions and various natural factors. For an optimal cropping pattern, these factors should also be considered.

2.5.1 Geographical location

Bangladesh lies in the northeastern part of South Asia between 20.34' - 26.38' north latitude and 88.01'- 92.41' east longitude. Environmentally, Bangladesh occupies a position in the transition zone between South and South-East Asia. The country is bounded by India on the west and north, India and Burma on the east and the Bay of Bengal on the south. The area of the country is 55,598 square miles or 143,937 square kilometre. Limits of the territorial waters of Bangladesh are 12 nautical miles, and the area of the high seas extending to 200 nautical miles measured from the base lines constitutes the economic zone of the country.

2.5.2 Soils

Bangladesh, in general, has fertile alluvial soils. There are many differences in the development of these soils, depending on the differences in constituents of the silt and sediment of which they are composed and the sites of deposition. Extensive agronomic trials showed that virtually all soil responded well to fertilisers and other agronomic practices. With the use of other inputs associated with modern technology, including high yielding varieties, plant protection, irrigation and/or drainage where appropriate, most cultivated areas are capable of providing increased yields (MPO, 1985c).

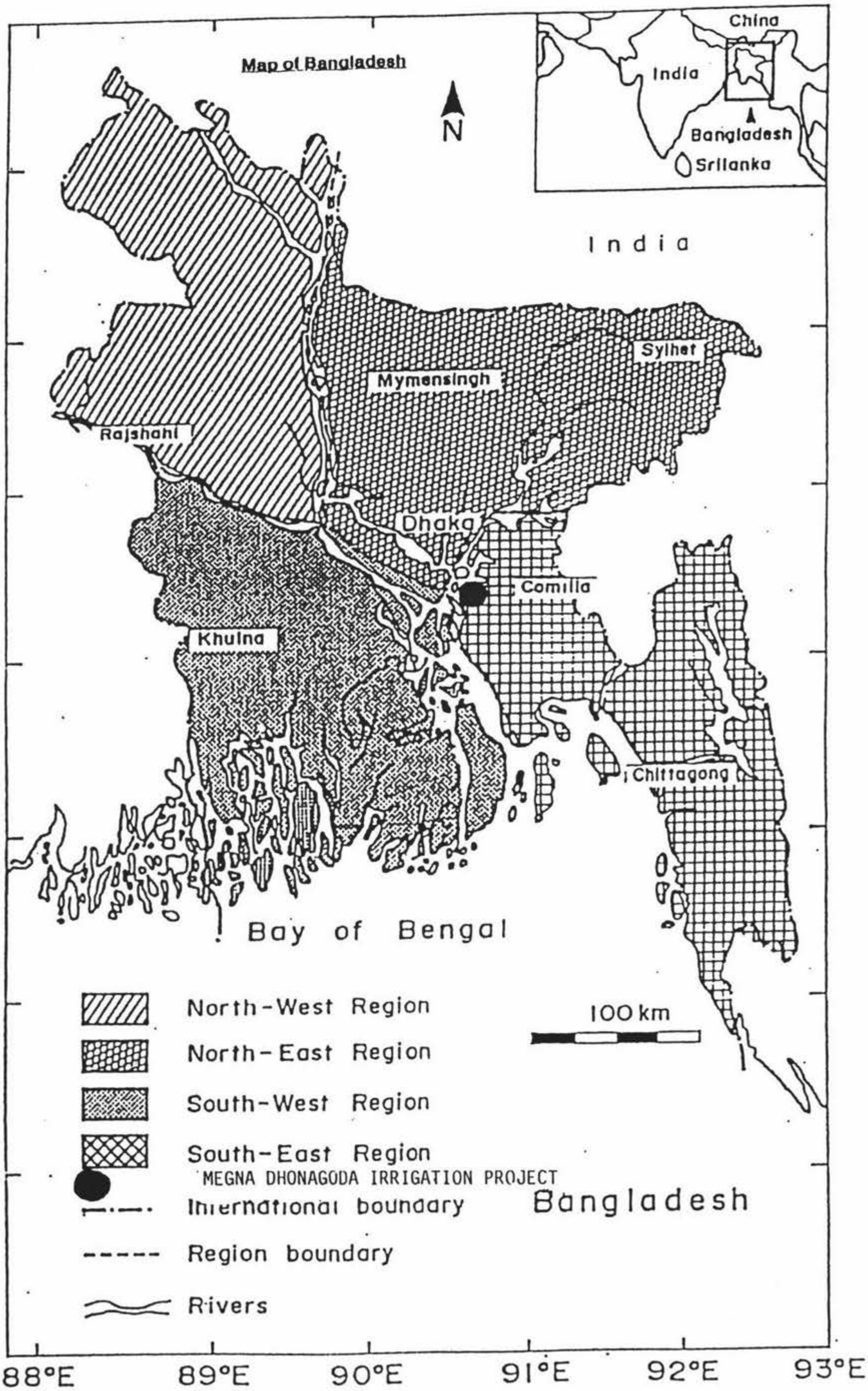

Figure 2.2 Map of Bangladesh

2.5.3 Rainfall

Bangladesh has seasonal rainfall, divided into three periods. During the pre-monsoon or Northwestern period (March-May), rainfall varies from 10 inches (250 mm) in the west to about 25 inches (630 mm) in the east. During the monsoon period (June to October), rainfall varies from 35 inches (890 mm) in the west to more than 60 inches (1520 mm) in the north-eastern and south-eastern parts of Bangladesh. During the dry winter months (November to March), about 2 inches (50 mm) of rainfall occurs, on the average.

From the point of view of agriculture, rainfall is deficient in one season (November to March) and excessive in another (June to October). The period of high rainfall also coincides with floods in rivers entering Bangladesh. Therefore, different problems of water supply arise in two different seasons. Moreover, not only are there the problems of seasonal variation of water surplus or water deficit, but there are also problems of excessive variability of rainfall in different seasons and different regions.

2.5.4 Temperature

Like rainfall, temperatures in Bangladesh also exhibit seasonal variation. Normal maximum temperatures in the summer months are between 32.7 and 35.5 degrees celsius, with temperatures occasionally exceeding 37.7 degrees during April and May, the hottest months; temperatures during the summer are seldom lower than 21.7 degrees anywhere in the plains, and the daily temperature range is almost nowhere greater than 12 degrees. The winter months are characterised by minimum temperature seldom falling below 10 degrees, and that only in certain areas such as the Chittagong Hill Tracts, South Sylhet and North Bengal. Even in these areas, however, maximum temperatures generally exceed 23.9 degrees. The temperature range in winter is usually no greater than 18 degrees.

2.5.5 Flood depth

The depth, timing and duration of flooding and the rate of inundation are important factors that influence when and what crops can be grown in the kharif and rabi seasons. For classification of the land types on the basis of flood plain and suitability to different crops the whole country is divided in to five regions by MPO. The classes are as follows:

Table 2.4 Classification of land based on depth of flood

Class	Land type	Flood depth	Nature of flooding
F0	high, suited to short stemmed HYV rice	0 t0 30 cm	intermittent
F1	medium high,suited to LV aus and aman	30 to 90 cm	seasonal
F2	medium low, suited to B.aman	90 to 180 cm	seasonal
F3	low, B.aman can be grown	> 180 cm	seasonal
F4	very low, donot permit growing even B.aman	> > 180 cm	perennial

Source: MPO, 1985c.

2.5.6 Climate

Bangladesh lies in the tropical monsoon region to the south of the Eastern Himalayas. These mountains, located just outside the country, act as a barrier between the lands to the north and those to the south and thus modify the climate of the country to a great extent. There are three distinctive climatic seasons in Bangladesh:

(i) The monsoon (rainy) season from May to October, during which more than 90 percent of the total annual rainfall is received and is characterised by high temperatures, high humidity and low solar radiation;

(ii) The dry (winter) season from November to February, which receives very little or no rainfall and is characterised by low temperature, low humidity and moderate solar radiation and

(iii) The pre-monsoon (hot) season from March to April, which receives some rainfall with occasional heavy thunder showers and hailstorms and which is characterised by the highest temperatures and evaporation.

2.5.7 Environmental pollution

Bangladesh is expecting a gradual increase of environmental problems due to population explosion, and the increasing trend of industrialisation and organisation. Manmade problems have been vastly aggravated by natural causes (like the greenhouse effect) on floods, droughts, cyclones, tidal waves,etc. which are almost annual features.

On the basis of monitoring by the Environment Pollution Control Department at a few locations, it appears that water of the rivers of Bangladesh is being polluted by the disposal of agricultural and industrial trash into the rivers, disposal of human excrete and disposal of organic bodies, and carcasses in water bodies. During the dry season, most of the water bodies in Bangladesh either dry up or shrink in area and volume. In many stagnant rivers, water at the bottom becomes covered with rotten vegetation. In such situation fish and other aquatic animals can not survive. They either die or migrate. The situation is more critical in the case of stagnant water such as beels, baors and ponds. Withdrawal of Ganges water in the upstream is affecting forest resources of the Sundarbans. Increased salinity has caused death to sundari trees, retrogression of forest type, slowed forest growth and reduced productivity of forest sites (MPO, 1985c).

2.5.8 Cropping seasons

There are two distinct cropping seasons during a year in Bangladesh. These are Kharif and Rabi seasons. The Kharif is the main cropping season which starts in March and ends in October. It is characterised by the monsoon climate. Based on crop adaptability and crop culture, the Kharif season is further divided into Kharif - I (March - June) and Kharif - II (July - October). "The crop environment during kharif season is not favourable for high yields because of the uneven distribution of rainfall, variable flooding depths, low solar radiation, high temperatures and high humidity. Due to high soil moisture, or submergence of soil during the kharif season, rice is the predominant crop; most other crops suitable for a high temperature regime suffer from excessive soil moisture" (MPO, 1985a). Among the different groups of rice, Aus is grown during the kharif - I season and transplanted aman (T.Aman) during the kharif - II season. Broadcast aman or long stem aman (B.Aman) requires both the kharif seasons to mature. Jute, vegetables and fruits are also grown during the kharif season.

Rabi is a short dry season which covers the period from November to February and is characterised by scanty or no rainfall, low temperatures and clear sky. "The crop environment during Rabi season is very favourable for higher yields per unit area because of high solar radiation, low humidity and wide variations in day and night temperatures, but lack of adequate soil moisture limits the cropped area Crops are restricted to areas where residual soil moisture is adequate or where irrigation is available" (MPO, 1985a). The number of crops grown during the Rabi (winter) season is large compared to the number grown during the Kharif season, but the cultivable area is small. Boro rice, wheat, potatoes, mustard, ground nuts, pulses, spices millets, vegetables, tobacco and melons are the main crops grown during the Rabi season. Sugarcane and orchards are periodical crops grown in both the Kharif and Rabi seasons.

2.5.9 Crops grown

Bangladesh is endowed with a climate favourable for the cultivation of a wide variety of both tropical and temperate crops. The field crops grown the country may be broadly classified into the following groups- cereals, millets, pulses, oil seeds, fibre crops, vegetables, fruits (seasonal and perennial), spices condiments.narcotics and beverage (Zaman,1984).

Although nearly 100 different kinds of crops are presently grown in Bangladesh, 32 crops cover about 96 percent of the total cropped area (BBS, 1986). MPO aggregated these 32 crops into 16 groups based on their similarity and importance for water resources planning. The area covered during 1987 -88 by different crops as multiple cropping are shown in the following table:

Table 2.5: Acreage under different crops and their relative position

Crop	Growing season	Cropped area in thousand ha	% of cropped area
L.AUS	KH-I	2291	16.57
HYV AUS	KH-I	498	3.60
L.T.AMAN	KH-II	3166	22.90
HYV TAMAN	KH-II	1198	8.67
B.AMAN	KH-I&II	1230	8.89
L.BORO	RABI	304	2.20
HYV BORO	RABI	1640	11.86
TOTAL RICE		(10327)	(74.70)
WHEAT	RABI	508	4.33
MILLET	RABI	112	0.81
TOTAL CEREAL		(11037)	(79.84)
PULSES	RABI	738	5.34
OIL SEEDS	RABI	547	3.39
JUTE	KH-I	513	3.71
COTTON	RABI	12	0.08
OTHER FIBRES	RABI	7	0.05
MAIZE	RABI	3	0.02
SPICES	RABI	143	1.03
SUGERCANE	YEAR ROUND	173	1.25
PALMS	YEAR ROUND	13	0.09
TEA	YEAR ROUND	47	0.34
TOBACCO	RABI	47	0.34
OTHER NARCOTICS	RABI	48	0.34
FRUITS	YEAR ROUND	165	1.99
VEGETABLES	YEAR ROUND	151	1.09
POTATO	RABI	123	0.89
SWEET POTATO	RABI	51	0.37
FODDER		7	0.05
OTHERS		1	-
TOTAL CROPPED AREA		13825	100.00
KHARIF			68.26
RABI			31.74

Source: Ministry of Agriculture, Crop Diversification Program Committee Report, 1989.

2.6 Conclusion

To protect the life and property of its inhabitants, flood control is indispensable for Bangladesh. But this demands significant resources and their careful planning. Although a relatively small country, and at first glance relatively uniform in characteristics, Bangladesh actually has a wide variety of conditions that present different needs and development opportunities. Many of the differences in elevation, soils, rainfall intensity, depth of flooding, environmental position and other factors make different regions suitable for particular types of development. For example, the hilly area of Chittagong is suitable for forestry and pineapple cultivation, whereas the saline coastal area of Khulna is suitable for shrimp culture. The soil and climate of Barind Tract make it unique for mango, lichi and melon where as rocky soil of Sylhet is well suited for tea and citrus fruits. Otherwise cropping practices are almost uniform throughout the country.

It is a difficult task for the planners to formulate plans for proper utilisation of the land, water and other scarce resources of the country . It is necessary to decide which sector should be expanded to what level and where, such that the cost of utilising scarce resources is minimised and uniform economic growth of the country is maintained. At the same time balanced regional development and minimum requirement of food, shelter and security against natural hazards of all the people is ensured. Different aid giving agencies and internationally reputed experts have unanimously indicated that flood control projects are to be taken and their costs are to be recovered from increased agricultural production.

CHAPTER III

LITERATURE REVIEW

3.1 Introduction

From the very earliest times, man has sought to reduce the damaging impacts of floods. With the advancement of science, complex technology and human understanding of floods have increased. Therefore, efforts to address the problem are quite diversified. A few of the related works have been listed in this chapter.

The aim of this chapter is to review the work on flood damage mitigation in Bangladesh and elsewhere, and on finding /predicting optimal land use patterns to suit a pre-determined objective function. Attention is given to the form of programming technique and the nature of objective function. Considering the applications of optimisation technique in agriculture, a few cases of optimal water pricing, irrigation and cropping pattern have been enumerated.

3.2 Classification of flood mitigation measures

Thampapillai et al. (1985), attempted to summarise the literature regarding decision frameworks for deriving flood mitigation from diversified sources such as public expenditure economics, management science, geography, agriculture and engineering. They classified flood mitigation measures into structural and non-structural varieties. Similarly the decision frameworks were classified into those dealing with (a) structural measures alone, (b) non-structural measures alone, and (c) structural and non-structural measures. Their classification is shown in Figure 3.1.

- FLOOD MITIGATION MEASURES
  - STRUCTURAL MEASURE
    - DAMS
    - RESERVOIRS
    - LEVEES
    - CHANNEL IMPROVEMENTS
    - FLOOD WAYS
  - NON-STRUCTURAL MEASURE
    - FLOOD WARNING AND EVACUATION
    - FLOOD PLAIN LAND USE
    - FLOOD PROOFING
    - FLOOD INSURANCE

Figure 3.1 Classification of flood mitigation measures

Source: Thampapillai et al. (1985)

3.3 Types of decision frameworks

Thampapillai, et al. were of the opinion that the adoption of flood mitigation measures creates economic benefits by reducing both the expected value of flood losses and the cost of risk taking. The maximisation of these economic benefits is the central objective underlying the strategies adopted for flood mitigation measures. The selection of techniques to evaluate the strategies depends mainly upon the nature of the problem and availability of pertinent data. The decision frameworks generally used in flood damage mitigation are summarised in Figure 3.2.

DECISION FRAMEWORK FOR FLOOD MITIGATION STRATEGIES

- Those Dealing with Structural Measures alone
  - minimise only Expected Value of Flood Losses
    - Discrete Enumeration of Costs and Benefits
    - Classical Optimisation
    - Linear Programming (& Related Techniques)
    - Dynamic Programming
  - minimise Expected Value of Flood Losses & Cost of Risk-taking
    - Stochastic Linear Programming & Reliability Programming
    - Simulation and Search
    - Stochastic Dynamic Programming
- Those Dealing with Non-structural Measure alone
  - minimise only Expected Value of Flood Losses
    - Discrete Enumeration of Costs and Benefits
    - Linear Programming and Related Techniques
    - Other Operations Research Techniques
  - minimise only Cost of Risk-taking
    - Simulation and Research
  - minimise Expected Value of Flod Losses and Cost of Risk-taking
    - Discrete Enumeration of Costs and Benefits
    - Quadratic Programming
- Those Dealing with Structural as well as Non-structural Measures
  - minimise only Expected Value of Flood Losses
    - Discrete Enumeration of Costs and Benefits
    - Linear Programming
    - Dynamic Programming
  - minimise Expected Value of Flood Losses and Cost of Risk-
    - Discrete Enumeration of Costs and Benefits
    - Classical Optimisation
    - Linear and Non-linear Programming

Figure 3.2 Types of decision frameworks for flood mitigation strategies

Source: Thampapillai et al. (1985)

3.4 Distribution of flood losses

According to Dudley (1973), flood losses are often assumed to be a random variable with a given distribution. The mean of this distribution, namely the expected value of flood losses, is assumed to be the losses due to flooding during a given time period. However, flood plain residents also take the risk of incurring losses other than those defined by the mean of the distribution. Further, if the adoption of flood mitigation alters the distribution of flood losses to reduce the expected value of such losses, then the cost of risk taking is reduced as well.

Structural measures alter the distribution function associated with flood losses to reduce both the expected value of flood losses and the cost of risk taking (that is the variance of flood losses). But the adoption of structural measures alone could lead to sub-optimal development of the flood plain. Therefore, the need to regulate flood plain development along with the adoption of structural measures is explicit. Such regulation may be achieved through certain non-structural measures like flood plain land use planning (Brown, 1972).

3.5 Non-structural measures

The various decision frameworks dealing with non-structural measures may be classified as those dealing with the minimisation of (a) the expected value of flood losses alone, (b) the cost of risk taking alone, and (c) the expected value of flood losses and the cost of risk taking together.

The decision frameworks of category (a) are used to formulate strategies in terms of flood plain land use, flood warning, and flood proofing. The objective function of these frameworks is either to minimise the expected value of flood losses or to maximise the expected net returns of production. The frameworks do not account for any properties of the distribution other than the mean.

The decision frameworks of this category could be further classified into three broad groups, namely those based on (i) discrete enumeration of costs and benefits, (ii) linear programming or related techniques, and (iii) other operations research techniques.

Flood insurance is the only flood mitigation measure/decision framework for the category (b).

The decision frameworks considered in the category (c) account for the mean as well as the variance of the distribution of flood losses. The variance is considered as a proxy for the cost of risk taking. The frameworks of this type observed in the literature may be classified into two broad groups, namely those based on (i) discrete enumeration of costs and benefits and (ii) quadratic programming and related procedures.

The frameworks based on discrete enumeration of costs and benefits are used to evaluate the economic efficiency of either a single non-structural strategy or a discrete set of strategies. The evaluation of the former involves absolute desirability while the latter involves relative desirability. In this approach expected cost is compared to the value of prescribed benefits and the lowest cost option is generally selected for implementation. The evaluation of economic efficiency rests on the computation of criteria such as net present value, benefit-cost ratio, or internal rate of return. Some literature of this type may be found in Sheaffer, 1960 and Chow,1964.

The major demerit of this approach is that generally one or two designs are selected and their expected costs as per pre-specified management strategies are compared with some pre-determined benefits. In reality the pre-specified strategies or benefits may not coincide with the optimum. In most of the cases, actual execution costs may overrun the estimates and the assumed operation level may not be achieved. As a result, the benefit component may fall short.

3.6 Flood plain land use planning

James (1971) stated that flood plain land use planning involves the derivation of a pattern of development on the flood plain in order to reduce the expected values of flood losses and the cost of risk taking. Such planning involves an analysis of various land use options on the flood plain. This analysis is often facilitated by the classification of the flood plain into various zones based on the frequency and severity of flooding. In his article, the term flood plain zoning was often used interchangeably with flood plain land use planning.

Brown(1972) worked on an optimal replacement strategy for flood plain capital which deteriorates rapidly because of floods. The outcome was a set of land use decisions which maximise expected economic return. This framework for optimal replacement of flood plain capital may be incorporated into an overall analysis of land use decisions based on mathematical programming with some modification. The framework is of the nature of replacement, not improvement, which might be given more weight by the decision makers.

3.7 Operations research

Day (1973) demonstrated the use of operations research in flood plain land use planning. His framework permits both the derivation of optimal land use decisions and optimal flood proofing decisions. The activities represent various land uses under different combinations of land type, geographic location, site elevation, and flood proofing. The framework seeks to maximise a stream of expected economic rents subject to various land resource and population constraints. The recursive nature of the framework permits the derivation of optimal decisions, spatially and inter temporally. The framework could be applied empirically if proper estimation for nonlinearity is made.

Hardaker, et al. (1979) criticised the above approach by noting that applications for the situations described above became restrictive when the relationships between the various land use and other options are non-linear.

A framework for estimating means and variances of net benefits from a discrete set of flood proofing decisions was presented by Willis, et al. (1974). The objective function was stated as

$$\text{maximise } W = \Sigma b1E - b2V$$

Where W is a measure of net benefits, E is expected net benefits, V is variance of net benefits, and b1 and b2 are weights which transform expected value and variance to the same dimension.

3.8 Linear programming in Indo-Pak subcontinent

The use of linear programming in agricultural research in developing countries, especially in the Indo-Pak subcontinent, is increasing rapidly. Linear programming in its different forms has been successfully adopted to find out the optimal crop mix under different constraints of land type, water shortage, seasonality and irrigation techniques. The applications developed for evaluating irrigation techniques or finding the optimal crop mix can successfully be utilised in decision making in flood mitigation as long as decision makers can accept the form of the objective function, the assumption of linearity used by the model, and the number and type of flood protection alternatives that the model can represent.

3.8.1 Linear programming used for optimal water use

Chaudhry and Young (1989) formulated linear programming models of a representative farm in a district of Pakistan's Panjab province for the purpose of estimating the value of irrigation water. The models provided for choices among several irrigation levels for each potential crop. Solutions of the model for several water supply situations provided the basis for approximating the total, average, and marginal values of irrigation water. The models were used to justify the public investments in water saving or water augmenting technologies by comparing the incremental returns obtained by adding water to the available water supply.

The measurement of willingness to pay for an incremental benefit is most frequently achieved by residual imputation (Young and Gray, 1985). The method allocates the total value of output among each of the resources used in production process. Under certain reasonably plausible assumptions (production functions homogeneous of the first degree, competitive resource market, prices of inputs constant and self interested resource allocation by producers) resources paid according to their marginal value productivities will result in complete exhaustion of total product (Eulers Theorem). If appropriate prices can be assigned to all inputs but one and if all input quantities are known, the residual of the total value of the product is imputed to the remaining resource. That is -

$$Xn * PXn = \sum_{j=1}^{m} Yj * PYj - \sum_{i=1}^{n-1} Xi * PXi$$

Where Xi (i = 1,2,3,.......n) refers to quantity of input i and Yj (j = 1,2,3,....m) is quantity of product j and PYi and PXi are prices of products and inputs.

Chaudhry and Young used the above methodology denoting water input as Xn and solved the equation for PXn, the imputed value or (shadow price) per unit of irrigation water.

Following a similar methodology, economic models to justify the public investment for flood control in Bangladesh might be formulated. A farmer's decision making model in a representative farm under domestic input and product prices will reflect the actual financial measure of the flood control project. This can be transformed into an economic model for a region, from which the derived demand for flood protection can be estimated.

The problems associated with conversion of farm models into sector modesl is the main hindrance to be sorted out before embarking on this type of approach.According to Hazel and Norton (1986) aggregation bias arises because all farms are not alike.

Bhargava, et al. (1985) utilised a linear programming technique in a study of Gandak Command Area in Uttar Pradesh in India for optimisation of water use and maximisation of benefits to farmers. The area is irrigated through a canal irrigation system diverting water from the river Gandak. The problem was water logging in the project area from the seepage of the surface irrigation. The study aimed at finding appropriate corrective measures which could be adopted in the command area so as to lower the water table in water logged pockets and to suggest an optimal cropping pattern keeping in view the available surplus water potential.

Three alternative measures could have been applied for the remedy of the problem. a) drainage improvement, b) pumping through shallow tube wells, augmentation tube wells and such other means, and c) optimal cropping pattern. To get the best results, keeping the socio-economic upliftment of the economically backward region in view, they argued that the most beneficial arrangement would be to utilise the maximum water storage available by changing over to a more profitable cropping pattern.

A field survey of the area was conducted to assure the cost of inputs, outputs and various constraints. The optimal cropping pattern was thereafter developed with the help of linear programming and the benefit of the farmers were optimised.

The problem of maximising the net benefit of the cultivators could be mathematically expressed as:

$$\text{MAX. } Z = \sum_{j=1}^{n} (Aj\ Yj\ Cj - Aj \sum_{i=1}^{m} Iij\ Cij\ )$$

where Z is the net benefit from command area, n is the number of crops considered, Aj is the area under jth crop, Yj is the yield potential per unit area of jth crop, Cj is the per unit price of the jth crop, Iij is the i input required per unit area of jth crop and Cij is the cost of input per unit area of jth crop.

The optimisation of net returns was subject to the following set of constraints:

i) the total quantity of water Qk available for irrigation in kth month was pre-determined value,

ii) the total area available for agriculture in any month was 0.52 million hectares. The constraint was mathematically expressed as:

$$\sum_{j=1}^{n} Aj\ qk <= Qk$$

and

$$\sum_{j=1}^{m} Aj <= A$$

where qk is the quantity of water required per unit area for irrigating jth crop in the kth month, A is the total area available for agriculture (0.52 million hectares) and m and n are the number of months and crops considered for the study.

Singh and Sirohi (1976) developed a linear programming model for optimal allocation of canal and tube well water among crop areas. The developed model has been applied for the command area of "Upper Ganga Canal". The objective function of the model was to maximise the net economic return subject to the canal and tube well water supply constraints, water budget constraints, canal capacity constraints, land, fertiliser and cropped area constraints. The results from the model indicated that the total cropped area increased considerably and the total returns in the optimal plan increased by 24 percent over the existing plan in the canal command area.

Kumar and Khepar (1980) conducted a study to demonstrate the usefulness of alternative levels of water use over the fixed yield approach when there was a constraint on water. The water production functions used in this study were square root and quadratic type. The model with alternative levels of water use was linear except the objective function which was separable into a sum of convex functions of individual variables. The objective function of the model was to maximise the annual net returns subject to the constraints on availability of water and other inputs. The models considering fixed yields and alternative levels of water use were applied on a selected canal command area (Kotkapura distributary, Ferozpur district, Panjab) having a discharge of 45 litres per second to determine the optimal cropping patterns. The conclusion of the study was that alternative levels of water use was superior to fixed yields for optimal utilisation of land and water resources.

Kumar, et al. (1982) analysed the problems associated with Gandak Command Area. They developed a linear programming model to maximise the benefits of the farmers with the consideration of the constraints due to the demand of existing sugar industries in the study area, availability of water and the needs of the people.

3.8.2 Linear programming used for cropping pattern

Sarker and Maji (1976) attempted a study to develop an optimal drainage program and a cropping pattern consistent with the most efficient use of available resources through the application of linear programming for an existing canal irrigation system in India. The objective of the model developed by them was to maximise the net economic return subject to the area, canal capacity, reservoir capacity and resources availability constraints.

Singh, et al. (1976) developed a linear programming model which was used as an analytical tool to determine optimal area under different rabi season crops at Hariana Agricultural University Farm, India to maximise the net profit on a command area of 70 hectares for a canal outlet having discharge of 1.19 cubic feet per second. The mathematical statement of the model was written as:

$$\text{Max. } Z = \sum_{j=1}^{k} Cj * Xj$$

subject to

$$\sum_{j=1}^{k} Aij * Xj <= Bi \; ; \quad i = 1,2,3...$$

$$Xj >= 0 \; ; \qquad j = 1,2,3....$$

where Z = the total net profit, Cj = net profit from an unit of jth activity, Xj = the level of jth activity, Aij = the amount of ith input required per unit of jth activity, and Bi = the quantity of ith available resources. The analysis of the result indicated that an area of 30.3 ha, 21.3 ha and 16.7 ha under wheat, gram and lentil respectively, gave a maximum profit of Rs. 114053.60.

Saksena and Chandra (1978) conducted a study for the development of an optimal cropping pattern in the command area of "Upper Ganga Canal" along with planned conjunctive use of surface and ground water. They formulated a linear programming model to maximise the annual aggregate benefits subject to the cropped area constraints, reservoir and tube well capacity constraints and resources availability constraints. The model was solved for ten crops and four decision variables. The result of the study indicated that to increase the irrigation intensity to its ultimate value (200 percent) more surface water would be needed in the command area. The study also demonstrated that to increase the agricultural production and to avoid water logging and salinity problems conjunctive planning of surface and ground water should be done.

3.9 Use of linear programming in Bangladesh

In Bangladesh, the optimisation technique has not been widely used in flood protection. A few instances are available where it has been utilised to optimise the water use in irrigation projects. Very scanty research reports have been published for the situation of Bangladesh. Some of those are presented below.

Smith (1973) performed a system analysis in a situation where there was conflict between the aggregate consumption and the food grain self-sufficiency objectives. He developed a linear programming model, consisting of the water balance of generalised irrigation system, to maximise the present value of additional aggregate consumption benefits of the project. The model was applied for an irrigation project in Bangladesh, where an aquifer of high potential underlies the project area and ground water exploitation to supplement the surface water was possible, to determine the project configuration that maximises net benefits.

Elias (1977) presented a paper in which he developed a multi period linear programming model especially for a project where the facility of irrigation in dry season and drainage and flood control in wet season is available. This model can be used to select a cropping pattern for a project command area. The objective of the model was the maximisation of the net return from the command area under the constraints of limited availability of resources. The model was empirically tested on the Dhaka-Narayanganj-Demra (DND) irrigation project in Bangladesh. The model decided the optimal cropping pattern which would give maximum return under limited land, water, labour and nitrogen availability and also decided the optimal number of pumps required to drain out excess rain water during wet season.

Bari (1985) developed a mathematical modeling approach to determine optimal cropping pattern suitable for the situation where both land and irrigation water are scarce resources. The objective function of the formulated model was to maximise the net economic return from cropping activity. The model was solved using available data for Bangladesh. The output of the model solution included cropping pattern, allocation of irrigation water by month and by crops, yield of crops, etc. The sensitivity analysis of the model was done by parametric linear programming.

More recently, Akhanda (1988) developed a mathematical model using an optimisation technique to find the optimal command area of a Flood Control and Irrigation Project (Teesta Barrage Project). On the basis of a certain probability of flow in the river Teesta and water requirement for a particular variety of rice in a particular growing season, optimal acreage of that variety of rice in the project area was calculated. Assuming the yield is directly related to the application of water, maximum expected yield of that variety of rice from the project area was determined.

To this application a simple static linear programming model was developed. A probabilistic description would have been more useful in making the best use of measurements in prediction. For the forecast of dependable river flows and expected yield, a probabilistic risk model or quadratic programming would suit the problem better.

3.10 Scope of this study

This dissertation is confined to non-structural flood mitigation techniques which deal with expected value of flood losses alone. A decision framework, with an objective function which maximises expected net returns from flood plain land use is proposed. Initially, a representative farm case is modeled. This model is next varied to suit different farm types and flood depths. Finally, the models are varied parametrically to test alternative scenarios and validate the model results.

3.11 Conclusion

The analytical methods applied in the above studies can be extended to analyse farm production activities over a larger area. Like many other developing countries, the agricultural sector of Bangladesh is characterised by a weak and confusing data base. Data published by one organisation conflicts with others. Moreover, knowledge about the existence of the various simultaneously interacting factors is inadequate. This situation (data uncertainty, information gaps and factor complexities) would altogether make the use of most of the sophisticated techniques difficult, as it will be difficult to build models that are truly representative of the typical farming system of Bangladesh.

In consequence, the situation warrants creating or devising methods that will take proper account of the problem of poor data (quality as well as quantity) and the complex interaction of various factors, such technological interactions, natural hazards, Government interventions, policy implications, etc.

It is therefore, important that the farming process be represented in terms of a model that is flexible and powerful enough to accommodate data and information gaps which exists in Bangladesh.

CHAPTER IV

METHOD

4.1 Introduction

Scarce agricultural resources in Bangladesh could be more profitably utilised through economic analysis to support the decision making processes. The economic analysis of agricultural resources, in a narrow sense, means the quantitative specification and description of some agricultural system or sub-system and the use of specification to study interactions within the system. Selection of a method which will be as problem specific as possible and yet abstract from real farm conditions is a great task. The applicability of the study will depend on the selection of appropriate methodology. As indicated in Chapter III, the method used in this dissertation is mathematical programming.

Mathematical programming is a technique designed to reveal the optimum allocation of resources with in a process, a firm or even an industry. Programming models provide normative estimates of the best plan or policy to be followed.

In more abstract language, mathematical programming is the systematic examination of a number of feasible alternatives in order to find the optimum. The alternative forms that the solution can take (or basic feasible schemes) are not specified in advance, but the conditions which each alternative must meet are defined properly at the beginning of the programming. The conditions or constraints as they are usually called, are independent of one another and must all be satisfied. But 'satisfying' of constraint does not require that they all be fulfilled exactly, but merely that the constraints not be exceeded. The economic significance of this is that only some of the resources are in limited supply and will bind the solution. Excess capacity or unutilised inputs can exist.

In addition to the attribute that the constraints do not have to be met exactly, the technique is chiefly characterised by its ability to optimise. The solution that is generated is the best that is obtainable.

Margaret (1984) categorised mathematical programming (i) by the functions (simulation, optimisation, forecasting, evaluation, scheduling) or (ii) by the mathematical technique involved (linear programming, dynamic programming, etc.).

Simulation models describe the operation of a system. The input variables follow pre-determined (deterministic) values or stochastic (random synthetic) values. The model evaluates system output based on these inputs.

Optimisation models maximise or minimise an objective function, such as net revenue, production costs, etc.

Perkins (1979) divides optimisation techniques into four types:

a) Linear programming, where the objective function and all constraints can be expressed by linear algebraic equations with known constant coefficients.

b) Integer programming, in which the objective function and constraint equations are linear but the decision variables take only integer values (like yes or no).

c) Non-linear programming, in which the objective function or a constraint equation involves non-linear terms.

d) Dynamic programming, in which the decision variables have a sequential character. Such problems are represented as a sequence of steps, with decision required at each step, and the decision at one step directly affecting only the next step, for example in reservoir operation.

4.2 Development of linear programming

"Linear programming is a universally accepted term and connotes exactly the same model and approach in all countries." (Heady, 1971).

In its simplest form, linear programming is a method of determining a profit maximising combination of farm activities. Early applications of linear programming in farm planning assumed profit maximising behavior, a single period planning horizon (no growth), and a certain environment (no uncertainty about prices, yields and so forth). But there have been many subsequent improvements that permit the construction of more flexible models with linear programming (Hazel, 1986).

Despite the analytical limitations of linear programming, these have been used widely by research personnel. Although they may be ill-adapted for developing empirical generalisations, because of their synthetic power, they appear well adopted for problems of the planning consultants (Baker, 1971).

4.3 Solving procedure of linear programming

Within the theory of linear optimisation, the simplex algorithm has become the most common calculation procedure. The application of the standard linear programming model is based on the same assumptions as the linear production model: (a) all production functions are linear, and (b) all goods and all factors are infinitely divisible, or at least the inputs gained from the factors are infinitely divisible.

The basic principle of parametric programming as mentioned by Heady (1958) is : each unit of the resource being varied must be invested where its marginal return is highest. It is necessary to enumerate the marginal productivity of the varying resource for each possible activities. This is done by dividing the negative values of the marginal revenue (z - c) by the appropriate input output co-efficient of the varying resource; which transforms the marginal revenue (z - c) from a "per unit of the activity" to a "per unit of the resource" basis.

4.4 Different approaches of linear programming

4.4.1 Parametric programming

Parmatric linear programming is a technique that allows a series of optimum plans to be produced for differing levels of any parameter of the problem. Such parameters may be product prices, variable factor costs, crop yields, supplies of fixed factors or the requirement per unit of any crop for any fixed factor (Rae, 1977).

If we wished to determine profit maximising farm plans for a number of holdings in the same region that differed from one another only in land area and size of the labour force, a series of optimum farm plans could be derived for different supply levels of each fixed factor. A management plan could than be recommended for individual holdings on the basis of their supplies of these factor of production. In this dissertation, four classes of farmers with different levels of land, labour, capital and draft power in a particular project area are considered.

The graph of any output against a function of that output (say price) can be considered as supply function as it indicates how output of this crop should be adjusted to changes in its price per unit output. Similarly the graph of value of the marginal products (VMPs) against the supply of any input may be interpreted as the derived demand function for this input since it indicates the quantity that should be purchased at various factor prices.

The fact that parametric LP can be used to derive product supply and factor demand functions, makes the technique extremely valuable as a research tool (Rae, 1977). The stepped functions can be considered as an approximation to the smoothly curved supply or demand functions commonly found in economic text books. Its stepped appearance results because the LP method represents the smooth production possibility boundary of economic theory by a series of linear segments.

4.4.2 Inter-temporal programming (dynamic programming)

Inter-temporal problems are those concerned with the allocation of resources, such as available funds, over several periods of time. The basic matrix for the inter-temporal linear programming is similar to a block-diagonal matrix, with resources and activities repeated for each year of the development period to form a sub-matrix. The sub-matrices are somewhat similar, but not identical. Activities of one year may also require resources in later years. The sub-matrices representing one year are disposed diagonally in the final matrix and linked together by investment and borrowing activities.

The technique is commonly used to obtain solutions to capital budgeting, farm development problems include computing the present value of the expected flow of future net returns, the internal rate of return from that flow, or the minimum payback period for the relevant investment alternatives (Gunn, et al., 1967).

Rae, (1968) developed an inter-temporal model in which the farm firm's overall objective function to be maximised was a weighted sum of net tax-free cash available to the firm at the end of the planning period and the value of assets owned by the firm at the end of the planning period.
Another attempt to make inter-temporal programming models more closely related to real-life situations include the treatment of indivisibilities in investment opportunities as integer programming problems,and the incorporation of price and cost variabilities into a quadratic capital budgeting program (Colyer, 1968).

4.4.3 Integer programming

The integer programming is a modified version of the simplex method. The basic approach common to most method is the introduction of new constraints which satisfy the integer requirements. There are mainly three ways (a) The cutting plane method, (b) The branch and bound method starting from a non integer optimal solution, and (c) The branch and bound method starting with an integer variable inside the polyhedron.

4.4.4 Recursive programming

Recursive programming is applied to growth problems. It can be defined as a sequence of mathematical programming in which the parameters of a given problem are functionally related to the optimal variables of preceding problems of the sequences. Unlike the multi period model, it uses sequential optimising to explain behavior and does not attempt to devise optimal decision rules which leads to optimal policies over the time period considered. These features make it applicable to describe an actual growth path rather than to show an optimal path. The growth path is described under the assumption of a given and defined behavior which deviates from the assumption of "classical decision models" mainly in the following points : (a) Investment and borrowing activities and sometimes the changes of output between periods underlie certain behavior restrictions, (b) Farmers decide on investments according to the assumptions of the static theory.

4.4.5 Goal programming

Traditional decision making technique, such as linear programming can only optimise one criterion. But in many situations goals of managers are likely to be many and complex, and perhaps conflicting. Multiple objectives of the farmers may be i) maximisation of profits, minimisation of risk, minimisation of hired labour, satisfaction of certain level leisure,etc. The goal programming technique form of linear programming has been developed for multi objective decision making. Boehlje and White, (1969) described the application of traditional linear programming to the problem of achieving multiple goals when a preferred goal was subject to specified constraints. However, goal programming allows one to consider multiple goals and to eliminate the infeasible solutions often obtained through linear programming.

In a goal programming objective function, one seeks to minimise the deviation from the goals. Goal programming requires only striving to obtain the goal (that is "satisfying"), not constraining the solution to the achievement of the goal. The goal programming objective function may be described as following :

$$\min Z = W_i^{+} Y_i^{+} + W_i^{-} Y_i^{-}$$

where Y_i^{+} is the deviation above (over achievement of) the ith specified goal level and Y_i^{-} is the deviation bellow (under achievement of) the ith specified goal level for each goal. The W_i^{+} and W_i^{-} are penalties or weights attached to the goal deviation. The goal weights and / or the target levels may be used to rank the goals according to the relative importance of each goals.

4.4.6 Risk programming (MOTAD)

Linear programming is widely recognised as a method for determining a profit maximisation combination for farm enterprises that is feasible with respect to linear fixed farm constraint. The conventional program is -

find $X >= 0$ such that $AX <= b$ and such that $cX = Z$ is a maximum (or minimum).

Where we know A, b and c for certain. In other words that all data (resource supplies, input-output coefficients, prices, costs and yields) must be known certainly. But uncertainties arise in activity costs, yields and prices that affect the objective function of the conventional linear programming models.

Simplest risk programs are those where only elements of c are random variables. One way of thinking about risk is to minimise the variance of the expected total gross margin. The expression of variance is a quadratic function of X so it requires a quadratic programming (Rae, 1990).

The expected gross margin - variance (E - V) criterion of quadratic programming assumes that (i) a farmer holds preferences among alternative farm plans solely on the basis of their expected income E and associated income variance V. This will be true if the farmer has an E - V utility function. Quadratic programming further assumes that (ii) the iso-utility curves are convex that is the farmer is a risk averter (along the iso-utility curves $dE/dV > 0$ the farmer would prefer a strategy with higher V only if E were also greater and $dE^2/dV^2 > 0$ the compensation must increase at an increasingly rate with the increase in V); (iii) income distributions are normally distributed (Hazel, 1979).

Given these assumptions, a farmer rationally should restrict his choice among those farm plans for which the associated income variances are minimum for the given expected income levels. Since short-run planning models assume farm overhead costs to be constant for the length of the planning horizon, the income distribution of a farm plan is totally specified by the total gross margin distribution.

Another way of measuring risk is the absolute deviations which is an alternative measure of the spread of the gross margin. Hazel (1979) developed a model which can be solved on conventional LP codes with the parametric options and provides a set of farm plans that are efficient for expected income and mean absolute income deviation. Since the model minimises the total absolute deviations he termed it as minimisation of Total Absolute Deviations (MOTAD).

4.5 Demerits of linear programming

The shortcomings of the linear model with respect to production techniques in agriculture are due to the fact that these assumptions are not always in accordance with reality. Because (a) production functions are non-linear in many cases, and (b) many factors and products cannot be divided infinitely.

The non-linear production function can be approximated by a number of activities of which each represents a point on the function. There are many possibilities of solving the problem of linear approximation. The reason for the limited application of non-linear programming methods in agriculture seems to be the following : (a) size of the problem (b) non availability of appropriate computer software.

4.6 Estimating model coefficients

Selection of representative farms, which are specific to the production possibilities and resource availability, is governed by the size and type of the cultivable land. Crop types suitable for the land depend upon the level of flood depth in that area. Resource endowments possessed by the farmer as well as those that can be captured by the farmer through different institutional arrangements (such as hiring land, labour, capital, etc.) become important elements of the model. After implementation of the project, production options of the farmers increase. Different crop varieties require different levels of resources like land (growing period), fertiliser, pesticide, manpower and provide different level of net returns. Above all, the main consideration of decision making for the farmers which is addressed in the model is the cost of production. The cost components may include :

- value of hired labour (supply of own and hired labour is considered in resource availability),
- value of bullock power, own and hired (supply of own and hired bullock is considered in resource availability),
- hired machinery charges,
- value of seeds, both purchased and home produced
- value of manures, both owned and purchased
- value of fertilisers (types of fertiliser required is considered in resource supply),
- value of insecticides and pesticides,
- irrigation charges, both hired and owned,
- land revenue and taxes,
- interest on working capital.

A questionnaire for data collection was designed to capture this farm production information. Data from the questionnaire was used to estimate the model coefficients such that these represent the real situation and reflect any changes that occur in without and with the project.

4.7 Conclusion

The challenge is to specify or formulate the model in a manner which is consistent with the planning environment and market conditions surrounding agriculture. In most empirical situations, it would be intolerably expensive and time consuming to estimate a model for each farm in a region and then to derive a regional model by summing the individual farm models. Therefore, the usual simplifying procedure is to construct a model for a small number of representative farms, each supposed to be characteristic of a large group of farms in the region. Each representative farm model is then weighted by the number of farms in its stratum, and the weighted models are then summed up to estimate the regional conditions (Flinn,1969)

A mathematical programming approach is appropriate and suitable in that:

i) it can handle a large number of variables of complex interdependence;

ii) the objective function (e.g. maximisation of net return of the farmers) can measure the achievement of the study;

iii) the model is capable of identifying an optimal strategy for allocation of resources in crop production.

CHAPTER V

FORMULATION OF THE MODEL

5.1 Introduction

In this chapter, the formulation of a linear programming model to maximise net returns from a typical farm is described.

The model analyses farm production plans for a representative flood plain - the Meghna Dhonagoda Irrigation Project. The objective is to explore the economic possibilities of integrating dry land and irrigated crops in a flood protected situation. Detailed budgets for representative farms are used to estimate coefficients for the models. The technically feasible farm plans are then examined parametrically to ascertain the degree of sensitivity of the plans to changes in commodity prices (paddy, wheat,pulse, potato, etc.) and changes in technical efficiency levels under irrigated agriculture.

5.2 Choice of the method

A number of methods could have been used to calculate the optimal crop mix to obtain utilisation of the flood protected area for maximum net revenue. These range from parametric budgeting to more sophisticated tools such as integer programming and Monte Carlo simulation. With the constraints of time and funds allocated to this study, and the purpose of the modeling, parametric (linear) programming is the best method.

Since the study addresses modal groups of farmers rather than a particular individual farm, results obtained serve as a pointer in the right direction for policy, rather than offering a solution to a specific individual farm. But, by using partial budgeting, the results for the modal groups could also be easily retailored for an individual farm.

The model is an equilibrium model for a representative farm for one year. The farmer begins the year with the savings of the previous year and operates farming as a profit - maximising business, keeping in view family requirements. Land, water, labour and capital constraints, as well as price and yield of individual crops, are parametrically varied to investigate in a continuous fashion the optimal farm plans relevant to various combinations of these constraints and variables.

5.3 Steps taken in formulation

The basic principle of parametric programming as mentioned by Heady (1958) is: each unit of the resource being varied must be invested where its marginal return is highest. It is necessary to enumerate the marginal productivity of the varying resource for each possible activities. This is done by dividing the negative values of the marginal revenue (z - c) by the appropriate input output coefficient of the varying resource; which transforms the marginal revenue (z - c) from a "per unit of the activity" to a "per unit of the resource" basis.

The scientific approach to the development of a parametric model as described by Kitanidis (1987) is a three-step procedure:

a) Selection of a parametric model for the means and covariance as deemed necessary after preliminary examination of the data.

b) Estimation of the parameters conditional on the validity of the model.

c) Confrontation of the model with the data. This procedure may lead to modification and/or scrutiny of the data.

The first two steps were completed using annualised secondary data taken from published / unpublished reports and the third step was taken after collection of field data from the field.

5.4 Considerations

The availability of labour, equipment, capital, quality seeds, fertiliser,etc. are the main considerations before formulating a model. For simplicity, all inputs other than land, labour, capital,draft power and water are assumed to be available in adequate quantities when required. It is also considered that the relative prices of the inputs and technology remains constant.

The main interest is in the structure and sensitivity of the plans other than the income levels which will be achieved after implementation of the plans. So farm fixed costs, interest of property investment, management charges, etc. are considered constant and met from the family expenses. Annual payments of different loan or mortgages have been assumed and accounted for in the model. Capital available for agricultural investment is the remaining balance after deduction of subsistence allowance from the last years return.

In order to understand why farmers plant different crops one would have to calculate net returns for different cropping patterns and to take account of the agro-ecological constraints under which farmers operate. On the basis of flood depth the land area is classified in to F0 (no flood), F1 (shallow flood), F2 (medium flood) and F3 (deep flood) groups.

The net return per ha. for each land type was calculated by multiplying a cropping pattern vector showing the proportion of the area under each crop by the budget for each crop. Once this was done for each land type it was possible to estimate the annual value added per hectare by a protection programme.

5.5. Objective function

The objective is to maximise the annual net revenue (year ending savings) considering crop returns and associated costs. Mathematically it can be written as:

$$R = \sum_{j=1}^{m} C_j X_j \qquad (5.1)$$

where C_j = the per unit net revenue

X_j = the jth activity that is, production of jth crop.

Assuming that C_j is independent of X_j, that is the production volume does not influence the per unit net revenue, then the objective function is linear. If C_j becomes a function of X_j then the objective function becomes a quadratic form.

For consideration of the problem in linear form, price and yield are assumed constant initially. Equation 5.1 is maximised subject to a series of constraints:

$$\sum_{i=1}^{z} A_{ij} X_j <= b_i \qquad (i= 1,2,......,z\ ) \qquad (5.2)$$

where A_{ij} = the input output coefficients, the amount of ith resource required for production of one unit of jth activity.

b_i = is the total available resource of the type i.

Another way of expressing the relationship is

$$\text{Max } Z = \sum_{i=1}^{n} (Yi * Pyi) - P_{xi} \quad Ai \qquad (5.3)$$

where
- i = each crop
- Y = average per unit yield
- Py = output price
- Px = input price
- A = acreage

such that

$$\sum_{i=1}^{n} A_i \leq A$$

where A is the total land available

and

$$\sum_{i=1}^{n} Pxi \leq F$$

where F is the saving plus borrowing and Y, Py, Px ≥ 0.

Again we can accommodate hired land available to the farmer into the model by developing a relationship like

AL = Ao + Ah, where Ao is own land and Ah is the hired land.

5.5.1 Components of the objective function

The objective function is split into three components: yield, price and production cost. This is done to have a more complete parametric sensitivity. The constraints of land, labour,draft power, capital and water can be managed by the farmer or in other words are deterministic constraints. On the other hand, yield, price and production costs are not under the control of the farmer. Because these are influenced by the market, weather, government interventions, policy, etc, these are stochastic constraints. To maintain the linearity of the model, these stochastic constraints are kept constant over the plan period.

By structuring combinations of transfer rows and production and selling activities into the model, the price of the product was made explicit in the objective function. The yield and price of the crop enter into the model as return row and selling activity respectively, showing objective function coefficients of all activities as zero except the year ending saving activity.

5.5.2 Merits of split in objective function

Since much of the region of Bangladesh is subjected to periodic inundation, supply of irrigation water/development of those areas through irrigation is dependent on flood control measures. To account for differences in development costs, the region is subdivided into subareas according to depth of flooding. With each subarea, there is associated a cost of flood protection which is different from subarea to subarea. In addition to that, there is some initial cost associated with irrigation development. A proportion of these initial development expenditures might be charged on the farmers as a development tax per hectare. This tax will cause the cost component to fluctuate even if technology and proportion of input use is constant. To have an idea of the extent of fluctuation in the production cost, the objective function is split. A split objective function will also make the model flexible enough to be used in all flood control regions.

5.6 Overview of major constraints

Factor substitution possibilities are commonly incorporated in models through alternative mechanisation options. The relationship between the yield or productivity of a crop and the rate of application of an input sometimes become very important for policy formulation. The level of production activity and the input can be jointly determined. This considerably enhances the ability of a model to adjust realistically to changes in relative price. Incorporating factor substitution possibilities into linear programming models usually renders the model much more flexible when solving for different prices or factor supplies (Hazel & Norton 1986). Hazel & Norton describe in detail methods of factor substitution and incorporation of concave input output relationship in farm model.

The effect of continuous rice cropping on soil structure is not known clearly, but it seems reasonable to assume that some crop rotations will be necessary in the long run. Thus a group of plans showing the optimal combination of other crops over a range of rice price may be formulated by parametric considerations.

The requirement of water for a crop varies with season, time of sowing/planting, texture and structure of the soil, fertility level of the land and the crop variety grown.

The components of water requirement for rice are evapotranspiration, seepage and percolation and surface drainage. Water is also required for land preparation. In a research conducted at Bangladesh University of Engineering and Technology (BUET), Dhaka it was found that rice field requires about 100 - 150 millimetre of water for land preparation and paddling operations (Khan, 1979).

Evapotranspiration of specific crop is determined from

ETcrop = Kc * ETr

where ETcrop = evapotranspiration of a specific crop grown in large fields under optimal soil water and land fertility conditions.

Kc = crop coefficient. Kc in a specified climatic condition varies with the development stages of the crop. The values of Kc for different crops grown in different area of the world have been calculated by FAO as well as different Agricultural Research Stations of that area. Crop coefficients for different crops grown in different areas of Bangladesh can be calculated from FAO irrigation and Drainage Paper No. 24.

ETr = Reference crop potential evapotranspiration. Saleh (1981) calculated potential evapotranspiration of a reference crop on mean monthly basis on a particular area of Bangladesh.

On consideration of the different results obtained by different research organisations of Bangladesh, crop water requirement for different crops considered in this study was calculated by using the above formula and adjusted with the findings of MPO and other organisations.

As the project authority is not constraining irrigation water supply, a water constraint is not applicable in Meghna Dhonagoda Irrigation Project.

MODEL MATRIX OF THE MODEL USED FOR THE STUDY

5.7 Assumptions of the matrix

Following assumptions were made for development of the initial model:

a) Al is the area sown to the lth crop, in hectares. This implies that the cropping pattern is selected by the program. Initially, an average farm of 1 hectare is considered.

Later on this is varied from a minimum to maximum observed value.

b) One family labourer can work in the field for a full year.

c) The farmer can hire labour at peak period of planting Kharif II crops or harvesting Kharif I crops (during the months of June-August) at a daily wage of Tk.'30'.

d) The farmer has an annual net income of Tk. 12,000.00 which he can explicitly invest in agriculture.

e) He can borrow an additional amount of Tk. 5,000.00 at the beginning of each season from the bank at an annual interest of 10 percent which would be repaid with interest at the end of the season.

f) He has one pair of bullocks but there is no facility of hiring bullock power, except for the smallest group.

g) He can use his 1/2 cusec capacity pump for 10 hours per day for 20 days in peak period of land preparation. This gives approximately 10,000 cubic millimetres of water to the field. He can use it in six similar occasions in a year. That is, 60,000 cubic millimetres of water is available to him in an average year. We can assume that in Kharif I and Kharif II seasons he uses about 50 percent of the facilities and remaining 50 percent is used in the Rabi (dry winter) season.

h) In a year he can use his land for single, double or triple cropping. There are Kharif I, Kharif II and Rabi seasons in a year. But summation of growing period in one field should not exceed 360 days.

i) For his subsistence of the family and feed of the livestock he has to grow minimum 4 tonnes of rice in his field which will vary in different classes of farmers.

5.8 The matrix:

A conventional linear programming model consisting of 30 activities and 28 constraints was drawn up (Table 5.1). The input-output coefficients for the matrix are denoted by a,b,c,d,e,which are assumed to be the same through out the year for convenience. The others, denoted by f,g,h,i,j and k, are assumed to take different values for different crops and periods 1,2 and 3. Negative coefficients indicate supply of and positive coefficients indicate the demand for the resources.

The choice of activities closely adhered to the information available in the project area. Only those crops which come into the farming practice were considered. Some domestic economic activities like rearing small poultry and cattle for own consumption were not included in the activities.

The criteria for considering two processes of production as two separate activities are -

(i) produce different products,

(ii) use different resources,

(iii) require different proportions of the same resources to produce the same product, or

iv) use the same resources in same proportions, but produce products in different proportions. (Rae, A.N 1990)

Key: HL = hiring land, HB = hiring labor, OF = off farm activities, BO = borrowing capital, IN = investment of capital in other than agriculture, PC = production crop of that season, SC = sale of the crop of that season, CC = consumption of crop of that season, T..- = transfer of the remaining cash to the next period, FEX = family expenses, MOR = mortgage taken for agricultural purposes, YES = year ending saving, 1,2,3 designated to the activities of period 1,2 and 3 respectively.

Table 5.1 : The model matrix showing interactions of the activities and constraints / input output coefficients.

MATRIXM: : MATRIX OF THE MODEL TO DESCRIBE THE FEATURES OF THE FORMULATED MODEL FOR THE STUDY

ACTIVITY NO. --> CONSTRAINTS ROWNAME. WITH UNIT	REL	IMIT OBJ. FU.	1 HL1	2 HB1	3 OF1	4 BO1	5 IN1	6 PC1	7 SC1	8 CC	9 T1-	10 HL2	11 HB2	12 OF2	13 BO2	14 IN2	15 PC2	16 SC2	17 CC2	18 T2-	19 HL3	20 HB3	21 OF3	22 BO3	23 IN3	24 PC3	25 SC3	26 CC3	27 T3-	28 FEX	29 MOR	30 YES
																																1
1 LAND1(AJ). HA	L	1	-1					1																								
2 HRL1(AJ). HA	L	0.5	1																													
3 LAB1(AJ). M-D	L	120		-1	1			f1																								
4 HLB1(AJ). M-D	L	120		1																												
5 DR. P1(AJ). P-D	L	100						g1																								
6 CAPI1. TK'000	L	12		b		-1	1	h1			1																			k1		
7 BOROW1. TK'000	L	5				1																										
8 RETURN C1. TONN	L							-i1	1	1																						
9 LAND2(AN). HA	L	1										-1																				
10 HRL2(AN). HA	L	0.5										1																				
11 LAB2(AN). M-D	L	120											-1	1			f2															
12 HLB2(AN). M-D	L	120											1																			
13 DR. P2(AN). P-D	L	100															g2															
14 CAPI2. TK'000	L		a		-c	d	-e		-j1		-1		b		-1	1	h2			1										k2		
15 BOROW2. TK'000	L	5													1																	
16 RETURN C2. TONN	L																-i2	1	1													
17 LAND3(DM). HA	L	1																			-1					1						
18 HRL3(DM). HA	L	0.5																			1											
19 LAB3(DM). M-D	L	120																				-1	1			f3						
20 HLB3(DM). M-D	L	120																				1										
21 DR. P3(DM). P-D	L	100																								g3						
22 CAPI3. TK'000	L											a		-c	d	-e		-j2		-1		b		-1	1	h3			1	k3		
23 BOROW3. TK'000	L	5																						1								
24 RETURN C3. TONN	L																									-i3	1	1				
25 RICECON. TONNES	G	4								1									1									1				
26 FAMIEX. TK'000	G	1																												1		
27 ANUITY. TK'000	G	1																													1	
28 YRESAV. TK'000	L																				a		-c	d	-e		-j3		-1		m	1

5.9 Activities

No.1 HL_1

A land hiring activity in Kharif-I season which extends from April through July. The unit of activity is one hectare. The activity supplies the cultivable land but the rent of hiring land for that period must be repaid at the end of the period, which will affect the capital of the next period. Generally, landlords are repaid fifty percent of the harvest but for convenience of calculation repayment in monetary value 'a' has been assumed; this varies in different periods or for different groups.

No.2 HB1

A labour hiring activity in Kharif-I season. The unit of activity is man-day. The activity supplies the labour but the wage of hiring man power must be paid before his swats get dry, which will affect the capital of the same period. So an amount of daily wage of 'b' per unit has been charged on the capital supply of the first period.

No.3 OF1

An off farm activity. The unit of the activity is man-day. It has been assumed that if family labour is not absorbed in farming work, they can be engaged in some other activities outside the farm. The scope of such work is limited, so the return obtained may not be used in the same period. An income of 'c' per unit labour may be obtained which may contribute to the capital supply of the next period. One point is to be mentioned here that the assumed return must be less than wage of hired labour that is, $c < b$, otherwise the model will hire labour and employ it in off farm activities.

No.4 BO1

A capital borrowing activity for period one. The unit of the activity is Tk 1000. It will increase the supply of capital in that period but must be repaid with interest at the end of the season, which is shown by 'd' in capital restraint of period two. 'd' may vary with the interest rate. It also depends on the size of the farm, because small farmers have access to a seasonal crop loan program at a lower interest rate as well as a long-term equipment loan program.

No.5 IN_1

An investment activity for period one. The unit of the activity is Tk 1000. If the available capital is not fully utilised in farming, then it is assumed that there is alternative scope of investing money. That will reflect the opportunity cost capital. It is obvious that the rate of interest in capital borrowing is higher than the return obtained by alternative investment, or $e<d$. It will take one unit from the capital of first period and contribute to the capital supply of the second period with interest which has been denoted by negative 'e'.

No.6 PC1

A crop production activity in period one. The unit of the activity is one hectare. It is a symbolic representation for all the crops grown in Kharif-I season. It uses one unit of land, f1 units of labour, g1 units of draft power and h1 units of capital in period one and returns i1 tonnes of yield of that crop. The coefficients f1, g1, h1, i1 are different for different varieties of crops and farm sizes. The data obtained from the field survey has been used in the model.

No.7 SC1

A crop selling activity in period one. The unit of the activity is one tonne. It takes one unit from the return row and contributes to capital supply of next period of an amount equal to its sale price which is represented by -J1 . The value obtained from different crops are different and surprisingly it varies with the class of farmers.

No.8 SC1

A crop consumption activity in period one. The unit of the activity is one tonne. It transfers one unit from the return row to rice consumption row. Thus, it takes that unit out of sales activity.

No.9 T_1

A transfer activity in period one. The unit of the activity is Tk.1000. It transfers the remaining balance of capital to the next period.

The sequence is repeated in the second and third period where the subscript 1 is replaced by 2 and 3 respectively. It covers up to activity No.27.

No.28 FEX

An activity which takes care of the fund required to operate the farming activity and maintenance of the family. The unit of the activity is Tk.1000. It takes the required amount from the capital supply of each period.

No.29 MOR

An activity which takes care of the fund required to repay the annual installments of the long term loans taken for farming activities which is denoted by 'm'.'m' varies with the size of the farm. The unit of the activity is Tk.1000.

No.30 YES

This is the desired activity for maximisation of yearly net return. Objective function coefficient of this activity is 1 and all other is zero. After meeting all the requirements, the remaining balance is deposited in this column. The unit of the activity is Tk.1000.

5.10 Constraints

Row No.1 LAND1(AJ)

A land constraint for the period April through July. Classification of the farmers has been done on the basis of the size of their cultivable land. Different groups have different land limits; a small farmer has one hectare of cultivable land. The input-output coefficients have been expressed per hectare.

No.2 HRL1(AJ)

A land hiring constraint in period 1. The limit varies with the size of the farm. Generally, small farmers are allowed by the landlords to rent a limited area of cultivable land. Big and large farmers rarely rent cultivable land. The unit of this row is per hectare.

No.3 LAB1(AJ)

A labour availability restriction in period 1. The unit is man-day. Generally, small and medium farmers work in the farm themselves throughout the year. At peak working periods some daily labourers are hired. Big and large farmers keep one or two labourers attached with the family which ensures the supply of labour throughout the year. These farmers may also like daily labourers in peak periods. Out of a 120 day period, the farmers take off one or two afternoons in a week for shopping and other family works but it is compensated by over working on other days. So on average, eight hours working day for the whole of the season may be considered.

No.4 HLB1(AJ)

A labour hiring restriction in Kharif-I season. The unit is man-day. Though Bangladesh is an overpopulated country of unemployed agricultural labourers, labour shortage occurs during peak periods. So labour hiring ability in different farmer groups varies.

No.5 DR.P1(AJ)

A draft power constraint. The unit is pair-day. Generally ploughing is started early in the morning and is stopped with rising of temperature. The afternoon is kept free for grazing of the bullocks. So actual working time is less than six hours per day. The availability of bullock power restricts land preparation period, but the main restriction comes from sowing / planting dates of particular varieties of crop. With the increase of cropping intensity, the period of bare land reduces drastically. At that time, farmers are compelled to overuse the draft power. Considering this, the average working hours achieved from a pair of bullocks per season has been assumed to be 100 days.

No.6 CAPI1

An initial capital restriction. The unit is Tk. 1000. The farmers start with the year ending savings of the last year. They have to spend in advance for inputs, daily hired labourers, and expenses for maintaining the family. The rent for the hired land and installment for the bank loan can be paid at the end of the season. Sale proceeds of crops of that period can be used for that and remaining amount is used as capital for the next period. This resource limit is different for different classes of farmers.

No.7 BORROW1

A capital borrowing constraint. The unit is Tk. 1000. The limit of borrowing is different for different classes of farmers.

No.8 RETURN C1

A yield transfer row of period 1 crops. It ensures the balance between supply of the crop through yield and demand for the crop for own consumption and sales. It may be termed as flexibility restraint as it is defined in such a way that it has no bearing on the optimisation process. It is a redundant constraint.

The sequence is repeated in the second and third periods where the subscript 1 is replaced by 2 and 3 respectively. It covers up to Row No.24.

No.25 RICECON

A family rice consumption restraint. The unit is tonnes. The relation is greater than a certain amount which varies with the farm size.

No.26 FAMIEX

A family living expense restraint. The unit is Tk.1000. It takes different proportions of capital (k1, k2 and k3) in different seasons. Capital supply in a particular season becomes a function of the family expense of that particular period.

No.27 ANUITY

A fixed cost restraint. It can also be directly subtracted from the result after optimisation. The whole amount of annuity, which varies with the size of the farm, has been considered as one unit and the relationship is greater than.

No.28 YRESAV

A transfer row to balance the all payments and savings as objective of the model.

5.11 Solution of the Problem

The model was run in GULP programming software which uses the simplex algorithm for solution. The simplex procedure continually strives to find a better operation strategy than the one currently at hand by reviewing at each step of the solution process the marginal cost reduction or profit potential of all the activities that are not in the current solution. The procedure not only determines which activities appear to be promising for further profit improvement or cost reduction, but it automatically determines the rate at which profit will decrease or cost will increase if it were to introduce unprofitable activities in to the solution.

5.12 Conclusion

Ideally, a farm model should consider not only the crops grown by the farmers but also other activities associated with farming which are performed by the farmers such as rearing livestock or small back yard poultry, or growing a small orchard. The model should also include feed requirements for cattle, transportation of the farm family, milk requirements of the family, and maintenance of the dwelling houses, etc. To include these additional activities would require a comparatively long period of time and additional financial resources for additional data collection. Neither was available for this project. However, the model captures the major elements of farmer choices and reasonably represents the economic situation faced by farmers.

CHAPTER VI

SURVEY DATA AND FINDINGS

6.1 Introduction

Survey research involves appropriate techniques of observation or measurement of phenomena, the detection of regularities or uniformities in this phenomena, the formulation of hypotheses and larger bodies of theory and the accumulation of reliable knowledge of the phenomena and evidence in relation to the hypotheses. It is dedicated to objectivity and concerned with accuracy; each individual inquiry is provisional, but the totality of inquiries are cumulative (Hyman, 1966)

The hypothesis of this dissertation was that farmers in the project area can derive maximum benefit from the created facilities only by selecting the appropriate crop mix, which is different for different farmers depending on their resource endowments and capability to cope with the Government policies. One recently completed Flood Control and Irrigation Project - the Meghna Dhonagoda Irrigation Project - was selected for this dissertation. A major consideration is whether farmers can provide information of with and without project conditions reliably from their memory, because the keeping of written expenditure accounts is rare in rural areas of Bangladesh.

This chapter is divided into two sections. In the first sections, headings / topics of data collection are described with their assumptions and level of participation by the farmers. The later sections summarise the findings of the survey in tabular form for different groups of farmers. Questionnaires and group wise field data are contained in Appendix I and Appendix II.

6.2 Survey area

The project comprises about 26,300 hectares of flood protected area, of which 14,200 hectares could be provided with irrigation water. Estimation for population from the 1981 census reveals that about 225,000 people in 38,000 households live in the project area. About 13,500 households are landless who maintain their families by working as agricultural labourers, fishermen and other activities. Out of 24,500 farm families, about 58 percent possess less than one acre of cultivable land. When landless farmers are included in this group, then the figure stands to 73 percent of total households. The size distribution of farms in the project area is shown in Table 6.1.

Table 6.1: Distribution of farms according to the size of cultivation area

Size of the farm	Group	Number of Total Farms	Irrigable area (hectares)	% of Total Farm	% of Total Cultivable Land
Up to 1 acre (.4 ha)	A	14,200	4,250	58	30
1>area<2.5ac (upto 1 ha)	B	8,500	6,400	35	45
2.5>area<5ac (upto 2 ha)	C	950	1,400	3.9	10
area > 5 ac (> 2 ha)	D	850	2,150	3.1	15
Total		24,500	14,200	100	100

6.3 Questionnaire

About 89 questions were asked of individual farmers under 24 broad headings in two questionnaires. The first questionnaire sought information on the general characteristics of the farms; the second collected data on the inputs and outputs in the production of all possible crops. Thirty one questions asked about farmers' resource endowments, three questions asked about their consciousness regarding project facilities and environmental impacts. The remaining 55 questions asked about crop mix and input output coefficients. From the first questionnaire, the resources available to different groups of farmers were derived. The second questionnaire was utilised to derive cropping intensity, inputs used, variety of crops cultivated and corresponding yields received in the without project condition as well as with project condition. The questionnaires used in the survey work are contained in Appendix I.

6.4 Sample size

The data were taken from the project area during November - December 1990. Farmers were randomly selected in classified groups. Farmers were classified into four groups according to size of land holdings. The number of farmers in each class was determined prior to the survey, to maintain the uniformity and to keep the volume of data within handling limits. Twelve / thirteen farmers in each group were contacted. They were requested to allocate time in the evening to answer the questions and provided with a small incentive of remuneration. They were asked about the crops grown before project implementation as well as the crops grown after project implementation. Each of them gave information about 5 - 6 crops grown in before project condition and 3 - 4 crops grown after project implementation.

6.5 Nature of the data and definitions

This is a study of appropriate crop mix in a recently completed Flood Control and Irrigation Project which has not yet attained its full development stage. Although the results reflect conditions in the Meghna Dhonagoda Irrigation Project, it would not be appropriate to draw any definite conclusions for the Bangladesh agricultural system as a whole by considering only 50 farmers in one area. So the data and its use in linear programming may be considered as a demonstration of the mathematical model developed for formulation of policies. In other words, it should be taken as indicative rather than conclusive.

6.5.1 Land

Land is the most scarce factor of production in Bangladesh. Generally, social status, leadership and dignity is associated with landholding. So every member of rural community has a great affinity to hold as much land as possible. With the implementation of the project, land productivity has increased and it became hard to acquire land even for sharecropping. Before the implementation of the project, the large and middle class of landholders rented out their lands to the landless or to small farmers and they were involved in business or service in the town. Better living facilities and better education facilities for the children is another attraction of living in the town, which has increased in size with the implementation of the project. So land owners themselves are managing their farming as a profitable business. The negligible number of share croppers in the project area could maintain their rented land for a special relationship with the land owners or some other strategic convenience.

Due to flood protection and provision of irrigation water, land types in the project area have changed. The low lying areas, which were only suitable for low yielding longstem broadcast varieties became suitable for the cultivation of high yielding varieties in all seasons. It is interesting to note that there is not any development tax charged for the lands within the project area. Moreover the irrigation water is supplied almost free.

Information about cultivable area, its ownership - whether owned or rented - and its approximate value was taken from the farmers. Generally, the current value of the land was given by the farmers.

6.5.2 Draft power

Bullocks and cows are the only sources of power for land preparation in the project area. Small farmers keep one or two cows for milk, most of which is sold in the market. They use cow dung as a manure. Sometimes they mutually exchange or help each other in ploughing and other agricultural activities. Medium farmers maintain at least one pair of bullocks for land preparation, fertiliser application and other agricultural activities. In addition to the inconvenience of initial capital cost, another problem of maintaining bullocks is the non-availability of fodder. A quarter of a day of a labour is required to look after one pair of bullocks. Large farmers keep two or more bullocks and engage one full time man for this work. Farmers were asked about the source and level of draft power available to them and whether they use their own bullocks or rented from others. The rate of renting in different years and cost incurred per acre for land preparation was also asked.

6.5.3 Labour force

Labour in general is not scarce but during the peak season of harvesting and planting at the end of each season, labour demand increases. Small farmers also hire some labour in the peak seasons. Medium and large farmers have one or two full time labourers attached with the family. Some landless farmers, engaged in part time works other than agriculture, form groups and work together on contract for planting, intercultural operations or during harvesting. Due to pressure to increase the per head share by finishing the contracted work in the shortest possible time, the quality of this work is generally inferior than hired or family labour. Hired labourers are generally available on man-day basis, about 8 hours work without food. Some times labourers are available at a lower wage rate with food and for a bit longer period of work from sunrise to sunset. The man-days of work were standardised by eight hours of work in a day but no adjustment could be made for the quality differences.

6.5.4 Irrigation facilities

Before the implementation of the project, well-to-do farmers arranged irrigation for their winter crops by low lift pumps or shallow tube wells or by some other traditional methods, if irrigation water was available near the fields. After implementation of the project, irrigation water is supplied from the main rivers to the main and secondary canals constructed by the project through pumping. Construction of tertiary and field channels is the responsibility of the farmers group or local irrigation committee.

Farmers were asked about the irrigation facilities used before project and the costs associated with it. When they were asked about present irrigation facilities and expected amount of tax, they generally tried to underestimate the benefits to avoid tax.

6.5.5 Manure and fertiliser

Local low yielding varieties were cultivated before the project which could be grown with less fertiliser application. Generally, every family has a ditch near their houses where they deposit the spell and exhausts of the cow shed. In course of time it becomes a good compost. Generally, farmers spread the compost evenly on the land before land preparation. Some landless farmers who are not engaged in farming but rear cows for business sell their compost. After project implementation, with the introduction of high yielding varieties, demand for compost as well as chemical fertiliser increased. Small farmers could not afford the recommended doses due to shortage of funds. Questions were asked about how much compost the farmer could afford from his own and how much he could buy. Level of acquisition of chemical fertiliser at the beginning of the season was also ascertained in the first questionnaire and application in growing different crops was ascertained in the second questionnaire as crop coefficients.

6.5.6 Capital

Capital is the second most scarce production function. Small farmers have been given priority for credit by Government intervention. Government policy is to provide agricultural loans to marginal farmers, so farmers having less than one hectare of cultivable land are eligible for seasonal short-term loans at 10 percent interest rate, where specific crops are taken as bond. In addition to the crop loan, farmers can take long-term loans at 17 percent interest rate from the bank for agricultural equipment. Short-term loans are payable after the cropping season whereas long-term loans are payable in quarterly / annual installments. Chemical fertiliser and casual hired labour are the two major inputs that have to be purchased from the market. Farmers pay a smaller amount for the chemical fertiliser than its actual production cost due to government subsidy. Farmers were also asked about the level of capital used in farming, its source and interest rate.

6.5.7 Crop mix

Before the implementation of the project, farmers sowed seeds of broadcast Aus and broadcast Aman at the same time on the field. The Aus variety would germinate first, which were harvested in June - July, leaving plants of broadcast Aman in the field. With the increase of the water level in July - August, the paddy plants will always be above the water surface. A demerit of this variety is that its yield is very low compared the other short stem varieties. In November, when the flood water recedes, farmers harvest the broadcast Aman and the land is opened for winter crops. In the without project conditions, farmers had to choose a winter crop considering the soil condition and other physical facilities. They had to take the risk of climate. Sometimes they harvested a bumper crop if the climate is favourable, but most of the time the yield is reduced and sometimes no harvest is obtained. After the implementation of the project, the flood risk has been greatly reduced and some of the area is provided with irrigation water. So farmers have changed their cropping pattern. Most of them practice two HYV rice accompanied with a leguminous crop in the winter season to increase the nitrogen content of soil. Some farmers grow three rice crops to assure family requirements. Farmers were asked about the number of crops cultivated before and after project implementation.

6.5.8 Living cost and family consumption

Most of the farmers are dependent on the crop they grow in their fields for maintaining their families, especially for food supply. This is one of the reasons why rice is the common crop. Small farmers try their best to meet the rice requirement of the family from their own harvest. For other expenses, they rear backyard poultry, cows, a few goats or sheep. Even a few banana plants at the backyard can provide some cash : the inner stem provides curry for the family and outer stem is burnt to ashes and is used as detergent. Some families even cannot produce all of the family requirement in their own fields. They have to manage food for their family by finding nonagricultural work. Medium farmers produce more than their family requirements, the excess is sold in the market. An estimate of this kind of disposable rice production was made by Ahmed,R.U (1979). They have better scope to choose cash crop in lieu of cultivating rice in all cultivable lands. This is one of the privileges of the medium and large farmers.

Farmers were asked about the level of family requirements, how they were fulfilled and the level of yearly nonagricultural income.

6.5.9 Benefits of the project

Farmers were asked about benefits of the project, other than improved cropping facilities, because the success of the project lies on the attitudes of the beneficiaries. The public investment could be worthwhile if the implementation costs of the project could be recovered from the beneficiaries. Unequal distribution of the taxpayers' money - that is, the development of a particular area by protecting flood and providing irrigation facilities free of cost, could create social / political imbalance of the country. Some sort of development tax might be required for the people of the project area. Farmers responded to this question cautiously.

6.5.10 Demerits of the project

Farmers' consciousness about the impact of the project is not yet clearly understood. Some farmers who lost their land or houses due to land acquisition for the project certainly are against the project, because they were not rehabilitated by the project. The lump sum compensation grant did not allow them to buy a similar area of land in the project area. Some landless families who were maintaining their families by fishing would be affected by implementation of the project. Shortage of fish might bear an adverse affect on small businessmen. This is also a social loss which generally did not get proper weightage during project formulation. These concerns would have been better reflected if landless households were interviewed.

6.5.11 Environmental impact

The project was completed on 1988 so it is too early to measure the environmental impact of the project. The question was asked to assess the apprehension of the farmers. Most of them responded positively. The common reply was the ecological imbalance. They mentioned the increase of insect pests and reduction of land fertility.

6.6 Crop coefficients

Crop coefficients varied greatly from farmer to farmer, season to season, and soil to soil. The problem is compounded by farmers' recollection of information from their memory, since farmers virtually do not keep written records. Cost accounting methods might provide more accurate information but this option was not pursued because it would involve huge expenditures, frequent visits, and time to collect information.

Detailed information about crops production in recent years, yields, prices, output, quantity and value of fixed and variable inputs were obtained through the survey. Inconsistencies and gaps were discussed with the local agricultural officials and were adjusted. Crops cultivated by different farmers of the same class in different years were grouped together to determine the average level of input use in project and without project conditions. Some crops were grown only before the project like broadcast Aman, whereas cultivation of some crops is only possible under flood protection and irrigation supply (i.e. with the project).

Summary of the findings is presented in Tables 6.2 and 6.3. Detailed survey data in tabular form for different groups is included in Appendix II.

Table 6.2: **COMPARISON OF VARIABLES IN DIFFERENT CLASSES OF FARMERS (Without project condition)**

Variables	Unit	Gr	L1	L3	L6	L8	L9	L10	L11	L12	L15
Yld(c)	TON/Ha	A	1.80	1.73	2.49	2.23	5.07	1.01	1.01	4.84	2.95
Yld(c)	TON/Ha	B		1.66		2.35	4.80	0.89	0.92		2.67
Yld(c)	TON/Ha	C		1.41	2.46	1.94	4.70	1.22	0.89	6.61	2.58
Yld(c)	TON/Ha	D		1.51	3.41	1.87	4.61	1.12	0.96	7.49	2.30
Yld(c)	TON/Ha	R		1.57	2.77	2.10	4.80	1.06	0.94	6.27	2.74
Price(c)	TK'000/T	A	4.42	5.91	4.42	4.02	4.10	9.41	9.32	6.16	4.93
Price(c)	TK'000/T	B		6.81		4.15	3.97	9.82	9.65		4.82
Price(c)	TK'000/T	C		6.51	4.11	4.82	3.67	9.11	10.74	4.82	4.82
Price(c)	TK'000/T	D		6.70	4.21	4.62	3.75	11.68	10.75	3.95	4.96
Price(c)	TK'000/T	R		6.48	4.25	4.40	3.87	9.99	10.10	4.98	4.85
F&P.Cost	TK'000/H	A	0.74	2.52	1.40	1.95	2.58	0.68	1.11	0.77	1.27
F&P.Cost	TK'000/H	B		3.11		1.61	2.08	0.87	0.62		0.61
F&P.Cost	TK'000/H	C		1.01	0.98	0.87	1.29	0.98	1.03	1.37	0.71
F&P.Cost	TK'000/H	D		1.19	1.68	1.28	1.57	1.15	1.04	1.50	0.89
F&P.Cost	TK'000/H	R		1.96	1.35	1.43	1.88	0.94	0.95	1.35	0.87

L 1 = Production of Broadcast Aus
L 3 = Production of Jute
L 6 = Production of Local Variety of Boro
L 8 = Production of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L12 = Production of Onion
L15 = Production of Brodcast Aman

Table 6.3: **COMPARISON OF VARIABLES IN DIFFERENT CLASSES OF FARMERS (With project condition)**

Variables	Unit	Gr	L1	L2	L3	L4	L5	L6	L7	L8	L9	L11	L14
Yld(c)	TON/Ha	A	2.57	3.41		3.60	3.25		3.69	2.77			
Yld(c)	TON/Ha	B	3.09	4.09	1.94	4.35	3.79	2.90	4.15			1.15	
Yld(c)	TON/Ha	C	3.24	4.21	1.79	4.87	3.69		5.00		5.07		
Yld(c)	TON/Ha	D	3.73	4.10		4.21	3.73	3.23	4.30	2.86	4.80	0.98	55.33
Yld(c)	TON/Ha	R	3.14	3.96	1.86	4.26	3.60	3.07	4.29	2.86	4.93	1.11	55.33
Price.c	TK'000/T	A	5.96	5.73		6.02	6.16		5.76	5.36			
Price.c	TK'000/T	B	5.36	5.71	8.57	5.70	5.55	5.36	5.81			12.06	
Price.c	TK'000/T	C	5.69	6.00	8.90	5.82	5.31		5.89		5.89		
Price.c	TK'000/T	D	5.76	5.69		6.07	6.23	5.49	5.54	5.36	5.36	12.5	0.78
Price.c	TK'000/T	R	5.71	5.78	8.74	5.89	5.94	5.43	5.64	5.36	5.63	12.27	0.78
F&P.Cos	TK'000/H	A	1.78	2.79		1.91	2.22		2.76	1.48			
F&P.Cos	TK'000/H	B	1.82	2.96	3.16	2.60	2.21	2.90	4.15		1.58		
F&P.Cos	TK'000/H	C	2.48	3.18	2.14	2.92	2.41		3.41		4.32		
F&P.Cos	TK'000/H	D	2.59	3.70		2.68	2.64	2.27	3.20	1.52	2.15	2.15	1.89
F&P.Cos	TK'000/H	R	2.16	2.98	2.65	2.53	2.37	2.58	3.38	1.50	3.39	1.85	1.89

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 3 = Production of Jute
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 6 = Production of Local Variety of Boro
L 7 = Production of High Yielding Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L14 = Production of Sugercane

6.7 Findings of the survey

Table 6.2 shows the per hectare yield variations of different crops cultivated by different groups of farmers in without project conditions. Broadcast Aus was cultivated by only one group of farmers so comparison was not possible. Jute was cultivated by all the groups. The average yield was 1.57 tonnes per hectare. Small farmers attained the highest yield which was about 10 percent higher than the average. Group C produced the lowest yield which was about 10 percent lower than the average. Small farmers received the lowest price. Immediately after harvest, supply in the market increases and as a result price falls. It increases after a few months. Sometimes large producers make contact with the mill manager and supply at the mill gate, therefore receiving a good price. Generally, the small farmers could not wait for the rise of market price. Fertiliser application rate was highest in Group B and lowest in Group C.

Local variety of Boro was cultivated by three groups. Highest yield was achieved by the large farmers who spent the highest amount for fertiliser and pesticide.

Wheat was cultivated by all groups of farmers in without project conditions. Highest yield of 2.35 tonnes per hectare was achieved by the medium group of farmers. This was about 12 percent higher than the average production of 2.10 tonnes per hectare. Lowest yield was in the large farmers group which was 11 percent less than the average. Fertiliser application rate was also higher in small and medium farmers groups. Fertiliser requirements in small plots sometimes became a fractional unit, maintaining of that smaller weight is difficult for the smaller farmers. So they apply the nearest round weight which gives a bigger figure when calculated for per hectare proportion. Price received did not vary significantly. The lowest price was achieved by the small farmers group.

Potatoes were cultivated by all the groups. The highest yield, price received and fertiliser application rates were in the small farmers group. Small plots with intensive care and marketing the crop at the earliest season may be the cause of highest achievement of the small farmers group. Fertiliser application expenditure for small farmer was about double that of the large farmers group. But compared to that yield achieved was only 6 percent higher than the average.

Pulse was cultivated by all the groups in without project condition. It is a winter crop can be grown in such soil which is not suitable for potato or other winter crops. Yield received was almost the same in all the groups though fertiliser application rate of large farmers was a bit higher than the small farmers. Price received by the large farmers was about 17 percent higher than the average. Storage facilities and ability gave this chance of higher price achievement.

Oil seed is a winter crop which can give some yield when grown in without irrigation facilities. It was cultivated by all the groups. Yield was not fluctuating but price variation reduced the return of the small farmers. After harvesting, the small farmers had to sell their crop at very low market price.

Onion is the main spice used by all families in Bangladesh. Farmers try to grow it even in the back yard. Commercial production requires sandy soil. Unlike other crops, yield received by large farmers group was the highest and that of small farmers group was the lowest. Group B farmers did not produce onion in their field.

Broadcast Aman was the common crop grown by all the farmers in without project condition. It is generally intercropped with Broadcast Aus and takes a longer period of combined Kharif season. Initially it requires some attention like weeding, mulching but in the rainy season after harvest of Broadcast Aus it grows rapidly with the water level. It is finally harvested after recession of flood water. It gives two harvests from the same field. Yield achieved by small farmers was the highest. They also spent a proportionally higher amount for fertiliser.

It becomes apparent from Table 6.2 that small farmers were most efficient in farming in without project conditions.

Table 6.3 shows the yield variation in production of different crops by different farmers groups in with project condition. After implementation of the project, cropping patterns changed. Low yielding drought and disease resistant varieties were replaced by high yielding varieties. A technology of increased fertiliser and pesticide with improved seed was introduced. Small farmers tried their best to cope with the modern technology but failed in some aspects.

All groups of farmers embarked on a Broadcast Aus crop, which gave an average yield of 3.14 tonnes per hectare, almost double that in without project conditions. The highest yield of 3.73 tonnes per hectare (19 percent higher than average) was achieved by the large farmers group. The small farmers group produced 2.57 tonnes per hectare which was about 18 percent lower than the average. Price achieved was more or less the same in all groups. Large farmers group spent about 20 percent above average where small farmers spent 18 percent lower than average per hectare fertiliser cost.

High Yielding Variety (HYV) of Aus was cultivated by all groups. The cultivation of Broadcast Aus and HYV Aus is done in the same season in with project conditions. The choice between these two varieties depend on the soil condition. Relatively better soil is suitable for HYV Aus. Similar features were observed in the case of HYV Aus. Average yield was 3.96 tons per hectare. Highest yield was achieved by the big farmers group. It was about 6 percent higher than the average where as the small farmers group achieved 14 percent lower yield than average. Highest expenditure incurred for fertiliser application in HYV Aus was by Group D. It was about 24 percent higher than the average of Tk. 2980/-. Small farmers fell 6 percent short of average.

After implementation of the project, a few medium and big farmers cultivated jute. After flood protection, yield of jute did not increased significantly. The 16 percent increase in yield may be attributed to 35 percent increased expenditure in fertiliser and pesticide.

In with project conditions most of the farmers cultivated HYV Aman. Its average yield was 4.26 tonnes per hectare. Average fertiliser cost per hectare was about Tk. 2530/- where small farmers group spent Tk. 1910/-, 25 percent less than average. Yield achieved by the small farmers group was also 15 percent less than average. Big farmers group spent considerably more for fertiliser and achieved the highest yield.

Transplanted Aman variety was on the same board of HVY Aman. Its average yield was 15 percent less than HYV. The difference between highest and lowest yield was only 10 percent.

Local variety of Boro was cultivated by a few farmers after implementation of the project. Though its average yield was 13 percent more than without project conditions, farmers tried their best to grow HYV Boro. But some times it was not possible to cultivate more than two high yielding varieties in one year in a field. So farmers had to cultivate any other short durational local varieties. After implementation of the project, the farmers had a trend of higher application of fertiliser in their fields. Fertiliser application rate was double than without project conditions for local Boro.

HYV Boro was another important Variety in with project condition. Availability of irrigation water is the main restraint to this variety. As the project authority did not apply any restraint on supply of irrigation water, most of the farmers cultivated this crop. Highest yield was achieved by the big farmers group which was 17 percent higher than the average yield of 4.29 ton per hectare. Small farmers group achieved the lowest yield which was 14 percent less than average. Price achieved did not fluctuate more than 2 - 4 percent. Medium farmers group spent most for fertiliser application, which was 23 percent higher than average. Small farmers group spent lowest for fertiliser which was 18 percent less than the average cost of Tk. 3380/- per hectare.

After implementation of the project, wheat was cultivated by a few farmers of small and large group. Average yield increase without project condition was 36 percent. In contrary to the without project conditions, large farmers group achieved the highest yield and small farmers group achieved the lowest yield.

Potatoes were cultivated by only big and large farmers group in with project conditions. They spent 80 percent higher cost in fertiliser application than the without project condition but achieved only 3 percent yield increase. Their increased expenditure for fertiliser was overweighted by increased price received. Because average price rise was about 45 percent. Increased storage facilities may be the cause of higher market price.

Oil seed was cultivated by a few farmers of medium and large groups. Average yield increase was about 18 percent where as expenditure on fertiliser increased by 95 percent. Enhanced fertiliser cost was commensurate by price rise of 21 percent.

After implementation of the project only a few farmers of large group cultivated sugarcane in their fields. So a comparison could not be made. Generally this crop is avoided for its long gestation period and ban on local preparation of molasses. Only in the sugar mill zones, a special protection subsidy is given to the farmer for the interest of sugar industry.

From the findings of Table 6.3, it may be concluded that farmers could not cope with the modern technology - not even the large farmers group. In with project conditions, only the big and large farmers group had the chance of diversification in farming, while small farmers confined themselves to rice production for subsistence of the family.

Table 6.4: **Average resource endowments possessed by different groups of farmers in the project area**

	Particulars of item	Unit	Amount of Possession by different groups A	B	C	D	R	Remarks
1	Cultivable Land							
	acre		0.72	1.82	3.41	5.88	3.00	Survey Data
	hectare		0.30	0.75	1.50	2.50	1.00	Approximate
2	No. draft Animal	pair	0	1	1	2	1	Survey Data
3	Milking Cows No.		1	2	1	2	2	Survey Data
4	Family Labour	No.	1	1	1	1	1	
5	Attached with Fa	No.						
	without project Condi'n		0	0	0	0	0	
	with Project Condition		.33	1	1	1	1	
6	Wage/labor/month	Tk.		800	625	525	650	Survey Data
7	Food Cost/lab/m	Tk.		600	488	500	529	Survey Data
8	Annual Farm Exp. Tk.		1000					
	without project Condi'n		3.80	6.44	12.85	17.92	10.26	
	with Project Condition							
9	Family Expend. Tk.		1000					
	without project Condi'n		6	6	15	24	10	
	with Project Condition		9	18	27	27	15	
10	Own Capital Tk.		1000	5	10	15	20	12
11	Borrowed Cap. Tk.		1000	5	5	8	10	5
12	Off Farm Income	Tk.	1000					
13	Annual Rice Prod'n							
	without project Condi'n							
	with Project Condition							
14	Family Consump'n							
	without project Condi'n		3	3	4.4	5.2	4.4	
	with Project Condition		3.5	6	9	9	7.4	
15	Annuity Tk.		1000					
	without project Condi'n		9	9	15	25	15	
	with Project Condition		14	18	20	30	25	

CHAPTER VII

RESULTS AND DISCUSSIONS

7.1 Introduction

The main focus of this chapter is on the achievements of different groups of farmers under with-project conditions. The base line is without-project conditions. The results obtained from model runs are presented in tabular form in Table 7.1.

7.2 Output from the Computer

The computer gives the optimal solution of the matrix and some other information which can be used for further analysis. It gives the optimum level of each activity required to derive the maximum net return. The computer classifies the activities into four groups-

(i) Activities which form the basis, denoted by A;

(ii) Z for zero indicating that it is not in the solution;

(iii) M for multiple solution indicating that although the activity is not in this plan but there is another equally profitable plan which does include it; and

(iv) D for degeneration indicating that the activity is included in this plan but at zero level. This is due to there being a redundant constraint in the problem limiting the activity to zero level. For example, all the selling activities of the crops production of which are not selected by the plan are denoted by D because their inclusion depends on the RETURN transfer row.

Table 7.1 Summary of the results obtained by model runs

Particulars of the item	Unit	GROUP A		GROUP B		GROUP C		GROUP D		GROUP R	
		with	without	with	without	with	without	with	without	with	without
Rice Production in Farm	Tons	12.37	5.13	18.89	4.18	28.16	5.83	28.85	7.73	13.36	5.19
- Own Consumption	Tons	3.5	3	8.5	3	10	4.4	9	5.2	7.4	4.4
- Saleable quantity	Tons	8.87	2.13	10.39	1.18	18.16	1.43	19.85	2.53	5.96	0.79
- Price/Ton	Tk. 1000	6.16	4.93	5.81	4.82	6	4.82	6.07	4.96	5.89	4.85
Cash Receipt from:											
- Sale of Rice	Tk. 1000	54.64	10.50	60.37	5.69	108.96	6.89	120.49	12.55	35.10	3.83
- Sale of other Crops	Tk. 1000	0	23.26	0	27.25	0	37.28	10.55	56.8	34.97	34.66
Total Cash Flow / yr	Tk. 1000	54.64	33.76	60.37	32.94	108.96	44.17	131.04	69.35	70.07	38.49
- Family Expenses /yr	Tk. 1000	9	6	12	6	28	15	27	24	15	10
- Year Ending Savings	Tk. 1000	5.34	5.77	10.65	10.49	30.73	15.79	41.42	20.58	13.47	12.76
Expenditure for Farming	Tk. 1000	40.30	21.99	37.72	16.45	50.23	13.38	62.62	24.77	41.60	15.73
% Increase from W.O.P											
- Rice prod'n		141.1		351.9		383.02		273.22		157.4	
- Own Consumption		16.67		183.3		127.27		73.077		68.18	
- Saleable quantity		316.4		780.5		1169.9		684.58		654.4	
- Price/Ton		24.95		20.54		24.481		22.379		21.44	
- Sale of Rice		420.3		961.4		1480.8		860.17		816.2	
- Sale of other Crops		-100		-100		-100		-81.43		0.894	
- Total Cash Flow		61.84		83.27		146.67		88.957		82.05	
- Family Expenses/yr		50		100		86.667		12.5		50	
- Year Ending Savings		-7.45		1.525		94.617		101.26		5.564	
- Farming Expenditure		83.25		129.3		275.34		152.82		164.5	

Table 7.2 **Optimal cropping pattern for different groups as received by model runs**

Particulars of item	unit	Amount of Possession by different groups					
		A	B	C	D	R	Remarks
Crop growing option	Crop No.	1,3,6,	3,6,8,	3,6,8,	3,6,8,	3,6,8,	
Without Project Condition		9,10,	9,10,	9,10,	9,10,	9,10,	
		11,12,	11,15	11,12,	11,12,	11,12.	
		15		15	15	15	
With Project Condition		1,2,4,	1,2,3,	1,2,3,	1,2,4,	1,2,3.	
		5,7,8,	4,5,6,	4,5,7.	5,6,7.	4,5,6.	
		7,11,	9		8,9,10,	7,8,9,	
					11,14,	11	
Recommended Varieties	Crop No.	6,12,	6,9,	6,12,	6,12,	6,12,	
Without Project Condition		15,	15,	15,	15,	15,	
Area distribution	Hectare	0.52,	0.07,	0.58,	0.58,	0.39,	
		0.78,	1.43,	1.42,	1.92,	1.11,	
		1.30,	1.50,	2.00,	2.50,	1.50,	
Recommended Varieties	Crop No.	2,4,7	2,4,7,	2,4,7	1,4,	2,4,9	
With Project Condition			11		7,9,	1.50,	
Area distribution	Hectare	1.30,	1.5,1.5 2,2,		2.5,	1.50,	
		1.30,	0.48,	2.	2.5,	1.50	
		1.30,	1.02,		2.09		
					0.41		
Net Yr Ending Saving	Tk.'000						
Without project Condi'n		5.77	10.49	15.79	20.58	12.76	
with Project Condition		5.99	12.66	30.73	41.42	14.14	

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 3 = Production of Jute
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 6 = Production of Local Variety of Boro
L 7 = Production of High Yielding Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L14 = Production of Sugarcane

7.2.1 Shadow cost

The shadow cost on an activity not in the solution indicates that an increase in net revenue for that activity that would be necessary to make a particular activity become part of the optimal solution. Thus the activities which are in the basis have a shadow cost of zero; they require no increase to enter the solution. The shadow costs of real activities not in the solution indicate by how much income would be penalised were they forced into the plan. Hence close competitors to these activities which are in the plan could be identified. The shadow costs on disposal activities indicate the marginal contribution to income of the last unit of resource. In the model all activities have a zero coefficient in the objective function, so the shadow cost gives the relative position of the activities which are not in the solution. The activity with the lowest shadow cost has greater possibility to enter the solution.

7.2.2 Shadow price

Shadow prices can be interpreted as the value of purchasing one extra unit of that resource, that is one extra unit of that resource will increase the net return by that amount (i.e. the objective function value). Resources which are not fully utilised, can not increase the net return, so their shadow prices are zero. A positive shadow price means the increase of the resource will increase the net return.

7.2.3 Range analysis

A range analysis indicates the ranges within which objective function or constraint limit terms could be altered without affecting the composition of the optimal solution, that is without affecting those activities which are in the basis. If an activity is not already part of the solution, making it less profitable is not going to cause it to enter the solution. On the other hand, making it more profitable is likely to bring it into the solution eventually. Range analysis shows how much more profitable it needs to be for this to happen.

7.3 Results of model runs

7.3.1 Recommended crop mix for group A

Table 7.2 shows the recommended cropping pattern for different farmers groups in the study area - in with and without project conditions.

The model runs for group A reveal that if a farmer of this group selects the best crop mix in the without-project conditions, he would maintain his initial capital with which he started at the beginning of a year. At best,he might increase capital it by 15 percent. In the with-project conditions though, his cash flow nearly doubles but the net increase of the initial capital would be 7 percent. Table 7. 1 shows that in without-project conditions the farmers were diversified. The farmers used to produce different crops as there was little chance of producing HYV due to a shortage of irrigation water and protection against flood risk. At best, a farmer of group A could produce 5 tonnes of rice and other crops worth Tk. 23260 from his own farm. During the with-project conditions, farmers try to grow high yielding varieties in all seasons, in which case the production of rice on an average farm of group A is increased by 141 percent at the cost of other crops. Ultimately, all farm requirements are met through sales of rice. With an increase in costly input-oriented HYV technology after-project implementation, annual farm expenditures increase by 83 percent.

It would be appropriate to add here that average farm size of group A farmers is 1.30 hectares, out of which only 0.3 hectares are the farmer's own land. For convenience of calculation, the share of crop paid to the landlord has been converted to monetary value. Out of the total cash flow of Tk. 54640 and Tk. 33760 in the with and without situations, respectively, a farmer could spend only Tk. 9000 and Tk. 6000 for his own family in the with and without project conditions, respectively. Similarly, though rice production increased from 5.13 tons to 12.37 tonnes, the increase in own family consumption of rice is only 0.5 tonnes.

7.3.2 Recommended crop mix for group B

The model runs for group B reveal that if a farmer of this group selects the best crop mix in the without-project conditions, he would either maintain his initial capital with which he started at the beginning of a year or at best increase it by 5 percent. In the with-project conditions, though, his cash flow is more than double but the net increase of the initial capital is only 7 percent. Table 7.1 shows that in the without-project conditions, the farmers were diversified and used to produce different crops as there were little chance of producing HYV due to a shortage of irrigation water and protection against flood risk. At best, a farmer of group B could produce 4.18 tonnes of rice and other crops worth Tk. 27250 from his own farm. During with-project conditions, farmers try to grow high yielding varieties in all the seasons and the production of rice is increased by 352 percent. Ultimately, all farm requirements are met through sales of rice. With the increase of costly input-oriented HYV technology after-project implementation, annual farm expenditures increase by 129 percent.

The average farm size of group B farmers is about 1.82 acres, or 1.50 hectares. Only 0.75 hectares are the farmer's own land. For convenience of calculation, the share of crops paid to the landlord has been converted to monetary value. Out of the total cash flow of Tk. 60370 and Tk. 5690 in the with and without situations, respectively, a farmer could spent only Tk. 12000 and Tk. 6000 for his own family in the with and without project conditions, respectively. Similarly, though rice production on the farm increased from 4.18 tons to 18.89 tons, the increase in own family consumption of rice is only 5.5 Tons. For the higher manpower requirement of HYV technology, farmers generally keep one or two labourers attached with the family. This requires more food as well as family expenses. Sometimes the attached labourer prefers to accept rice as his salary at the end of the season, because he also needs that to maintain his own family. So the own consumption of rice and family expenses are complementary to each other. On average the salary of an attached labourer was Tk. 650 per month, i.e. Tk.2600 per season. If this amount was to be spent at the beginning of the season, the farmer would have a shortage of capital. On this ground, paying part of the salary in kind after harvest is preferable for both parties concerned .

7.3.3 Recommended crop mix for group C

The model runs for group C reveal that if a farmer of this group selects the best crop mix in the without-project conditions, he would maintain his initial capital with which he started at the beginning of a year or at best increase it by 5 percent. In with-project conditions, though, his cash flow is about doubled but the net increase of the initial capital would be 105 percent. Table 7.1 shows that in without-project conditions, the farmers were diversified and used to produce different crops as there were little chance of producing HYV due to a shortage of irrigation water and protection against flood risk. At best, a farmer of group C could produce 5.83 tonnes of rice and other crops worth Tk. 37280 from his own farm. During the with-project conditions, the production of high yielding varieties of rice in an average farm of group C increase by 383 percent. All farm requirements are met through sales of rice. With the increase of costly input-oriented HYV technology after-project implementation, annual farm expenditures increase by 275 percent.

Average farm size of group C farmers is about 3.41 acres, out of which 0.5 hectare is hired land and 2 hectares could be rented. For convenience of calculation, the share of crops that are paid to the landlord have been converted to monetary value. Out of the total cash flow of Tk. 108960 and Tk. 6890 in with and without situations, respectively, a farmer could spend only Tk. 28000 and Tk. 15000 for his own family in the with and without project conditions, respectively. Similarly, while rice production on the farm increases from 5.83 tonnes to 28.16 tonnes, the increase in own family consumption of rice is only 5.6 tonnes.

7.3.4 Recommended crop mix for group D

The model runs for group D show that a farmer of this group in the without-project conditions would maintain his initial capital with which he started at the beginning of a year or at best increase it by 3 percent. In with-project conditions, though, his cash flow is about doubled and the net increase of the initial capital would be 107 percent. Table 7.1 shows that in the with-project condition the farmers were diversified. At best, a farmer of group D could produce 7.73 tonnes of rice and other crops worth Tk. 56800 from his own farm. During the with-project conditions, farmers try to grow high yielding varieties in all the seasons and the production of rice in an average farm of group D increases by 273 percent at the cost of other crops. Ultimately, all farm requirements are met through sales of rice. With the increase of costly input-oriented HYV technology after project implementation, annual farm expenditures increase by 153 percent.

Average farm size of group D farmers is about 5.88 acres, or 2.50 hectares. Out of the total cash flow of Tk. 120490 and Tk. 12550 in with and without situations, respectively, a farmer could spend only Tk.24000 and Tk. 6000 for his own family in with and without project conditions, respectively. Similarly, though rice production in the farm increases from 7.73 tonnes to 28.85 tonnes, increase in own family consumption of rice is only 3.8 tonnes.

7.3.5 Recommended crop mix for group R

The model runs for group R reveals that if a farmer of this group would select the best crop mix in the without-project conditions, he would maintain his initial capital with which he started at the beginning of a year or perhaps increase it by 3 percent. In the with-project conditions, though, his cash flow is about doubled but the net increase of the initial capital would be 12 percent. Table 7. 1 shows that in the without-project conditions the farmers were diversified and produced different crops, as there was little chance of producing HYV due to a shortage of irrigation water and protection against flood risk. At best, a farmer of group R could produce 5.19 tonnes of rice and other crops worth Tk. 34660 from his own farm. During the with-project conditions, farmers try to grow high yielding varieties in all seasons and increase the production of rice by 157 percent. Ultimately, all farm requirements are met through sales of rice. With the increase of costly input-oriented HYV technology after project implementation, annual farm expenditures increase by 164 percent.

Average farm size of group R farmers is about 3 acres. Out of the total cash flow of Tk. 351000 and Tk. 3830 in the with and without situations, respectively, a farmer could spend only Tk. 13470 and Tk.12760 for his own family in the with and without project conditions, respectively. Similarly, though rice production in the farm increases from 5.19 tonnes to 13.36 tonnes, the increase in own family consumption of rice is only 3 tonnes.

7.3.6 Sensitivity of the recommended crop mixes

The model runs for group A in the without-project conditions, with the options of growing 8 crops (B.Aus, jute, L.Boro, potatoes, pulses, onion, B.Aman) and associated activities such as hiring land, labour, capital, draft power, etc. gave an optimal solution which recommends production of L.Boro, oil seed and B.Aman. The solution gave the different levels of those three activities and stability of the plan through range analysis. The competitive positions of the other six crops not selected were indicated in the form of shadow costs.

For example, production of 0.52 hectare of the local variety of Boro crop was recommended by the optimal plan. Its lower limit of range analysis showed a figure -16.42, which mean that in the recommended crop mix (those activities which became the basis of the optimal solution) would remain profitable / practicable until the level of net return from cultivation of one hectare of Local Boro was reduced by Tk.16420, since the objective function coefficient of LBoro was zero in the model. Similarly, it would be practicable until the net returns increased by Tk.17620 from the optimal level.

The change of the objective function value of LBoro might occur for different reasons; yield of LBoro might be reduced from the estimated level of 2.49 tonnes per hectare, or the price of LBoro might drop from the estimated level of Tk.4420 per tonne, or production costs might increase. The model assigns costs only to those constraints which are scarce, that is which are fully utilised (land, labour, capital). Those not fully utilised in the plan do not influence the net returns (hired labour, hired draft power).

From the range analysis, the sensitivity of the plan can be determined. As in the optimal solution, cultivation of Broadcast Aman was more sensitive than cultivation of LBoro or Onion. If the per hectare return from cultivation of BAman was reduced more than Tk.5310, the crop mix would

change. Similarly, jute cultivation would occur if the net return from cultivation of one hectare of jute increased by Tk.6910, jute would substitute for BAman. BAus, pulses, oil seed, wheat and potato would enter the crop mix if the net returns from cultivation of one hectare of those crops was increased by Tk.7830, Tk.11060, Tk.15450, Tk.19100 and Tk.112060, respectively.
These changes would be applicable only for the considered levels of constraints. If any one of the constraint levels was changed, then the whole crop mix and relative position of other crops would change. The ranges shown in the optimal solution identity potential changes in activities only if constraint levels remain unaltered.

The optimal solution also describes the importance of the constraints. The shadow price column give the level of increase in total net return if one unit of that constraint was increased (+ve shadow price) or decreased (-ve shadow price). The range indicates the extent up to which the plan could accommodate the increase or decrease of that constraint.

For example, the optimal solution indicated that an additional one hectare of land in period one would increase the net return by Tk.14184 . But the optimal plan could accommodate land from 0.2371 hectares to 0.30 hectares in period one. In this manner, the position of all constraints and their sensitivity can be determined from the optimal solution.

The model runs for group A in the with-project conditions with the options of growing 6 crops (B.Aus, HYV Aus, HYV Aman, T.Aman, HYV Boro and HYV wheat) and associated activities like hiring land, labour, capital, draft power, etc. gave an optimal solution that recommends production of three crops (HYV Aus, HYV Aman and HYV Boro). The solution also gave the different levels of those three activities and stability of the plan through range analysis. The competitive positions of the other three crops (B.Aus, T.Aman and HYV wheat) not selected, are also indicated in shadow cost form.

For example, production of 1.30 hectares of HYV Aus crop was recommended by the optimal plan. Its lower limit of range analysis of -1.4253 means that the recommended crop mix (those activities which became the basis of the optimal solution) would remain profitable / practicable until the level of net return from cultivation of one hectare of Broadcast Aus was reduced by Tk.1425. Similarly, it would be practicable until the net return was increased by any positive number from the considered level.

From the range analysis the sensitivity of the plan could be determined. As in the optimal solution, cultivation of local variety of Aman was more sensitive than cultivation of HYVBoro or BAus. If the per hectare return from cultivation of LAman was reduced more than Tk.121, the crop mix would change. Similarly, the inclusion of HYVAman cultivation would occur if the net return from cultivation of one hectare of HYVAman increased by Tk.121. The cultivation of wheat and HYVAus would occur if the net return from cultivation of one hectare of those crops was increased by Tk.1057 and Tk.1425, respectively.

For example, the optimal solution indicates that additional one hectare of land in period two would increase the net return by Tk.9720 . But the optimal plan could accommodate land from 0.0769 hectares to 0.4286 hectares in period two. In this manner the position of all activities, constraints and the sensitivity of group A farmers in with-project condition is determined from the optimal solution.

The optimal solutions received by model runs for different groups of farmers are included in Appendix III. Sensitivity of other groups of farmers (groups B, C, D and R) can be obtained from optimal solutions in the same way as described for group A above.

7.4 Conclusion

Discussion on the previous pages focused on the possible crop varieties. But the model runs gave range analysis as well as shadow costs for all the variables and limits as well as shadow prices for all the constraints. Selling activities of particular crops indicates the price sensitivity of the crop. Sensitivity of individual crop coefficients on overall net returns could be determined by varying the coefficient from a minimum value to a maximum possible value and plotting the net return against different levels of coefficient would give the importance of that particular coefficient on overall net return.

The results obtained by model runs are only indicative of what is possible as the sample taken was scanty for establishment of challenging ideas. But the results do provide some guidelines to thinking about the issues that need consideration before embarking on a massive investment program. These issues are to be addressed if sustainable agricultural growth is expected to be maintained. There is no doubt about the need for increased production through investment in flood protection but the distribution of welfare poses a great question mark. Because sometimes capital investing / saving technique might apparently increase the immediate output, but if it fails to increase the productivity of farmer in the long run it will lessen the capacity to invest and hence hinder ultimate growth. Increasing farmer productivity through production of high yielding varieties (HYV) will provide the basis for sustained agricultural output growth.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary

The main focus of this dissertation was on the decision making process of farmers under conditions of flood risk. Decision making processes of farmers was the main focus of this dissertation. Farming in Bangladesh, mostly for subsistence, may be a profitable or a losing concern, depending on the selection of an appropriate crop mix. In other words, farming depends on the decision making process of the farmers. The farm environment in a flood protected project area was described with its agro-socio-ecological linkages. Flood mitigation literature which described crop mix optimising technologies was reviewed. Theoretical details of different quantitative methods were brought together for the purpose of selection of an appropriate model that could capture the diversified interactions as much as possible. Concepts, data, and theories from relevant academic disciplines were utilised to address a set of problems related to decision making at the grass roots level.

The empirical component of this dissertation was mainly based on a survey of production relations in the Meghna Dhonagoda Irrigation Project, in Chandpur district of Bangladesh. The survey comprised randomly, but purposively, chosen farmer respondents within 5 groups to capture a generalisable picture of agricultural production relations within the project area.

A linear programming model was formulated incorporating the main farming activities possible and average resource endowments possessed by the five different groups of farmers estimated from the field survey. Optimal cropping patterns were found for each farmer group both with and without project conditions.

Results obtained from the model runs show that rice production on all farms increases by 140 to 383 percent with the project. At the same time, production of other crops diminishes significantly. The net year ending savings of group A (deficit) farmers decreases by 7 percent though their living standard is improved (as indicated by increased family rice consumption and expenses). Group B (small) farmers are in a slightly improving position, with a 1.5 percent increase in net year ending savings. The net year ending savings of groups C (medium) and D (large) doubles. The achievements of these two groups, as compared to that of the other two groups (groups A and B), shows the anomaly in welfare distribution of the public investments.

The impacts on net return due to changes in resource endowments or crop coefficients were obtained from sensitivity and range analysis.

Also, the increase in returns per hectare was compared. For example, a small farmer possesses 0.3 hectare of land with which his increase in year ending saving is Tk 340, that is 340/.3 = 1133 per hectare per year. A large farmer possesses 2.5 hectares of land through which his year ending saving is increased by Tk. 21420, that is 21420/2.5 = 8568 per hectare per year. But this comparison depends not only on land but on other resources as well.

Before implementation of the project, farmers often mixed different crops in the same field to reduce the risk if a particular crop failed. They grew a variety of staple crops and vegetables to meet family food needs, and they rarely purchased artificial chemical fertilisers or pesticides. In other words they were diversified and less susceptible to natural disasters. After the project, farmers grew more rice and fewer other crops, thus increasing their risk and use of inputs.

8.2 Conclusions

Three significant features of the public investment in flood protection and irrigation are:

(a) Rapid economic growth, though with significant evidence of diminishing return

(b) Increased rice production at the expense of other crops

(c) Unequal welfare distribution between rich and poor.

The results obtained through model runs conform to general trends in Bangladesh. All available evidence indicates that past activities on flood control and irrigation contributed significantly to the growth in agricultural production in Bangladesh. The complementarity between proven yield-increasing technologies and water application points out the importance of water resources development. Thus there should be no question about the desirability of flood control projects. But equitable distribution of facilities or at least betterment of the majority of population, may not be achieved at the desired rate by flood control projects.

The agricultural progress observed in the country after implementation of several development projects, especially flood control and irrigation, is an aggregate figure. From the results of this study it appears that the aggregate statistics could hide a large group of farmers who could not accelerate their economic growth through development projects - they are the small farmers raising food for their families on marginal land. Because their agriculture remains unproductive and vulnerable to increased input prices, failing to address their needs has slowed economic progress for them.

The early benefits of project implementation apparently are not equally shared. Relatively prosperous farmers who controlled more land and so had the financial means to purchase fertilisers, pesticides, and equipment, gain most by adopting high-yielding varieties. Small farmers who tend to adopt new varieties and technologies later, can profit but not as much.

Because of their traditional focus on improving yields, policymakers and researchers in Bangladesh have emphasised regions where the economic return on investment in agriculture would be the highest, rather than seeking to distribute public resources equitably throughout the country. This approach naturally overlooks the plight of farmers of other regions of the country, such as those considered in this study.

8.3 Policy Implications

Selection of strategies for agricultural development is a complex issue. The decisions required involve

* export versus food crop production,
* expansion of agricultural versus the agro-industrial sector,
* the role of external assistance, and the role of the private versus the public sector, and
* large versus small scale farming.

Sometimes, increasing domestic food production to achieve self-sufficiency may not be the proper policy, when comparative advantage lies in export crop production, such as shrimp culture, tea and venison. This may be true in particular when agricultural labour productivity is substantial in exportable crop production.

In Bangladesh, expansion of cash cropping for export is not always at the expense of staple food production. The saline land of the coastal area is suitable for shrimp culture where rice productivity is minimum. The hilly area of northeast is explicitly suitable for tea, whereas the southeast and southwest forests are suitable for deer farming.

Macro-economic policies have a direct and far reaching impact on producer and consumer economic activity, which in turn affects the incomes, resource allocation and investment decisions of individual farmers. The benefits of agricultural investments, including investment programs supporting environmental and natural resource management objectives, are sensitive to change in overall economic and agricultural policies.

Changes are essential for economic growth. New opportunities must be seized, and old ones, no longer profitable, discarded. Government policies can affect the ability of individuals and businesses to recognise profitable activities and to adapt. Government can dramatically influence the incentive for sustainable agriculture. Government policy on commodity prices, farmers' incentives, and input subsidies all have significant implications for erosion, pollution, and use of scarce resources. These policies include such things as fiscal measures, border protection, the operation of state-owned enterprises, and product or factor markets.

Just as the agricultural sector contributes to industrial development, the industrial sector provides a market for agricultural output and creates conditions which are favourable to enhance agricultural productivity (Johnston and Kilby, 1975). Both these sectors interact mutually and add to each other's development. For example, if small food industries like bread making or fish and chips supply is encouraged it will help in changing the food habits of the nation. In order to understand the process of transition from traditional agriculture, it is desirable to examine the nature and magnitude of various forward and backward linkages among various sectors of the economy.

For example, the macroeconomic goal of stimulating increased productivity of an agricultural commodity must be weighed not only against the overall national objective of sustaining agricultural development, but also against the impact of such a policy (and the pricing and other instruments used to implement it) on the sustainability, equity and stability of local production systems.

On these considerations, the best strategy may be a mixed one, emphasising continued promotion of food crop production coupled with selective specialisation in export crops to boost foreign exchange.

8.4 Recommendations

From this dissertation, three general comments can be made on agricultural development in Bangladesh through flood control and irrigation projects:

(i) Farmers with small or marginal holdings benefit less than wealthier farmers,

(ii) Intensive monocropping of rice may be more susceptible to environmental stresses and shocks, and

(iii) Already there is evidence of diminishing returns from intensive production with high yielding varieties and intensive chemical agricultural production. That is, the system may not be stable.

If 'sustainability' is a key issue for agricultural development strategy it will include the following :

* high, efficient and stable production
* low and inexpensive inputs, in particular making full use of the techniques of organic farming and indigenous traditional knowledge
* food security and self-sufficiency
* conservation of wildlife and biological diversity
* preservation of traditional values and small family farms
* help for poorest and disadvantaged (in particular those on marginal land, the landless, women, children and tribal minorities)
* a high level of participation in development decisions by the farmers themselves.

(Conway,G.R and Barbier,E.B 1990)

It is not easy to combine high sustainability with high productivity, stability and equity. Often there are several trade-offs which require explicit recognition and analysis.

The major problem confronting sustainability is the linkage among local production systems, domestic markets, and agro-ecological zones, which in turn are linked to the national level and to the outside world through international trade. Thus a shift in world prices or in national agricultural policies can exert powerful influences on the livelihoods of farming households. Similarly, a change in global climates, droughts and floods etc. could have a profound impact on local production.

Planners have to evaluate trade offs - productivity at the expense of equity, or sustainability at the expense of productivity. The problems of moving from the conceptual stage of evaluating this trade offs are so complex that much applied research must be completed to move fully understood the issues.

8.5 Limitations

Work reported in the previous chapters indicates changes which may occur due to a shift in resource levels or production relationships of different groups of farmers in one area of Bangladesh. These changes were identified based on some primary data collected from a flood control and irrigation project as well as secondary published / unpublished data in different reports. The model developed was only concerned with establishing optimum agricultural production plans under the assumption that the supply of resources for the agricultural sector was fixed. The study focused only on a limited number of the complex processes of agricultural development. Models are only a way of analysing a situation; they fully depend upon the assumptions made and nature of data (Chadee, 1991). It cannot be assured that the results obtained in the solution file of the computer must happen if the parameter is changed accordingly. It is nothing but a tool of analysis.

The purpose of the study was to provide a basis for analysis of alternative crop production levels and technologies in relation to flood protection and irrigation projects. The results obtained can be judged in relation to policy changes. However, the possible impacts of policies should be thoroughly checked prior to advocating or implementing policy.

This dissertation involves a number of oversimplified hypotheses which are required for understanding the nature of complex decision making process in the policy and their impact on the economy. It sheds light on some patterns in the chaotic and seemingly disconnected events in the practical and economic life of Bengali farmers in recent years within a flood protected area. For example, fiscal, monetary and exchange rate policies have a strong effect on the performance of farmers and the agricultural sector as a whole. These effects are especially important in relation to policies such as use of quantitative import restrictions and large changes in institutional arrangements, and those associated with trade and financial liberalisation programs. It is not possible to bring all the consequences in single model, so the results obtained after implementation of the project can never be attributed to only changes of crop coefficients or resource endowments.

8.6 Scope for further research

As emphasised by Langham "Farm level research is needed to better understand household behavior and to develop benchmark input-output information by regions, enterprises, and types of farms. Micro-analysis can provide insights into how micro units are likely to respond to a specific policy. And enterprise budgets can be used to support basic linear programming work to examine effects on farm income under varying market and resource conditions. It is also necessary to investigate transportation cost, other marketing cost and marketing margins. This information will help in assessing both the adequacies and efficiencies of markets." (Langham, 1985)

Economic analysis that is useful for guiding Government decisions is highly effective when supplemented by good judgement derived from experience of how human beings and institutions react. "Mathematics may allow us to describe the general outlines of a system of relationship as algebraic equations we can then always discover the specific numbers to replace the symbols to make the equations fit the particular situation we are concerned with. It does not follow at all in mathematical programming of economic events. The mesh of the net that economists can weave to catch economic reality is much coarser than that of the natural scientists in the realm (Kamarock, Andrew, 1983).

Further research required can be classified on the basis of the nature of the problem which is to be addressed such as i) those for maintaining sustainability, ii) those required to improve environmental degradation by monocropping, and iii) those that will address equity.

8.6.1 Sustainability considerations

Agricultural scientists have recently began to recognise that many farming systems that have persisted for millennia exemplify careful management of soil, water, and nutrients; precisely the methods required to make high -input farming practices sustainable. This overdue reappraisal stems in part from the need to use inputs more efficiently, and in part from the growing interest in biological technologies. Most traditional crop varieties have limited genetic potential for high grain yields. They are often large-leaved and tall, for example. These traits help farmers meet non food needs, supplying thatch, fuel, and fodder as well as food to farm household animals.

Biotechnologies offer promising tools for more resource efficient and sustainable agriculture. Several developing countries, formerly food importers, now have achieved food self-sufficiency and this has led some policymakers to question the value of assisting poor countries to increase food production further. But for Third World farmers who never shared in the agricultural advances of the green revolution , the issue is still economic survival (Wolf 1986).

Intercropping, agroforestry, shifting cultivation, and other traditional farming methods mimic natural ecological processes, and the sustainability of many traditional practices lies in the ecological models they follow. In pursuit of higher productivity, many agricultural scientists overlooked the need for long-term sustainability and this must change.

For example, farmers who plant high-yielding varieties of wheat and rice need continuous research to sustain their yields. Promising approaches for Bangladeshi farmers include the nitrogen-fixing blue-green algae sustained by a fern called Azolla that thrives in flooded rice paddies, and types of bacteria that could enhance soil fertility.

8.6.2 Environmental considerations

Regenerative approaches seek to maximise biological contributions to agricultural productivity. They make the most of natural resources such as nitrogen, phosphorus, and potash, as well as the way these nutrients are cycled and conserved in natural ecosystems. Regenerative farming practices include sowing different crops together to use fully the soil's fertility, rotating food grains with nitrogen-fixing legumes, and planting trees and shrubs whose roots draw nutrients from deep soil layers to the surface. Agricultural research that emphasises biological approaches to raising productivity can help poor farmers better cope with the risks imposed by erratic rainfall and less fertile soils.

A new strategy of efficiency and regeneration could help meet the needs of subsistence farmers, and begin to address the environmental and economic problems linked to more intensive cropping practices as well. Such a strategy would stress the efficient use of fertilisers, chemicals, water, and mechanised equipment. As a supplement to efficiency, farmers could blend biological technologies and traditional farm practices to increase the contribution that the land's natural fertility makes to food production.

On the other hand, farmers achieve less than optimum production when they apply the nitrogen, phosphorus, and potash in incorrect proportions. The productive potential of internal resources of land is some times masked or even diminished by heavy use of artificial fertilisers and other farm chemicals.

8.6.3 Equity considerations

For consideration of equity, research is required as to whether emphasis should be shifted from food grain self-sufficiency to labour-intensive light agro-industry manufacturing sector, relying on a combination of domestic human resources and efficient foreign capital investment, such as that pursued in South Korea. Such a shift will provide employment to rural landless and the benefits of public investments could trickle down to the poor. At that time the agriculture sector will continue to play a critical role as a supplier of food and resources to the nonagricultural sector and also provide a domestic market for agro-industrial produces.

The biggest losers in agriculture have been farmers in areas where new crop varieties performed poorly, and those growing crops primarily for subsistence. These farmers earned no new income from bigger harvests, and may have become poorer as prices for their occasional marketable surplus declined as well as farming expenditures increased.

The most significant factor that will affect the direction of agricultural biotechnology is the rapid shift of research from the public to the private sector. Research efforts on crops will be proportional to the value of the crop and the size of the market. Because improving crops for small farmers in developing countries means producing low-cost agronomic innovations, many of which must be site-specific and thus not suitable for mass-marketing, crop improvements for the vast majority of the world's farmers offer little profit. Few private companies are likely to enter such an unpromising market.

Study programs can be taken to develop an adequate analytical framework or an approach that shows how the benefits of the development process can be effectively extended to the small farmers, landless labourers and non-farm workers, who constitute the poor majority of the country's rural population. An analytical basis for choices among alternative investment and policy options will be able to somewhat offset the process of imprecise identification of goals and subjective evaluations of expected results.

According to Conway "In most situations equity is affected not only by the distribution of products but also by the distribution of costs." Implementation costs of the project are borne by the whole nation whereas only a group of people receive benefits of the project. Not only that, most of the operation and maintenance costs of the completed projects are provided from the Treasury. So methodology should be formulated to distribute the operation and maintenance costs of the project over the beneficiaries and impose an appropriate tax to recover part of the implementation cost. Policy formulation based on a market economy could improve the welfare of society.

Planners face several types of uncertainty in the present situation. Two of the major uncertainties include world conditions which influence import markets outside Bangladesh and the degree of success of programmes for agriculture.

Developing countries are generally characterised by the inefficiency of their marketing systems, so that if farmers do not receive an economic return from the sale of their marketable surplus production, they will tend to produce at the subsistence level only (Arnon, 1981).

In low income countries, the resources generated by a high rate of growth can contribute markedly to increase equity and stability. Indeed, it may be only through growth that a low income country can marshal the resources necessary to improve conditions for the large proportion of its population in absolute poverty or to reduce the instability that results when a large proportion of national income is subject to the vagaries of weather and wildly fluctuating international commodity prices (Mellor, J.W and Ahmed, R.U 1989).

APPENDIX I

THE QUESTIONNAIRES USED FOR DATA COLLECTION AND SURVEY

A : FARM SIZE AND RESOURCE POSITION
(FORMS TO BE FILLED IN FOR INDIVIDUAL FARMER)

1. *Land*

a. How much cultivable land do you have ? acre decimal

b. How much land do you cultivate yourself? b.

c. (+) How much land do you rent out ? c.
or(-) you rent in ? (b + c = a)

d. Types of your cultivable land
high medium low flood plain others

e. Price of your land
high medium low flood plain others

f. Terms of share cropping -
Portion for Farmer Portion for landlord Portion for Inputs

g. Amount of Tax imposed per acre for the benefit of the Project

2. *Draft Power*

a. How many numbers of draft power do you have ?

b. Bafellow c. Bullock d. Cow e.Other

f. Do you use cows for ploughing ? Yes No

3. *Labour Force*

a. How many of your family members work in the field ?
b. How many permanent labours are attached to your family ?
c. Their monthly salary ?
d. Approximate value of food given to them in a month ?

4. *Irrigation Facilities*

a. Do you have your own pump ?
if yes,
i) How long it was used to irrigate which crop at a cost of :-
season crop area(ac) O&M cost
ii) Initial cash Installment for capital for interest

b. Do you have access to any irrigation source ?
(like DTW, LLP, others STW, or own manual device)
specify type cost/acre/season limitation

5. *Manure and Fertilizer*

a. Cow dung and composed used per year (in mounds)
own bought at a cost of

b. Do you purchase chemical fertilizer at the beginning of the season? If so please specify -

Type	Quantity	Av.price/kg	remarks on availability
Urea			
TSP			
MP			
Sulpher			
Zinc			
Pesticide			
Others.			

6. *Capital*

a. How much money do you spend from your own source per season?

b. How much you can borrow per season from -

i) Bank at an interest rate of
ii) Others at an interest rate of

7. *Crop mix*

How many of the following crops could you grow in your farm without implementation of this project. Please give detail information as much you can. Please fill in a separate form for crops of different years (before and after implementation of the project.

For the standing crops of this year please mention expected costs and expected returns).

<u>Name of the Crops with Serial Numbers</u>
(please use this serial number of the crop in the B form).

(1) Broadcast Aus,
(2) High Yielding Variety of Aus,
(3) Jute,
(4) High Yielding Variety of Aman,
(5) Local Transplanted Aman,
(6) Local Boro,
(7) High Yielding Variety of Boro,
(8) High Yielding Variety of Wheat,
(9) Potato,(please specify if there is scope for Cold Storage and its cost per mound),
(10) Pulses (Masuri),
(11) Oil Seed (Sharisha),
(12) Onion,
(13) Vegetables (Cauliflower / cabbage), (14) Sugercane,(please specify if there is scope for molacess production and its return per acre),
(15) Broadcast Aman,
(16) Others
a) Without Project b) With Project

8. Living Cost and Family Consumption

a. How much paddy do you produce in your farm per year ?
b. How much is consumed by the family as food ?
c. Is there any scope for off-farm activities in a year?
d. How much is earned in a year ?

9. Benefit of the Project

What are the other benefits (other than the changes in cropping pattern, irrigation availability) received from the project ? (Like protection of the homestead from flood, better transportation and communication system, marketing facilities, etc. Please specify).

10. Demerits of the project.

(Like water logging, reduction of soil fertility due to flood protection, fishery losses, etc. Please specify which is applicable to you and try to quantify).

11. Environmental Impact.

Do you suspect about any environmental disaster is associated with the implementation of the project or in adopting the changed agricultural practices (like increase of insect pest and mosquto, desertification, reaction on public health through contaminated water,etc)? If so, please describe in details and try to quantify.

Signature of the farmer

FORM B: CROP COEFFICIENTS
(FORMS TO BE FILLED IN FOR EACH CROP)

12. *Name of the crop.*

Dates of- Planting/sowing harvesting

13. *Area planted*

Total Own Hired Rent/acre (for hired)

14. *Draft Power used for land preparation*

Total Own Hired Rent/pair-day (for hired)

15. *Water required for land preparation (cost incurred)*

Total Own Hired Cost/acre (for hired)

16. *Manpower used for planting / sowing*

Total Own Hired Wage/man-day (for hired)

17. *Seed / seedling used per acre*

Total Own Hired Cost/unit (for hired)

18. *Manpower used for inter culture operations, like weeding, mulching, top dressing, spraying, etc.*

Total Own Hired Wage/man-day (for hired)

19. *Irrigation cost*

Total Own Hired Cost/acre (for hired)

20. *Harvesting (please answer either a or b)*

a. Manpower used for harvesting (bringing up to the yard manually) -

Total Own Hired Wage/man-day (for hired)

b. Manpower used for harvesting (bringing up to the yard by craft) -

Total Own Hired Wage/man-day (for hired)

c. Cost and number of animals required for transportation

Total Own Hired Rent/pair-day (for hired)

21. *Manpower and animal used for processing*

Total Own Hired Wage/man-day (for hired)

a. Man power
b. Animal Rent/pair-day (for hired)

22. *Fertilizer and Pesticide used per acre*

Type	Quantity	Average price/acre	Remarks
Urea			
TSP			
MP			
Sulpher			
Zinc			
Pesticide			
Others .			

23. *Yield per acre*

a. Yield of crop (mounds) b. Yield of Byproduct (mounds)

24. *Price per mound of*

a. Crop b. Byproduct

____

Signature of the farmer

Name and Address of the farmer

APPENDIX II

SUMMARY OF THE FINDINGS OF FIELD SURVEY

Table II.1 : **Average resources endowments possessed by different groups of farmers in the project area**

	articulars of item	unit	Amount of Possession by different groups					Remarks
			A	B	C	D	R	
	Cultivable Land	acre	0.72	1.82	3.41	5.88	3.00	Survey Data
		hectare	0.30	0.75	1.50	2.50	1.00	Approximate
	No. draft Animal	pair	0	1	2	3	1	Survey Data
	Milking Cows	No.	1	2	1	2	2	Survey Data
	Family Labor	No.	1	1	0	0	1	
	Attached with Fa	No.						
	Without project Condi'n		0	0	1	1	0	
	With Project Condition		.33	1	2	2	1	
	Wage/labor/month	Tk.		800	625	525	650	Survey Data
	Food Cost/lab/m	Tk.		600	488	500	529	Survey Data
	Annual Farm Exp.	Tk.1000						
	Without project Condi'n		3.80	6.44	12.85	17.92	10.26	Survey Data
	With Project Condition							
	Family Expend.	Tk.1000						
	Without project Condi'n		6	6	15	24	10	
	With Project Condition		9	12	28	27	15	
).	Own Capital	Tk.1000	5	10	15	20	12	
I.	Borrowed Capi.	Tk.1000	5	5	5	10	5	
?.	Off Farm Income	Tk.1000	9.37	17.50	18.25	10	13.78	Survey Data
3.	Annual Rice Prod'n Ton							
	Without project Condi'n		5.13	4.18	5.83	7.73	5.19	Calculated
	With Project Condition		12.37	18.89	28.16	28.85	13.36	Calculated
l.	Family Consump'n							
	Without project Condi'n		3	3	4.4	5.2	4.4	
	With Project Condition		3.5	8.5	10	9	7.4	
i.	Annuity	Tk.1000						
	Without project Condi'n		9	9	15	25	15	
	With Project Condition		14	18	20	30	25	
i.	Wage of daily Labor Tk/day							
	Without project Condi'n		30	30	30	30	30	
	With Project Condition		40	40	40	40	40	
'.	Int.Rate for 1 season %							
	Without project Condi'n		10	10	10	10	10	
	With Project Condition		10	10	20	20	10	
3.	Land Rent/season Tk.1000/H							
	Without project Condi'n		3	3	3		3	
	With Project Condition		4	4	4		4	

Table II.2 : **Distribution of Farms According to the Size of Cultivation Area**

Size of the farm	Group	Number of Farms	Total Irri-gable area in hectare	% of total farm	% of cultivable land
Up to 1 acre(.4 ha)	A	14,200	4,250	58	30
1 >area<2.5ac(upto 1 ha)	B	8,500	6,400	35	45
2.5 >area<5ac(upto 2 ha)	C	950	1,400	3.9	10
area > 5 ac (> 2 ha)	D	850	2,150	3.1	15
Total		24,500	14,200	100	100

Table I-2.3 shows the average resource limit and input output coefficients of the crops grown by the small farmers (Group A) before project implementation. The net return shown in the table is tentative. Because it does not include the combination of other activities done in between cropping like rearing cattle, using managerial skill, etc.

Table II.3 : **The input output coefficients of the crops grown before project implementation by Group A farmers**

Vari/actrela.LIMIT			L1	L3	L6	L8	L9	L10	L11	L12	L15
No. of farms considered			2	8	2	6	4	4	12	2	12
Activities		Unit									
Net.ret		TK'000/H	1.37	4.47	5.11	3.65	4.81	7.21	5.28	21.66	7.22
Yld(c)		TON/Ha	1.80	1.73	2.49	2.23	5.07	1.01	1.01	4.84	2.95
Yld(byp)		T/Ha	2.07	2.94	2.30	2.17	0	2	1.75	0	2.10
Price(c)		TK'000/T	4.42	5.91	4.42	4.02	4.10	9.41	9.32	6.16	4.93
Pric(byp)		TK'000/T	0.27	0.52	0.42	0.55	0	0.5	0.34	0	0.41
T.Prdn.Cost		TK'000	7.13	7.28	6.86	6.49	15.98	3.35	4.70	8.18	8.19
Cash spent		TK'000	4.77	4.14	4.43	3.97	7.89	1.57	2.34	3.90	5.93
F&pest.Cost		TK'000	0.74	2.52	1.40	1.95	2.58	0.68	1.11	0.77	1.27
constraints											
LAND1	R1	< = 0.3	1	1							1
LAND2	R2	< = 0.3									1
LAND3	R3	< = 0.3			1	1	1	1	1	1	
HRL1	R4	< = 1									
HRL2	R5	< = 1									
HRL3	R6	< = 1									
LAB1	R7	< = 120	142	145							90
LAB2	R8	< = 120									87
LAB3	R9	< = 120			184	111	211	67	102	172	
HLB1	R10	< = 120									
HLB2	R11	< = 120									
HLB3	R12	< = 120									
HDP/DP1	R13	< = 50	43	41							34
HDP/DP2	R14	< = 50									
HDP/DP3	R15	< = 50			35	25	66	15	21	25	
INI.CAP	R16	< = 5	0.74	2.52							1.27
CAPI2	R17	< = 0									
CAPI3	R18	< = 0			1.40	1.95	4.31	0.68	1.11	0.77	
BORROW1	R19	< = 5									
BORROW2	R20	< = 5									
BORROW3	R21	< = 5									
FA.EXP1	R22	> = 2									
FA.EXP2	R23	> = 2									
FA.EXP3	R24	> = 2									
R.CONS	R25	> = 2									
ANNUITY	R26	> = 10									

L 1 = Production of Brodcast Aus
L 3 = Production of Jute
L 6 = Production of Local Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L12 = Production of Onion
L15 = Production of Brodcast Aman

Table I-2.4 shows the average resource limit and input output coefficients of the crops grown by the medium farmers (Group B) before project implementation.

Table II.4 : **The input output coefficients of the crops grown before project implementation by Group B farmers**

Activities			L3	L8	L9	L10	L11	L15
No. of farms considered			6	6	5	3	11	12
Variables		UNIT						
Net.Ret		TK'000/H	3.94	2.41	5.64	4.48	3.69	4.37
Yld(c)		TON/Ha	1.66	2.35	4.80	0.89	0.92	2.67
Yld(byp)		TON/Ha	3.18	2.04	0	1.29	.18	1.48
Price(c)		TK'000/T	6.81	4.15	3.97	9.82	9.65	4.82
Pric(byp)		TK'000/T	0.63	0.40	0	0.36	0.07	0.40
T.Prdn.Cost		TK'000/H	9.35	8.18	13.37	4.74	5.22	9.12
Cash spent		TK'000/H	6.19	2.95	4.05	3.47	1.46	4.27
F&pest.Cost		TK'000/H	3.11	1.61	2.08	0.87	0.62	0.61
constraints								
	Rela.	Limit						
LAND1	R1	< = 0.75	1					1
LAND2	R2	< = 0.75						1
LAND3	R3	< = 0.75		1	1	1	1	
HRL1	R4	< = 1						
HRL2	R5	< = 1						
HRL3	R6	< = 1						
LAB1	R7	< = 240	202					100
LAB2	R8	< = 240						108
LAB3	R9	< = 240		132	203	107	101	
HLB1	R10	< = 120						
HLB2	R11	< = 120						
HLB3	R12	< = 120						
HDP/DP1	R13	< = 100	38					37
HDP/DP2	R14	< = 100						
HDP/DP3	R15	< = 100		39	65	28	27	
INI.CAP	R16	< = 10	3.11					0.61
CAPI2	R17	< = 0						
CAPI3	R18	< = 0		1.61	3.00	0.87	0.62	
BORROW1	R19	< = 5						
BORROW2	R20	< = 5						
BORROW3	R21	< = 5						
FA.EXP1	R22	> = 3						
FA.EXP2	R23	> = 3						
FA.EXP3	R24	> = 4						
R.CONS	R25	> = 4						
ANNUITY	R26	> = 20						

L 3 = Production of Jute
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L15 = Production of Brodcast Aman

Table X2.5 shows the average resource limit and input output coefficients of the crops grown by the large farmers (Group C) before project implementation.

Table II.5 **The input output coefficients of the crops grown before project implementation by Group C farmers**

Variables		Unit	L3	L6	L8	L9	L10	L11	L12	L15
No. of farms consi'd			10	3	5	10	8	13	3	12
Net.Ret		TK'000/H	2.84	2.14	2.68	3.54	5.27	3.28	22.60	1.96
Yld(c)		TON/Ha	1.41	2.46	1.94	4.70	1.22	0.89	6.61	2.58
Yld(byp)		TON/Ha	2.30	2.15	0	0	0	0	0	2.06
Price(c)		TK'000/T	6.51	4.11	4.82	3.67	9.11	10.74	4.82	4.69
Pric(byp)		TK'000/T	0.72	0.36	0	0	0	0	0	0.31
T.Prdn.Cost		TK'000/H	8.01	8.73	6.66	13.72	5.86	6.25	9.27	10.8
Cash spent		TK'000/H	2.55	2.59	1.16	3.10	1.13	1.86	2.68	2.76
F&pest.Cost		TK'000/H	1.01	0.98	0.87	1.29	0.98	1.03	1.37	0.71
constraints		Limit								
LAND1	R1	<= 1.5	1							1
LAND2	R2	<= 1.5								1
LAND3	R3	<= 1.5		1	1	1	1	1	1	
HRL1	R4	<= 0.5								
HRL2	R5	<= 0.5								
HRL3	R6	<= 0.5								
LAB1	R7	<= 240	188							90
LAB2	R8	<= 240								84
LAB3	R9	<= 240		183	122	190	107	109	203	
HLB1	R10	<= 240								
HLB2	R11	<= 240								
HLB3	R12	<= 240								
DP1	R13	<= 200	36							37
DP2	R14	<= 200								
DP3	R15	<= 200		30	39	57	42	39	49	
INI.CAP	R16	<= 15	1.01							0.71
CAPI2	R17	<= 0								
CAPI3	R18	<= 0		0.98	0.87	2.60	0.98	1.03	1.37	
BORROW1	R19	<= 5								
BORROW2	R20	<= 5								
BORROW3	R21	<= 5								
FA.EXP1	R22	>= 6								
FA.EXP2	R23	>= 6								
FA.EXP3	R24	>= 6								
R.CONS	R25	>= 5								
ANNUITY	R26	>= 20								

L 3 = Production of Jute
L 6 = Production of Local Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L12 = Production of Onion
L15 = Production of Brodcast Aman

Table I-2.6 shows the average resource limit and input output coefficients of the crops grown by the big farmers (Group D) before project implementation.

Table II.6 : **The input output coefficients of the crops grown before project implementation by Group D farmers**

Variables		Unit	L3	L6	L8	L9	L10	L11	L12	L15
No. of farms consi'd			12	7	8	1	7	12	4	10
Net.Ret		TK'000/H	1.13	3.94	1.29	2.86	6.51	2.40	20.39	3.99
Yld(c)		TON/Ha	1.51	3.41	1.87	4.61	1.12	0.96	7.49	2.30
Yld(byp)		TON/Ha	2.00	1.84	0	0	0.17	0	0	1.14
Price(c)		TK'000/T	6.70	4.21	4.62	3.75	11.68	10.75	3.95	4.96
Pric(byp)		TK'000/T	0.74	0.27	0	0	0.19	0	0	0.27
T.Prdn.Cost		TK'000/H	10.43	10.92	7.35	14.43	6.60	7.93	9.23	7.70
Cash spent		TK'000/H	3.34	3.96	1.96	4.21	1.15	1.82	3.08	2.10
F&pest.Cost		TK'000/H	1.19	1.68	1.28	1.57	1.15	1.04	1.50	0.89
constraints Limit										
LAND1	R1	< = 2.5	1							1
LAND2	R2	< = 2.5								1
LAND3	R3	< = 2.5		1	1	1	1	1	1	
HRL1	R4	< = 0								
HRL2	R5	< = 0								
HRL3	R6	< = 0								
LAB1	R7	< = 240	180							70
LAB2	R8	< = 240								91
LAB3	R9	< = 240		177	108	225	88	111	145	
HLB1	R10	< = 360								
HLB2	R11	< = 360								
HLB3	R12	< = 360								
DP1	R13	< = 300	34							37
DP2	R14	< = 300								
DP3	R15	< = 300		35	27	47	38	36	40	
INI.CAP	R16	< = 20	1.19							0.89
CAPI2	R17	< = 0								
CAPI3	R18	< = 0		1.68	1.28	3.11	1.15	1.04	1.50	
BORROW1	R19	< = 10								
BORROW2	R20	< = 10								
BORROW3	R21	< = 10								
FA.EXP1	R22	> = 9								
FA.EXP2	R23	> = 9								
FA.EXP3	R24	> = 9								
R.CONS	R25	> = 8								
ANNUITY	R26	> = 30								

L 3 = Production of Jute
L 6 = Production of Local Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L12 = Production of Onion
L15 = Production of Brodcast Aman

Table I-2.7 shows the average resource limit and input output coefficients of the crops grown by an average farmer (Group R) before project implementation.

Table II.7 : The input output coefficients of the crops grown before project implementation by an average farmer

Variables	Unit	L3	L6		L8	L9	L10	L11	L12	L15
No. of farms consi'd			36	12	25	20	22	48	9	46
Net.Ret	TK'000/H		3.10	3.73	.512	4.22	5.87	3.66	22.36	4.73
Yld(c)	TON/Ha		1.57	2.77	2.10	4.80	1.06	0.94	6.27	2.74
Yld(byp)	TON/Ha		2.58	2.12	2.12	0	1.20	1.01	0	1.66
Price(c)	TK'000/T		6.48	4.25	4.40	3.87	9.99	10.10	4.98	4.85
Pric(byp)	TK'000/T		0.64	0.35	0.48	0	0.35	0.21	0	0.35
T.Prdn.Cost	TK'000/H		8.77	8.83	7.17	14.38	5.14	6.02	8.89	8.95
Cash spent	TK'000/H		3.98	3.66	2.51	4.81	1.83	1.87	3.22	3.77
F&pest.Cost	TK'000/H		1.96	1.35	1.43	1.88	0.94	0.95	1.21	0.87
constraints Limit										
LAND1 R1	< = 1		1							1
LAND2 R2	< = 1									1
LAND3 R3	< = 1			1	1	1	1	1	1	
HRL1 R4	< = 0.5									
HRL2 R5	< = 0.5									
HRL3 R6	< = 0,5									
LAB1 R7	< = 120		178							80
LAB2 R8	< = 120									100
LAB3 R9	< = 1205			180	119	208	91	106	173	
HLB1 R10	< = 240									
HLB2 R11	< = 240									
HLB3 R12	< = 240									
HDP/DP1 R13	< = 100		37							37
HDP/DP2 R14	< = 100									
HDP/DP3 R15	< = 100			32	32	59	30	30	37	
INI.CAP R16	< = 12		1.96							0.87
CAPI2 R17	< = 0									
CAPI3 R18	< = 0			1.35	1.43	3.25	0.98	0.95	1.21	
BORROW1 R19	< = 5									
BORROW2 R20	< = 5									
BORROW3 R21	< = 5									
FA.EXP1 R22	> = 3									
FA.EXP2 R23	> = 3									
FA.EXP3 R24	> = 3									
R.CONS R25	> = 4									
ANNUITY R26	> = 20									

L 3 = Production of Jute
L 6 = Production of Local Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L12 = Production of Onion
L15 = Production of Brodcast Aman

Table I-2.8 shows the average resource limit and input output coefficients of the crops grown by the small farmers (Group A) after project implementation.

Table II.8 : The input output coefficients of the crops grown after project implementation by Group A farmers

Variables	Unit	L1	L2	L4	L5	L7	L8
No.of farms considered		8	8	11	9	11	1
Net.Ret	TK'000/H	3.99	7.98	9.38	8.66	7.22	0.62
Yld(c)	TON/Ha	2.57	3.41	3.60	3.25	3.69	2.77
Yld(byp)	TON/Ha	1.61	1.95	0.77	1.79	2.05	1.84
Price(c)	TK'000/T	5.96	5.73	6.02	6.16	5.76	5.36
Pric(byp)	TK'000/T	0.38	0.42	0.46	0.42	0.68	0.27
T.Prdn.Cost	TK'000/H	11.95	12.38	12.65	12.11	15.43	14.70
Cash spent	TK'000/H	6.50	7.28	7.87	6.62	10.24	7.52
F&pest.Cost	TK'000/H	1.78	2.79	1.91	2.22	2.76	1.48
constraints Limit							
LAND1 R1	< = 0.3	1	1				
LAND2 R2	< = 0.3			1	1		
LAND3 R3	< = 0.3					1	1
HRL1 R4	< = 1						
HRL2 R5	< = 1						
HRL3 R6	< = 1						
LAB1 R7	< = 120	154	188				
LAB2 R8	< = 120			161	166		
LAB3 R9	< = 120					223	136
HLB1 R10	< = 120						
HLB2 R11	< = 120						
HLB3 R12	< = 120						
HDP/DP1 R13	< = 50	35	33				
HDP/DP R14	< = 50			44	38		
HDP/DP3 R15	< = 50					40	39
INI.CAP R16	< = 5	1.78	2.79				
CAPI2 R17	< = 0			1.91	2.22		
CAPI3 R18	< = 0					2.76	1.48
BORROW1 R19	< = 5						
BORROW2 R20	< = 5						
BORROW3 R21	< = 5						
FA.EXP1 R22	> = 2						
FA.EXP2 R23	> = 2						
FA.EXP3 R24	> = 2						
R.CONS R25	> = 2						
ANNUITY R26	> = 10						

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 7 = Production of High Yielding Variety of Boro
L 8 = Production of High Yielding Variety of Wheat

Table II.9 shows the average resource limit and input output coefficients of the crops grown by the medium farmers (Group B) after project implementation.

Table II.9 : **The input output coefficients of the crops grown after project implementation by Group B farmers**

Variables		Unit	L1	L2	L3	L4	L5	L6	L7	L11
No.of farms consi'd			4	10	2	11	7	2	9	2
Net.Ret		TK'000/H	4.47	7.48	6.27	8.08	5.94	4.12	2.48	6.50
Yld(c)		TON/Ha	3.09	4.09	1.94	4.35	3.79	2.90	5.74	1.15
Yld(byp)		TON/Ha	1.72	1.81	5.07	1.49	1.78	2.90	3.02	0
Price(c)		TK'000/T	5.36	5.71	8.57	5.70	5.55	5.36	5.36	12.06
Pric(byp)		TK'000/T	0.27	0.42	0.54	0.78	0.38	0.39	0.54	0
T.Prdn.Cost		TK'000/H	12.55	16.64	13.06	17.88	15.80	12.57	21.38	7.40
Cash spent		TK'000/H	4.88	7.12	7.75	8.05	7.35	5.79	11.38	2.20
F&pest.Cost		TK'000/H	1.82	2.96	3.16	2.60	2.21	2.90	4.15	1.58
constraints Limit										
LAND1	R1	< = 0.75	1	1	1					
LAND2	R2	< = 0.75				1	1			
LAND3	R3	< = 0.75						1	1	1
HRL1	R4	< = 1								
HRL2	R5	< = 1								
HRL3	R6	< = 1								
LAB1	R7	< = 240	151	215	184					
LAB2	R8	< = 240				219	217			
LAB3	R9	< = 240						178	318	85
HLB1	R10	< = 120								
HLB2	R11	< = 120								
HLB3	R12	< = 120								
HDP/DP1	R13	< = 100	38	46	32					
HDP/DP	R14	< = 100				48	46			
HDP/DP3	R15	< = 100						49	38	38
INI.CAP	R16	< = 10	1.82	2.96	3.16					
CAPI2	R17	< = 0				2.60	2.21			
CAPI3	R18	< = 0						2.90	4.15	1.58
BORROW1	R19	< = 5								
BORROW2	R20	< = 5								
BORROW3	R21	< = 5								
FA.EXP1	R22	> = 3								
FA.EXP2	R23	> = 3								
FA.EXP3	R24	> = 4								
R.CONS	R25	> = 4								
ANNUITY	R26	> = 15								

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 3 = Production of Jute
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 6 = Production of Local Variety of Boro
L 7 = Production of High Yielding Variety of Boro
L11 = Production of Oilseeds

Table II.10 shows the average resource limit and input output coefficients of the crops grown by the large farmers (Group C) after project implementation.

Table XII.10 : **The input output coefficients of the crops grown after project implementation by Group C farmers**

Variables		Unit	L1	L2	L3	L4	L5	L	L9
No.of farms consi'd			8	10	5	11	9	12	1
Net.Ret		TK'000/H	4.37	7.33	2.68	4.79	3.25	7.49	4.08
Yld(c)		TON/Ha	3.24	4.21	1.79	4.87	3.69	4.15	5.07
Yld(byp)		TON/Ha	1.84	2.53	2.12	4.44	1.67	2.81	0
Price(c)		TK'000/T	5.69	6.00	8.90	5.82	5.81	5.89	5.89
Pric(byp)		TK'000/T	0.27	0.52	0.64	0.39	0.52	0.47	0
T.Prdn.Cost		TK'000/H	14.57	19.29	14.59	25.30	19.03	23.32	25.82
Cash spent		TK'000/H	4.31	6.06	6.48	11.84	6.21	8.08	12.73
F&pest.Cost		TK'000/H	2.48	3.18	2.14	2.92	2.41	3.41	4.32
constraints		Limit							
LAND1	R1	<= 1.5	1	1	1				
LAND2	R2	<= 1.5				1	1		
LAND3	R3	<= 1.5						1	1
HRL1	R4	<= 0.5							
HRL2	R5	<= 0.5							
HRL3	R6	<= 0.5							
LAB1	R7	<= 240	149	213	219				
LAB2	R8	<= 240				205	209		
LAB3	R9	<= 240						218	222
HLB1	R10	<= 240							
HLB2	R11	<= 240							
HLB3	R12	<= 240							
DP1	R13	<= 200	51	49	41				
DP2	R14	<= 200				51	51		
DP3	R15	<= 200						53	49
INI.CAP	R16	<= 15							
CAPI2	R17	<= 0							
CAPI3	R18	<= 0							
BORROW1	R19	<= 5							
BORROW2	R20	<= 5							
BORROW3	R21	<= 5							
FA.EXP1	R22	>= 6							
FA.EXP2	R23	>= 6							
FA.EXP3	R24	>= 6							
R.CONS	R25	>= 5							
ANNUITY	R26	>= 20							

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 3 = Production of Jute
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 7 = Production of High Yielding Variety of Boro
L 9 = Production of Potato

Table II.11 shows the average resource limit and input output coefficients of the crops grown by the big farmers (Group D) after project implementation.

Table II.11 : **The input output coefficients of the crops grown after project implementation by Group D farmers**

Variables	Unit		L1	L2	L4	L5	L6	L7	L8	L9	L10	L11	L14
No.of farms consi'd			5	10	11	11	4	9	2	1	1	3	2
Net.Ret	TK'000/H		5.09	5.41	4.84	2.04	3.92	4.38	1.36	5.70	15.99	0.17	19.71
Yld(c)	TON/Ha		3.73	4.10	4.21	3.73	3.23	4.30	2.86	4.80	1.38	.98	55.33
Yld(byp)	TON/Ha		1.84	2.67	2.66	2.15	2.33	2.92	0	0	0.46	0	2.77
Price(c)	TK'000/T		5.76	5.69	6.07	6.23	5.49	5.54	5.36	5.36	21.44	12.5	0.78
Pric(byp)	TK'000/T		0.32	0.48	0.41	0.71	0.27	0.28			0.54		0.60
T.Prdn.C	TK'000/H		17.0	19.2	21.8	22.8	14.4	20.3	14.0	20.0	13.9	12.1	25.0
Cash spnt	TK'000/H		4.10	7.30	6.78	6.71	4.30	8.50	3.04	7.20	2.30	2.77	10.75
F&p.Cost	TK'000/H		2.59	3.70	2.68	2.64	2.27	3.20	1.52	2.15	2.30	2.15	1.89
constraints		Limit											
LAND1	R1	<= 2.5	1	1									1
LAND2	R2	<= 2.5		1	1							1	
LAND3	R3	<= 2.5				1	1	1	1	1	1	1	
HRL1	R4	<= 0											
HRL2	R5	<= 0											
HRL3	R6	<= 0											
LAB1	R7	<= 240	155	196									150
LAB2	R8	<= 240			244	227							75
LAB3	R9	<= 240					178	237	132	222	124	115	219
HLB1	R10	<= 360											
HLB2	R11	<= 360											
HLB3	R12	<= 360											
DP1	R13	<= 300	41	51									
DP2	R14	<= 300			46	44							
DP3	R15	<= 300					39	46	47	49	40	32	54
INI.CAP	R16	<= 20											
CAPI2	R17	<= 0											
CAPI3	R18	<= 0											
BORROW1	R19	<= 10											
BORROW2	R20	<= 10											
BORROW3	R21	<= 10											
FA.EXP1	R22	>= 9											
FA.EXP2	R23	>= 9											
FA.EXP3	R24	>= 9											
R.CONS	R25	>= 8											
ANNUITY	R26	>= 30											

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 6 = Production of Local Variety of Boro
L 7 = Production of High Yielding Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L14 = Production of Sugarcane

Table II.12 shows the average resource limit and input output coefficients of the crops grown by an average farmer (Group R) after project implementation.

Table II.12 : **The input output coefficients of the crops grown after project implementation by an average farmer**

Variables	Unit	Limit	L1	L2	L3	L4	L5	L6	L7	L8	L9	L11	L14
No. of farms cons			25	38	4	44	34	6	41	3	2	5	2
Net.Ret	TK'000/H		4.45	7.05	4.48	6.77	4.97	4.02	5.39	1.12	4.89	3.81	19.7
Yld(c)	TON/Ha		3.14	3.96	1.86	4.26	3.60	3.06	4.29	2.86	4.93	1.11	55.3
Yld(byp)	TON/Ha		1.75	2.14	3.60	2.30	1.84	2.58	2.67	0.92	0	0	2.77
Price(c)	TK'000/T		5.71	5.78	8.74	5.89	5.94	4.43	5.64	5.36	5.63	12.27	0.78
Pric(byp)	TK'000/T		0.32	0.46	0.59	0.51	0.51	0.32	0.48	0.13	0	0.16	0.6
T.Prdn.C	TK'000/H		14.01	15.1	13.8	19.4	17.4	13.5	20.5	14.3	22.9	9.77	25.0
Cash spnt	TK'000/H		4.95	6.83	7.12	8.64	6.72	5.05	9.55	5.28	9.96	2.49	10.8
F&p.Cost	TK'000/H		2.16	2.98	2.65	2.53	2.37	2.58	3.38	1.50	3.39	1.85	1.89
constraints	Limit												
LAND1	R1	< = 1	1	1	1								1
LAND2	R2	< = 1				1	1						1
LAND3	R3	< = 1						1	1	1	1	1	1
HRL1	R4	< = 0.5											
HRL2	R5	< = 0.5											
HRL3	R6	< = 0.5											
LAB1	R7	< = 120	153	205	203								125
LAB2	R8	< = 120				208	205						75
LAB3	R9	< = 120						178	250	133	222	101	269
HLB1	R10	< = 240											
HLB2	R11	< = 240											
HLB3	R12	< = 240											
HDP/DP1	R13	< = 100	42	42	37								
HDP/DP2	R14	< = 100				47	44						
HDP/DP3	R15	< = 100						44	44	44	49	35	54
INI.CAP	R16	< = 12											
CAPI2	R17	< = 0											
CAPI3	R18	< = 0											
BORROW1	R19	< = 5											
BORROW2	R20	< = 5											
BORROW3	R21	< = 5											
FA.EXP1	R22	> = 3											
FA.EXP2	R23	> = 3											
FA.EXP3	R24	> = 3											
R.CONS	R25	> = 4											
ANNUITY	R26	> = 20											

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 3 = Production of Jute
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 6 = Production of Local Variety of Boro
L 7 = Production of High Yielding Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L11 = Production of Oilseeds
L14 = Production of Sugarcane

Table II.13: **Comparison of variables in different classes of farmers (Without project condition)**

Variables	Unit	Gr	L1	L3	L6	L8	L9	L10	L11	L12	L15
Net.Ret	TK'000/H	A	1.37	4.47	5.11	3.65	4.81	7.21	5.28	21.66	7.22
Net.Ret	TK'000/H	B		3.94		2.41	5.64	4.48	3.69		4.37
Net.Ret	TK'000/H	C		2.84	2.14	2.68	3.54	5.27	3.28	22.60	1.96
Net.Ret	TK'000/H	D		1.13	3.94	1.29	2.86	6.51	2.40	20.39	3.99
Net.Ret	TK'000/H	R		3.10	2.51	3.73	4.22	5.87	3.66	22.36	4.73
Yld(c)	TON/Ha	A	1.80	1.73	2.49	2.23	5.07	1.01	1.01	4.84	2.95
Yld(c)	TON/Ha	B		1.66		2.35	4.80	0.89	0.92		2.67
Yld(c)	TON/Ha	C		1.41	2.46	1.94	4.70	1.22	0.89	6.61	2.58
Yld(c)	TON/Ha	D		1.51	3.41	1.87	4.61	1.12	0.96	7.49	2.30
Yld(c)	TON/Ha	R		1.57	2.77	2.10	4.80	1.06	0.94	6.27	2.74
Price(c)	TK'000/T	A	4.42	5.91	4.42	4.02	4.10	9.41	9.32	6.16	4.93
Price(c)	TK'000/T	B		6.81		4.15	3.97	9.82	9.65		4.82
Price(c)	TK'000/T	C		6.51	4.11	4.82	3.67	9.11	10.74	4.82	4.82
Price(c)	TK'000/T	D		6.70	4.21	4.62	3.75	11.68	10.75	3.95	4.96
Price(c)	TK'000/T	R		6.48	4.25	4.40	3.87	9.99	10.10	4.98	4.85
F&P.Cost	TK'000/H	A	0.74	2.52	1.40	1.95	2.58	0.68	1.11	0.77	1.27
F&P.Cost	TK'000/H	B		3.11		1.61	2.08	0.87	0.62		0.61
F&P.Cost	TK'000/H	C		1.01	0.98	0.87	1.29	0.98	1.03	1.37	0.71
F&P.Cost	TK'000/H	D		1.19	1.68	1.28	1.57	1.15	1.04	1.50	0.89
F&P.Cost	TK'000/H	R		1.96	1.35	1.43	1.88	0.94	0.95	1.35	0.87

L 1 = Production of Brodcast Aus
L 3 = Production of Jute
L 6 = Production of Local Variety of Boro
L 8 = Production of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L12 = Production of Onion
L15 = Production of Brodcast Aman

Table II.14: Comparison of variables in different classes of farmers (With project condition)

Variables	Unit	Gr	L1	L2	L3	L4	L5	L6	L7	L8	L9	L11	L14
Net.Ret	TK'000/H	A	3.99	7.98		9.38	8.66		7.22	0.62			
Net.Ret	TK'000/H	B	4.47	7.48	6.27	8.08	5.94	4.12	2.48			6.50	
Net.Ret	TK'000/H	C	4.37	7.33	2.68	4.79	3.25		7.49		4.08		
Net.Ret	TK'000/H	D	5.09	5.41		4.84	2.04	3.92	4.38	1.36	5.70	0.17	19.71
Net.Ret	TK'000/H	R	4.45	7.05	4.48	6.77	4.97	4.02	5.39	1.12	4.89	3.81	19.71
Yld(c)	TON/Ha	A	2.57	3.41		3.60	3.25		3.69	2.77			
Yld(c)	TON/Ha	B	3.09	4.09	1.94	4.35	3.79	2.90	4.15		1.15		
Yld(c)	TON/Ha	C	3.24	4.21	1.79	4.87	3.69		5.00		5.07		
Yld(c)	TON/Ha	D	3.73	4.10		4.21	3.73	3.23	4.30	2.86	4.80	0.98	55.33
Yld(c)	TON/Ha	R	3.14	3.96	1.86	4.26	3.60	3.07	4.29	2.86	4.93	1.11	55.33
Price.c	TK'000/T	A	5.96	5.73		6.02		6.16		5.76	5.36		
Price.c	TK'000/T	B	5.36	5.71	8.57	5.70	5.55	5.36	5.81		12.06		
Price.c	TK'000/T	C	5.69	6.00	8.90	5.82	5.81		5.89	5.89			
Price.c	TK'000/T	D	5.76	5.69		6.07	6.23	5.49	5.54	5.36	5.36	12.5	0.78
Price.c	TK'000/T	R	5.71	5.78	8.74	5.89	5.94	5.43	5.64	5.36	5.63	12.27	0.78
F&P.Cos	TK'000/H	A	1.78	2.79		1.91	2.22		2.76	1.48			
F&P.Cos	TK'000/H	B	1.82	2.96	3.16	2.60	2.21	2.90	4.15			1.58	
F&P.Cos	TK'000/H	C	2.48	3.18	2.14	2.92	2.41		3.41		4.32		
F&P.Cos	TK'000/H	D	2.59	3.70		2.68	2.64	2.27	3.20	1.52	2.15	2.15	1.89
F&P.Cos	TK'000/H	R	2.16	2.98	2.65	2.53	2.37	2.58	3.38	1.50	3.39	1.85	1.89

L 1 = Production of Brodcast Aus
L 2 = Production of High Yielding Variety of Aus
L 3 = Production of Jute
L 4 = Production of High Yielding Variety of Aman
L 5 = Production of Local Variety of Transplanting Aman
L 6 = Production of Local Variety of Boro
L 7 = Production of High Yielding Variety of Boro
L 8 = Production of High Yielding Variety of Wheat
L 9 = Production of Potato
L10 = Production of Pulses
L11 = Production of Oilseeds
L14 = Production of Sugarcane

APPENDIX III

Optimal solutions for with and without project for different groups of farmers obtained through model runs

Optimal Solution

Problem name : A(BEFORE)
Problem direction : MAX
Objective function value : 5.767109
Number of iterations : 35

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL1	A	1.0000	0.0000	-5.3091	0.0000	INFINITY
2	HL2	A	1.0000	0.0000	-5.3091	0.0000	8.0683
3	HL3	A	1.0000	0.0000	-9.5213	0.0000	INFINITY
4	HLB1	A	6.1000	0.0000	-0.0547	0.0000	0.0601
5	HLB2	Z	0.0000	0.0619	-INFINITY	0.0000	0.0619
6	HLB3	A	109.8352	0.0000	-0.0532	0.0000	0.0685
7	OFA1	Z	0.0000	0.0601	-INFINITY	0.0000	0.0601
8	OFA2	A	6.9000	0.0000	-0.0269	0.0000	0.0610
9	OFA3	Z	0.0000	0.0707	-INFINITY	0.0000	0.0707
10	BO1	Z	0.0000	0.2663	-INFINITY	0.0000	0.2663
11	BO2	A	4.7152	0.0000	-0.0414	0.0000	0.2421
12	BO3	A	5.0000	0.0000	-1.5894	0.0000	INFINITY
13	IN1	A	0.2820	0.0000	-0.0296	0.0000	0.2663
14	IN2	Z	0.0000	0.2421	-INFINITY	0.0000	0.2421
15	IN3	Z	0.0000	1.6794	-INFINITY	0.0000	1.6794
16	T.1-2	Z	0.0000	0.0296	-INFINITY	0.0000	0.0296
17	T.2-3	Z	0.0000	0.2689	-INFINITY	0.0000	0.2689
18	T.3-S	Z	0.0000	1.6894	-INFINITY	0.0000	1.6894
19	YE.SA	A	5.7671	0.0000	0.0000	1.0000	INFINITY
20	BAUS	Z	0.0000	7.8276	-INFINITY	0.0000	7.8276
21	Jute	Z	0.0000	6.9143	-INFINITY	0.0000	6.9143
22	PBAUS	Z	0.0000	0.1829	-INFINITY	0.0000	0.1829
23	PJUT	D	0.0000	0.0000	-17.4841	0.0000	3.9967
24	LBOR	A	0.5196	0.0000	-16.4152	0.0000	17.6201
25	WHEA	Z	0.0000	19.1017	-INFINITY	0.0000	19.1017
26	Potato	Z	0.0000	112.0601	-INFINITY	0.0000	112.0601
27	PULS	Z	0.0000	11.0586	-INFINITY	0.0000	11.0586
28	Oilseed	Z	0.0000	15.4526	-INFINITY	0.0000	15.4526
29	Onio	A	0.7804	0.0000	-16.0342	0.0000	INFINITY
30	BAMA	A	1.3000	0.0000	-5.3091	0.0000	INFINITY
31	PLBOR	Z	0.0000	8.8390	-INFINITY	0.0000	8.8390
32	PWHEA	D	0.0000	0.0000	-4.0200	0.0000	8.5658
33	Ppot	D	0.0000	0.0000	-4.1000	0.0000	22.1026
34	Ppulses	D	0.0000	0.0000	-9.4100	0.0000	10.9491
35	Poils	D	0.0000	0.0000	-9.3200	0.0000	15.2996
36	Ponion	A	3.7771	0.0000	-3.3128	0.0000	INFINITY
37	PBAMA	A	2.1288	0.0000	-0.1857	0.0000	7.0764
38	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	17.2716
39	CBAU	D	0.0000	0.0000	-0.1829	0.0000	4.3487
40	CLBO	A	1.2938	0.0000	-6.5925	0.0000	7.0764
41	CBAM	A	1.7062	0.0000	-3.1901	0.0000	0.1857
42	MORT	A	1.0000	0.0000	-INFINITY	0.0000	9.0000
43	HDP1	A	44.2000	0.0000	-0.1561	0.0000	0.0598
44	HDP2	Z	0.0000	0.0592	-INFINITY	0.0000	0.0592
45	HDP3	A	37.6960	0.0000	-0.3091	0.0000	0.0528

Optimal Solution

Problem name : A(BEFORE)
Problem direction : MAX
Objective function value : 5.767109
Number of iterations : 35

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LND1	L	0.0000	14.1842	0.2371	0.3000	0.3000
2	LND2	L	0.0000	8.0683	0.3000	0.3000	1.3000
3	LND3	L	0.0000	12.5213	-0.1606	0.3000	0.3568
4	HRL1	L	0.0000	5.3091	0.9371	1.0000	1.0000
5	HRL2	L	0.0000	0.0000	1.0000	1.0000	INFINITY
6	HRL3	L	0.0000	9.5213	0.3943	1.0000	1.0568
7	LAB1	L	0.0000	0.0896	110.6000	120.0000	126.1000
8	LAB2	L	0.0000	0.0269	113.1000	120.0000	696.0148
9	LAB3	L	0.0000	0.0807	110.1549	120.0000	226.3806
10	HLB1	L	113.9000	0.0000	6.1000	120.0000	INFINITY
11	HLB2	L	120.0000	0.0000	0.0000	120.0000	INFINITY
12	HLB3	L	10.1648	0.0000	109.8352	120.0000	INFINITY
13	DP1	L	0.0000	0.0598	-5.8000	0.0000	44.2000
14	DP2	L	0.0000	0.0000	-0.0000	0.0000	INFINITY
15	DP3	L	0.0000	0.0538	-12.0859	0.0000	37.0280
16	HDP1	L	5.8000	0.0000	44.2000	50.0000	INFINITY
17	HDP2	L	50.0000	0.0000	0.0000	50.0000	INFINITY
18	HDP3	L	12.3040	0.0000	37.6960	50.0000	INFINITY
19	CA1	L	0.0000	2.9880	4.7180	5.0000	9.6685
20	CA2	L	0.0000	2.9584	-0.2848	0.0000	4.7152
21	CA3	L	0.0000	2.6894	-2.1443	0.0000	5.7601
22	BOR1	L	5.0000	0.0000	0.0000	5.0000	INFINITY
23	BOR2	L	0.2848	0.0000	4.7152	5.0000	INFINITY
24	BOR3	L	0.0000	1.5894	1.3716	5.0000	10.7601
25	YESA	L	0.0000	1.0000	-5.7671	0.0000	INFINITY
26	WA3	L	1557.8407	0.0000	442.1593	2000.0000	INFINITY
27	R.BAUS	L	0.0000	13.2590	-0.0000	0.0000	1.1684
28	R.JUTE	L	0.0000	17.4841	-0.0000	0.0000	0.7978
29	R.LBORO	L	0.0000	13.2590	-0.4350	0.0000	1.1684
30	R.WHEAT	L	0.0000	4.0200	-0.0000	0.0000	INFINITY
31	R.POTATO	L	0.0000	4.1000	-0.0000	0.0000	INFINITY
32	R.PULSE	L	0.0000	9.4100	-0.0000	0.0000	INFINITY
33	R.OILSEED	L	0.0000	9.3200	-0.0000	0.0000	INFINITY
34	R.ONION	L	0.0000	6.1600	-0.9362	0.0000	INFINITY
35	R.BAMAN	L	0.0000	13.2590	-0.4350	0.0000	1.1684
36	FA.EX	G	0.0000	-17.2716	0.1031	1.0000	1.0709
37	T.R.CON	G	0.0000	-13.2590	1.8316	3.0000	3.4350
38	ANNUITY	G	0.0000	-9.0000	0.0000	1.0000	1.6408

Optimal Solution

Problem name : A(AFT2
Problem direction : MAX
Objective function value : 5.335990
Number of iterations : 39

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	1.0000	0.0000	-2.9071	0.0000	INFINITY
2	HL.2	A	1.0000	0.0000	-5.4405	0.0000	INFINITY
3	HL.3	A	1.0000	0.0000	-1.5040	0.0000	INFINITY
4	HLB.1	A	29.5000	0.0000	-0.0253	0.0000	0.0195
5	HLB.2	A	49.0000	0.0000	-0.0419	0.0000	0.0039
6	HLB.3	A	49.9000	0.0000	-0.0067	0.0000	0.0178
7	OFA.1	Z	0.0000	0.0218	-INFINITY	0.0000	0.0218
8	OFA.2	Z	0.0000	0.0190	-INFINITY	0.0000	0.0190
9	OFA.3	Z	0.0000	0.0178	-INFINITY	0.0000	0.0178
10	BO.1	A	2.5740	0.0000	-0.3643	0.0000	0.0343
11	BO.2	Z	0.0000	0.0321	-INFINITY	0.0000	0.0321
12	BO.3	Z	0.0000	0.0300	-INFINITY	0.0000	0.0300
13	IN.1	Z	0.0000	0.0343	-INFINITY	0.0000	0.0343
14	IN.2	A	2.5950	0.0000	-0.0736	0.0000	0.0321
15	IN.3	A	10.2666	0.0000	-0.0700	0.0000	0.0300
16	T.1-2	Z	0.0000	0.1145	-INFINITY	0.0000	0.1145
17	T.2-3	Z	0.0000	0.0749	-INFINITY	0.0000	0.0749
18	T.3-S	Z	0.0000	0.0700	-INFINITY	0.0000	0.0700
19	YE.SA	A	5.3360	0.0000	0.0000	1.0000	INFINITY
20	BCAus	A	1.3000	0.0000	-1.4253	0.0000	INFINITY
21	HYVAus	Z	0.0000	1.4253	-INFINITY	0.0000	1.4253
22	Pbcaus	A	3.3410	0.0000	-0.5546	0.0000	INFINITY
23	Phyvaus	D	0.0000	0.0000	-0.8003	0.0000	0.4180
24	HYVAman	Z	0.0000	0.1214	-INFINITY	0.0000	0.1214
25	LCAman	A	1.3000	0.0000	-0.1214	0.0000	INFINITY
26	Phyvaman	D	0.0000	0.0000	-0.6814	0.0000	0.0337
27	Plcaman	A	4.2250	0.0000	-0.0374	0.0000	INFINITY
28	HYVBoro	A	1.3000	0.0000	-1.0572	0.0000	INFINITY
29	HYVWht	Z	0.0000	1.0572	-INFINITY	0.0000	1.0572
30	Phyvboro	A	1.7970	0.0000	-0.2865	0.0000	0.6814
31	Phyvwht	D	0.0000	0.0000	-5.3600	0.0000	0.3817
32	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	10.1586
33	CBAU	Z	0.0000	1.0636	-INFINITY	0.0000	1.0636
34	CHAU	Z	0.0000	0.8003	-INFINITY	0.0000	0.8003
35	CHAM	Z	0.0000	0.6814	-INFINITY	0.0000	0.6814
36	CLAM	Z	0.0000	0.8312	-INFINITY	0.0000	0.8312
37	CHBO	A	3.0000	0.0000	-0.6814	0.0000	5.7600
38	MORT	A	1.0000	0.0000	-INFINITY	0.0000	12.0000
39	HDP1	A	26.0000	0.0000	-0.1454	0.0000	0.1008
40	HDP2	A	45.5000	0.0000	-0.1554	0.0000	0.0135
41	HDP3	A	49.4000	0.0000	-0.0396	0.0000	0.0856

Optimal Solution

Problem name : A(AFT2
Problem direction : MAX
Objective function value : 5.335990
Number of iterations : 39
Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	7.4867	0.0435	0.3000	0.6040
2	LAND(2)AN	L	0.0000	9.7205	-0.0769	0.3000	0.4286
3	LAND(3)DM	L	0.0000	5.5040	0.0762	0.3000	0.3158
4	HRL.1(AJ)	L	0.0000	2.9071	0.7435	1.0000	1.3040
5	HRL.2(AN)	L	0.0000	5.4405	0.6231	1.0000	1.1286
6	HRL.3(DM)	L	0.0000	1.5040	0.7762	1.0000	1.0158
7	LAB.1(AJ)	L	0.0000	0.0504	61.0236	120.0000	149.5000
8	LAB.2(AN)	L	0.0000	0.0458	55.1260	120.0000	169.0000
9	LAB.3(DM)	L	0.0000	0.0428	169.9000	240.0000	289.9000
10	HLB.1	L	90.5000	0.0000	29.5000	120.0000	INFINITY
11	HLB.2	L	71.0000	0.0000	49.0000	120.0000	INFINITY
12	HLB.3	L	70.1000	0.0000	49.9000	120.0000	INFINITY
13	DP1	L	0.0000	0.1008	-24.0000	0.0000	26.0000
14	DP2	L	0.0000	0.0916	-4.5000	0.0000	45.5000
15	DP3	L	0.0000	0.0856	-0.6000	0.0000	49.4000
16	HDP.1(AJ)	L	24.0000	0.0000	26.0000	50.0000	INFINITY
17	HDP.2(AN)	L	4.5000	0.0000	45.5000	50.0000	INFINITY
18	HDP.3(DM)	L	0.6000	0.0000	49.4000	50.0000	INFINITY
19	CAPI.1(AJ)	L	0.0000	1.2594	2.6409	5.0000	7.5740
20	CAPI.2(AN)	L	0.0000	1.1449	-2.5950	0.0000	INFINITY
21	CAPI.3(DM)	L	0.0000	1.0700	-4.9869	0.0000	INFINITY
22	BORROW.1	L	2.4260	0.0000	2.5740	5.0000	INFINITY
23	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
24	BORROW.3	L	5.0000	0.0000	0.0000	5.0000	INFINITY
25	YR.E.SAV	L	0.0000	1.0000	-5.3360	0.0000	INFINITY
26	WATER.3	L	1350.0000	0.0000	650.0000	2000.0000	INFINITY
27	R.BAUS	L	0.0000	6.8236	-0.4354	0.0000	INFINITY
28	R.HAUS	L	0.0000	6.5603	-0.0000	0.0000	INFINITY
29	R.HAMAN	L	0.0000	6.4414	-0.0000	0.0000	INFINITY
30	R.LAMAN	L	0.0000	6.5912	-0.8096	0.0000	INFINITY
31	R.HBORO	L	0.0000	5.7600	-0.9264	0.0000	INFINITY
32	R.WHEAT	L	0.0000	5.3600	-0.0000	0.0000	INFINITY
33	FA.EX	G	0.0000	-10.1586	0.0000	1.0000	1.5253
34	T.R.CON	G	0.0000	-5.7600	-0.0000	3.0000	3.9264
35	ANNUITY	G	0.0000	-12.0000	0.0000	1.0000	1.4447

Optimal Solution

Problem name : B(BEFORE)
Problem direction : MAX
Objective function value : 10.488288
Number of iterations : 31

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	0.7500	0.0000	-0.3603	0.0000	INFINITY
2	HL.2	A	0.7500	0.0000	-0.3603	0.0000	4.2978
3	HL.3	A	0.7500	0.0000	-4.3518	0.0000	INFINITY
4	HLB.1	A	42.0000	0.0000	-0.0033	0.0000	0.0109
5	HLB.2	Z	0.0000	0.0102	-INFINITY	0.0000	0.0102
6	HLB.3	A	183.1582	0.0000	-0.0227	0.0000	0.0188
7	OFA.1	Z	0.0000	0.0109	-INFINITY	0.0000	0.0109
8	OFA.2	D	0.0000	0.0000	-0.0358	0.0000	0.0045
9	OFA.3	Z	0.0000	0.0180	-INFINITY	0.0000	0.0180
10	BO.1	Z	0.0000	0.0460	-INFINITY	0.0000	0.0460
11	BO.2	Z	0.0000	0.0430	-INFINITY	0.0000	0.0430
12	BO.3	A	5.0000	0.0000	-0.3326	0.0000	INFINITY
13	IN.1	A	5.8250	0.0000	-0.1073	0.0000	0.0460
14	IN.2	A	1.9828	0.0000	-0.1003	0.0000	0.0430
15	IN.3	Z	0.0000	0.3626	-INFINITY	0.0000	0.3626
16	T.1-2	Z	0.0000	0.1073	-INFINITY	0.0000	0.1073
17	T.2-3	Z	0.0000	0.1003	-INFINITY	0.0000	0.1003
18	T.3-S	Z	0.0000	0.4326	-INFINITY	0.0000	0.4326
19	YE.SA	A	10.4883	0.0000	0.0000	1.0000	INFINITY
20	Jute	Z	0.0000	2.6708	-INFINITY	0.0000	2.6708
21	Pjute	D	0.0000	0.0000	-10.4388	0.0000	1.6089
22	LBOR	A	0.0706	0.0000	-7.0852	0.0000	4.4240
23	HYVWht	Z	0.0000	5.5788	-INFINITY	0.0000	5.5788
24	Potato	A	1.4294	0.0000	-4.4240	0.0000	INFINITY
25	Pulses	Z	0.0000	4.4569	-INFINITY	0.0000	4.4569
26	Oilseed	Z	0.0000	3.7027	-INFINITY	0.0000	3.7027
27	BCAman	A	1.5000	0.0000	-0.3603	0.0000	INFINITY
28	PLBO	Z	0.0000	2.6551	-INFINITY	0.0000	2.6551
29	Phyvwht	D	0.0000	0.0000	-4.1500	0.0000	2.3739
30	Ppot	A	6.8610	0.0000	-0.9217	0.0000	INFINITY
31	Ppulses	D	0.0000	0.0000	-9.8200	0.0000	5.0078
32	Poils	D	0.0000	0.0000	-9.6500	0.0000	4.0247
33	Pbcaman	A	1.1808	0.0000	-0.1374	0.0000	1.7767
34	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	9.2113
35	CLBO	A	0.1758	0.0000	-2.8455	0.0000	1.7767
36	CBAM	A	2.8242	0.0000	-1.7767	0.0000	2.8455
37	MORT	A	1.0000	0.0000	-INFINITY	0.0000	9.0000

Optimal Solution

Problem name : B(BEFORE)
Problem direction : MAX
Objective function value : 10.488288
Number of iterations : 31

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	4.9590	0.3611	0.7500	0.7500
2	LAND(2)AN	L	0.0000	4.2978	0.7500	0.7500	1.0631
3	LAND(3)DM	L	0.0000	7.3518	0.6350	0.7500	0.7858
4	HRL.1(AJ)	L	0.0000	0.3603	0.3611	0.7500	0.7500
5	HRL.2(AN)	L	0.0000	0.0000	0.7500	0.7500	INFINITY
6	HRL.3(DM)	L	0.0000	4.3518	0.6350	0.7500	0.7858
7	LAB.1(AJ)	L	0.0000	0.0492	58.2321	120.0000	147.3490
8	LAB.2(AN)	L	0.0000	0.0358	120.0000	120.0000	157.5743
9	LAB.3(DM)	L	0.0000	0.0430	112.8519	120.0000	151.3119
10	HLB.1	L	78.0000	0.0000	42.0000	120.0000	INFINITY
11	HLB.2	L	120.0000	0.0000	0.0000	120.0000	INFINITY
12	HLB.3	L	6.8418	0.0000	183.1582	190.0000	INFINITY
13	DP.1(AJ)	L	4.5000	0.0000	55.5000	60.0000	INFINITY
14	DP.2(AN)	L	60.0000	0.0000	0.0000	60.0000	INFINITY
15	DP.3(DM)	L	2.6186	0.0000	95.3814	98.0000	INFINITY
16	CAPI.1(AJ)	L	0.0000	1.6402	8.1470	10.0000	10.8205
17	CAPI.2(AN)	L	0.0000	1.5329	-1.9828	0.0000	0.8779
18	CAPI.3(DM)	L	0.0000	1.4326	-7.3212	0.0000	0.9394
19	BORROW.1	L	5.0000	0.0000	0.0000	5.0000	INFINITY
20	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
21	BORROW.3	L	0.0000	0.3326	0.0000	5.0000	5.9394
22	YR.E.SAV	L	0.0000	1.0000	-10.4883	0.0000	INFINITY
23	WATER.3	L	570.6188	0.0000	1429.3812	2000.0000	INFINITY
24	R.JUTE	L	0.0000	10.4388	-0.0000	0.0000	0.1289
25	R.LBOR	L	0.0000	6.9051	-1.5189	0.0000	0.1949
26	R.WHEAT	L	0.0000	4.1500	-0.0000	0.0000	INFINITY
27	R.POTATO	L	0.0000	3.9700	-2.6419	0.0000	INFINITY
28	R.PULSE	L	0.0000	9.8200	-0.0000	0.0000	INFINITY
29	R.OILSEED	L	0.0000	9.6500	-0.0000	0.0000	INFINITY
30	R.BAMAN	L	0.0000	6.9051	-1.5189	0.0000	0.1949
31	FA.EX	G	0.0000	-9.2113	0.8539	1.0000	1.4789
32	T.R.CON	G	0.0000	-6.9051	2.8051	3.0000	4.5189
33	ANNUITY	G	0.0000	-9.0000	0.0000	1.0000	2.1654

Optimal Solution

Problem name : B(AFT2
Problem direction : MAX
Objective function value : 10.650150
Number of iterations : 31

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	0.7500	0.0000	-4.7031	0.0000	INFINITY
2	HL.2	A	0.7500	0.0000	-6.4968	0.0000	INFINITY
3	HL.3	A	0.7500	0.0000	-7.5400	0.0000	INFINITY
4	HLB.1	A	82.5000	0.0000	-0.0219	0.0000	0.0218
5	HLB.2	A	88.5000	0.0000	-0.0297	0.0000	0.0190
6	HLB.3	A	87.0000	0.0000	-0.0226	0.0000	0.0178
7	OFA.1	Z	0.0000	0.0218	-INFINITY	0.0000	0.0218
8	OFA.2	Z	0.0000	0.0190	-INFINITY	0.0000	0.0190
9	OFA.3	Z	0.0000	0.0178	-INFINITY	0.0000	0.0178
10	BO.1	A	1.1900	0.0000	-0.3393	0.0000	0.0343
11	BO.2	Z	0.0000	0.0321	-INFINITY	0.0000	0.0321
12	BO.3	Z	0.0000	0.0300	-INFINITY	0.0000	0.0300
13	IN.1	Z	0.0000	0.0343	-INFINITY	0.0000	0.0343
14	IN.2	A	19.6818	0.0000	-0.0070	0.0000	0.0321
15	IN.3	A	29.5796	0.0000	-0.0507	0.0000	0.0300
16	T.1-2	Z	0.0000	0.1145	-INFINITY	0.0000	0.1145
17	T.2-3	Z	0.0000	0.0749	-INFINITY	0.0000	0.0749
18	T.3-S	Z	0.0000	0.0700	-INFINITY	0.0000	0.0700
19	YE.SA	A	10.6502	0.0000	0.0000	1.0000	INFINITY
20	BCAus	Z	0.0000	2.6121	-INFINITY	0.0000	2.6121
21	HYVAus	A	1.5000	0.0000	-2.6121	0.0000	INFINITY
22	Jute	Z	0.0000	6.8214	-INFINITY	0.0000	6.8214
23	Pbcaus	D	0.0000	0.0000	-0.0377	0.0000	0.8453
24	Phyvaus	A	6.1350	0.0000	-0.4384	0.0000	INFINITY
25	Pjute	D	0.0000	0.0000	-9.8118	0.0000	3.5162
26	HYVAman	A	1.5000	0.0000	-2.7628	0.0000	INFINITY
27	LCAman	Z	0.0000	2.7628	-INFINITY	0.0000	2.7628
28	Phyvaman	A	4.2500	0.0000	-0.1605	0.0000	0.0377
29	Plcaman	Z	0.0000	0.1605	-INFINITY	0.0000	0.1605
30	LCBoro	Z	0.0000	4.5743	-INFINITY	0.0000	4.5743
31	HYVBoro	A	1.5000	0.0000	-2.9996	0.0000	INFINITY
32	Oilseed	Z	0.0000	2.9996	-INFINITY	0.0000	2.9996
33	Plcboro	Z	0.0000	0.7390	-INFINITY	0.0000	0.7390
34	Phyvboro	Z	0.0000	0.2890	-INFINITY	0.0000	0.2890
35	Poils	D	0.0000	0.0000	-12.0600	0.0000	2.6083
36	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	10.4229
37	CBAU	Z	0.0000	0.0377	-INFINITY	0.0000	0.0377
38	CHAU	Z	0.0000	0.4384	-INFINITY	0.0000	0.4384
39	CHAM	A	2.2750	0.0000	-0.0377	0.0000	0.1605
40	CLAM	D	0.0000	0.0000	-0.1605	0.0000	0.7290
41	CLBO	D	0.0000	0.0000	-0.7390	0.0000	1.5773
42	CHBO	A	6.2250	0.0000	-0.2890	0.0000	INFINITY
43	MORT	A	1.0000	0.0000	-INFINITY	0.0000	18.0000
44	HDP1	A	9.0000	0.0000	-0.1022	0.0000	0.0630
45	HDP2	A	12.0000	0.0000	-0.1354	0.0000	0.0572
46	HDP3	Z	0.0000	0.0535	-INFINITY	0.0000	0.0535

Optimal Solution

Problem name : B(AFT2
Problem direction : MAX
Objective function value : 10.650150
Number of iterations : 31

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	9.2827	0.6641	0.7500	0.8804
2	LAND(2)AN	L	0.0000	10.7768	0.5000	0.7500	0.8125
3	LAND(3)DM	L	0.0000	11.5400	0.3509	0.7500	0.8289
4	HRL.1(AJ)	L	0.0000	4.7031	0.6641	0.7500	0.8804
5	HRL.2(AN)	L	0.0000	6.4968	0.5000	0.7500	0.8125
6	HRL.3(DM)	L	0.0000	7.5400	0.3509	0.7500	0.8289
7	LAB.1(AJ)	L	0.0000	0.0504	202.5000	240.0000	269.7500
8	LAB.2(AN)	L	0.0000	0.0458	208.5000	240.0000	328.5000
9	LAB.3(DM)	L	0.0000	0.0428	207.0000	240.0000	327.0000
10	HLB.1	L	37.5000	0.0000	82.5000	120.0000	INFINITY
11	HLB.2	L	31.5000	0.0000	88.5000	120.0000	INFINITY
12	HLB.3	L	33.0000	0.0000	87.0000	120.0000	INFINITY
13	DP.1(AJ)	L	0.0000	0.0630	54.0000	60.0000	69.0000
14	DP.2(AN)	L	0.0000	0.0572	57.0000	60.0000	72.0000
15	DP.3(DM)	L	3.0000	0.0000	57.0000	60.0000	INFINITY
16	HDP1	L	6.0000	0.0000	9.0000	15.0000	INFINITY
17	HDP2	L	3.0000	0.0000	12.0000	15.0000	INFINITY
18	HDP3	L	15.0000	0.0000	0.0000	15.0000	INFINITY
19	CAPI.1(AJ)	L	0.0000	1.2594	6.1900	10.0000	11.1900
20	CAPI.2(AN)	L	0.0000	1.1449	-9.3023	0.0000	INFINITY
21	CAPI.3(DM)	L	0.0000	1.0700	-9.9534	0.0000	INFINITY
22	BORROW.1	L	3.8100	0.0000	1.1900	5.0000	INFINITY
23	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
24	BORROW.3	L	5.0000	0.0000	0.0000	5.0000	INFINITY
25	YR.E.SAV	L	0.0000	1.0000	-10.6502	0.0000	INFINITY
26	WATER.3	L	1250.0000	0.0000	750.0000	2000.0000	INFINITY
27	R.BAUS	L	0.0000	6.1367	-0.0000	0.0000	INFINITY
28	R.HAUS	L	0.0000	6.5374	-1.6291	0.0000	INFINITY
29	R.JUTE	L	0.0000	9.8118	-0.0000	0.0000	INFINITY
30	R.HAMAN	L	0.0000	6.0990	-1.7462	0.0000	INFINITY
31	R.LAMAN	L	0.0000	6.0990	-0.0000	0.0000	2.2750
32	R.LBORO	L	0.0000	6.0990	-0.0000	0.0000	2.2750
33	R.HBORO	L	0.0000	6.0990	-1.7462	0.0000	2.2750
34	R.OILSEED	L	0.0000	12.0600	-0.0000	0.0000	INFINITY
35	FA.EX	G	0.0000	-10.4229	0.6033	1.0000	2.0218
36	T.R.CON	G	0.0000	-6.0990	6.2250	8.5000	10.2462
37	ANNUITY	G	0.0000	-18.0000	0.0000	1.0000	1.5917

Optimal Solution

Problem name : C(BEFORE)
Problem direction : MAX
Objective function value : 15.789384
Number of iterations : 27

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	0.1216	0.0000	-0.3067	0.0000	0.9520
2	HL.2	A	0.1216	0.0000	-0.3067	0.0000	0.9520
3	HL.3	A	0.3392	0.0000	-10.3599	0.0000	3.0000
4	HLB.1	A	42.1622	0.0000	-0.0031	0.0000	0.0095
5	HLB.2	Z	0.0000	0.0129	-INFINITY	0.0000	0.0129
6	HLB.3	A	240.0000	0.0000	-0.0541	0.0000	INFINITY
7	OFA.1	Z	0.0000	0.0182	-INFINITY	0.0000	0.0182
8	OFA.2	Z	0.0000	0.0041	-INFINITY	0.0000	0.0041
9	OFA.3	Z	0.0000	0.1010	-INFINITY	0.0000	0.1010
10	BO.1	Z	0.0000	0.0769	-INFINITY	0.0000	0.0769
11	BO.2	Z	0.0000	0.0719	-INFINITY	0.0000	0.0719
12	BO.3	A	5.0000	0.0000	-1.2957	0.0000	INFINITY
13	IN.1	A	7.5838	0.0000	-0.1794	0.0000	0.0769
14	IN.2	A	2.7498	0.0000	-0.1036	0.0000	0.0440
15	IN.3	Z	0.0000	1.3257	-INFINITY	0.0000	1.3257
16	T.1-2	Z	0.0000	0.1794	-INFINITY	0.0000	0.1794
17	T.2-3	Z	0.0000	0.1677	-INFINITY	0.0000	0.1677
18	T.3-S	Z	0.0000	1.3957	-INFINITY	0.0000	1.3957
19	YE.SA	A	15.7894	0.0000	0.0000	1.0000	INFINITY
20	Jute	Z	0.0000	2.4003	-INFINITY	0.0000	2.4003
21	Pjute	D	0.0000	0.0000	-16.6875	0.0000	1.7024
22	LCBoro	A	0.6683	0.0000	-17.8412	0.0000	15.6934
23	HYVWht	Z	0.0000	11.1055	-INFINITY	0.0000	11.1055
24	Potato	Z	0.0000	12.7815	-INFINITY	0.0000	12.7815
25	Pulses	Z	0.0000	7.7156	-INFINITY	0.0000	7.7156
26	Oilseed	Z	0.0000	9.6430	-INFINITY	0.0000	9.6430
27	Onio	A	1.1710	0.0000	-13.6477	0.0000	INFINITY
28	BCAman	A	1.6216	0.0000	-0.3067	0.0000	0.9520
29	Plcboro	Z	0.0000	7.4371	-INFINITY	0.0000	7.4371
30	Phyvwht	D	0.0000	0.0000	-4.8200	0.0000	5.7245
31	Ppot	D	0.0000	0.0000	-3.6700	0.0000	2.7195
32	Ppulses	D	0.0000	0.0000	-9.1100	0.0000	6.3243
33	Poils	D	0.0000	0.0000	-10.7400	0.0000	10.8348
34	Ponion	A	7.7401	0.0000	-2.0647	0.0000	INFINITY
35	Pbcaman	A	1.4277	0.0000	-0.1201	0.0000	0.3578
36	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	38.5091
37	CLBO	A	1.6440	0.0000	-7.2525	0.0000	6.3794
38	CBAM	A	2.7560	0.0000	-6.3794	0.0000	7.2525
39	MORT	A	1.0000	0.0000	-INFINITY	0.0000	15.0000

Optimal Solution

Problem name : C(BEFORE)
Problem direction : MAX
Objective function value : 15.789384
Number of iterations : 27

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	7.6901	1.1216	1.5000	1.6216
2	LAND(2)AN	L	0.0000	7.1870	1.1216	1.5000	1.6216
3	LAND(3)DM	L	0.0000	3.0000	1.3392	1.5000	1.8392
4	HRL.1(AJ)	L	0.3784	0.0000	0.1216	0.5000	INFINITY
5	HRL.2(AN)	L	0.3784	0.0000	0.1216	0.5000	INFINITY
6	HRL.3(DM)	L	0.1608	0.0000	0.3392	0.5000	INFINITY
7	LAB.1(AJ)	L	0.0000	0.0823	34.3370	120.0000	162.1622
8	LAB.2(AN)	L	0.0000	0.0640	111.0000	120.0000	148.0000
9	LAB.3(DM)	L	0.0000	0.1260	51.8934	120.0000	152.2748
10	HLB.1	L	197.8378	0.0000	42.1622	240.0000	INFINITY
11	HLB.2	L	240.0000	0.0000	0.0000	240.0000	INFINITY
12	HLB.3	L	0.0000	0.0541	175.0742	240.0000	270.7675
13	DP.1(AJ)	L	60.0000	0.0000	60.0000	120.0000	INFINITY
14	DP.2(AN)	L	120.0000	0.0000	0.0000	120.0000	INFINITY
15	DP.3(DM)	L	42.5745	0.0000	77.4255	120.0000	INFINITY
16	CAPI.1(AJ)	L	0.0000	2.7428	12.4301	15.0000	21.1400
17	CAPI.2(AN)	L	0.0000	2.5634	-2.7498	0.0000	6.5698
18	CAPI.3(DM)	L	0.0000	2.3957	-6.5908	0.0000	7.0297
19	BORROW.1	L	5.0000	0.0000	0.0000	5.0000	INFINITY
20	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
21	BORROW.3	L	0.0000	1.2957	0.0000	5.0000	12.0297
22	YR.E.SAV	L	0.0000	1.0000	-15.7894	0.0000	INFINITY
23	WATER.3	L	1347.6911	0.0000	652.3089	2000.0000	INFINITY
24	R.JUTE	L	0.0000	16.6875	-0.0000	0.0000	1.0092
25	R.LBORO	L	0.0000	11.5471	-1.3674	0.0000	1.6793
26	R.WHEAT	L	0.0000	4.8200	-0.0000	0.0000	INFINITY
27	R.POTATO	L	0.0000	3.6700	-0.0000	0.0000	INFINITY
28	R.PULSE	L	0.0000	9.1100	-0.0000	0.0000	INFINITY
29	R.OILSEED	L	0.0000	10.7400	-0.0000	0.0000	INFINITY
30	R.ONION	L	0.0000	4.8200	-3.2758	0.0000	INFINITY
31	R.BAMAN	L	0.0000	11.5471	-1.3674	0.0000	1.6793
32	FA.EX	G	0.0000	-38.5091	0.5627	1.0000	1.2657
33	T.R.CON	G	0.0000	-11.5471	2.7207	4.4000	5.7674
34	ANNUITY	G	0.0000	-15.0000	0.0000	1.0000	2.0526

Optimal Solution

Problem name : C(AFTER)
Problem direction : MAX
Objective function value : 30.729343
Number of iterations : 29

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	0.5000	0.0000	-8.1563	0.0000	INFINITY
2	HL.2	A	0.5000	0.0000	-13.3161	0.0000	INFINITY
3	HL.3	A	0.5000	0.0000	-14.1579	0.0000	INFINITY
4	HLB.1	A	190.0000	0.0000	-0.0379	0.0000	0.0263
5	HLB.2	A	170.0000	0.0000	-0.0650	0.0000	0.0190
6	HLB.3	A	196.0000	0.0000	-0.0649	0.0000	0.0178
7	OFA.1	Z	0.0000	0.0263	-INFINITY	0.0000	0.0263
8	OFA.2	Z	0.0000	0.0190	-INFINITY	0.0000	0.0190
9	OFA.3	Z	0.0000	0.0178	-INFINITY	0.0000	0.0178
10	BO.1	A	4.9600	0.0000	-0.6924	0.0000	0.1488
11	BO.2	Z	0.0000	0.1391	-INFINITY	0.0000	0.1391
12	BO.3	Z	0.0000	0.1300	-INFINITY	0.0000	0.1300
13	IN.1	Z	0.0000	0.1488	-INFINITY	0.0000	0.1488
14	IN.2	A	18.9280	0.0000	-0.0505	0.0000	0.1391
15	IN.3	A	49.2798	0.0000	-0.0563	0.0000	0.1300
16	T.1-2	Z	0.0000	0.2290	-INFINITY	0.0000	0.2290
17	T.2-3	Z	0.0000	0.0749	-INFINITY	0.0000	0.0749
18	T.3-S	Z	0.0000	0.0700	-INFINITY	0.0000	0.0700
19	YE.SA	A	30.7293	0.0000	0.0000	1.0000	INFINITY
20	BCAus	Z	0.0000	3.2245	-INFINITY	0.0000	3.2245
21	HYVAus	A	2.0000	0.0000	-3.2245	0.0000	INFINITY
22	Jute	Z	0.0000	9.4718	-INFINITY	0.0000	9.4718
23	Pbcaus	D	0.0000	0.0000	-0.2871	0.0000	0.9952
24	Phyvaus	A	8.4200	0.0000	-0.6420	0.0000	INFINITY
25	Pjute	D	0.0000	0.0000	-10.1896	0.0000	5.2915
26	HYVAman	A	2.0000	0.0000	-6.9476	0.0000	INFINITY
27	LCAman	Z	0.0000	6.9476	-INFINITY	0.0000	6.9476
28	Phyvaman	A	9.7400	0.0000	-0.0107	0.0000	0.2871
29	Plcaman	Z	0.0000	0.0107	-INFINITY	0.0000	0.0107
30	HYVBoro	A	2.0000	0.0000	-2.4196	0.0000	INFINITY
31	Potato	Z	0.0000	2.4196	-INFINITY	0.0000	2.4196
32	Phyvboro	Z	0.0000	0.3274	-INFINITY	0.0000	0.3274
33	Ppot	D	0.0000	0.0000	-5.8900	0.0000	0.4772
34	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	32.6072
35	CBAU	Z	0.0000	0.2871	-INFINITY	0.0000	0.2871
36	CHAU	Z	0.0000	0.6420	-INFINITY	0.0000	0.6420
37	CHAM	D	0.0000	0.0000	-0.2871	0.0000	0.0107
38	CLAM	D	0.0000	0.0000	-0.0107	0.0000	1.8828
39	CHBO	A	10.0000	0.0000	-0.3274	0.0000	INFINITY
40	MORT	A	1.0000	0.0000	-INFINITY	0.0000	20.0000

Optimal Solution

Problem name : C(AFTER)
Problem direction : MAX
Objective function value : 30.729343
Number of iterations : 29

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	12.7359	1.0789	1.5000	1.5034
2	LAND(2)AN	L	0.0000	17.5961	0.6707	1.5000	1.8415
3	LAND(3)DM	L	0.0000	18.1579	0.6009	1.5000	1.5000
4	HRL.1(AJ)	L	0.0000	8.1563	0.0789	0.5000	0.5034
5	HRL.2(AN)	L	0.0000	13.3161	0.0000	0.5000	0.8415
6	HRL.3(DM)	L	0.0000	14.1579	0.0000	0.5000	0.5000
7	LAB.1(AJ)	L	0.0000	0.0550	239.0000	240.0000	364.0000
8	LAB.2(AN)	L	0.0000	0.0458	170.0000	240.0000	410.0000
9	LAB.3(DM)	L	0.0000	0.0428	196.0000	240.0000	436.0000
10	HLB.1	L	50.0000	0.0000	190.0000	240.0000	INFINITY
11	HLB.2	L	70.0000	0.0000	170.0000	240.0000	INFINITY
12	HLB.3	L	44.0000	0.0000	196.0000	240.0000	INFINITY
13	DP.1(AJ)	L	22.0000	0.0000	98.0000	120.0000	INFINITY
14	DP.2(AN)	L	18.0000	0.0000	102.0000	120.0000	INFINITY
15	DP.3(DM)	L	14.0000	0.0000	106.0000	120.0000	INFINITY
16	CAPI.1(AJ)	L	0.0000	1.3739	14.9600	15.0000	19.9600
17	CAPI.2(AN)	L	0.0000	1.1449	-18.9280	0.0000	INFINITY
18	CAPI.3(DM)	L	0.0000	1.0700	-28.7190	0.0000	INFINITY
19	BORROW.1	L	0.0400	0.0000	4.9600	5.0000	INFINITY
20	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
21	BORROW.3	L	5.0000	0.0000	0.0000	5.0000	INFINITY
22	YR.E.SAV	L	0.0000	1.0000	-30.7293	0.0000	INFINITY
23	WATER.3	L	1000.0000	0.0000	1000.0000	2000.0000	INFINITY
24	R.BAUS	L	0.0000	6.5145	-0.0000	0.0000	INFINITY
25	R.HAUS	L	0.0000	6.8694	-3.1547	0.0000	INFINITY
26	R.JUTE	L	0.0000	10.1896	-0.0000	0.0000	INFINITY
27	R.HAMAN	L	0.0000	6.2274	-4.9345	0.0000	INFINITY
28	R.LAMAN	L	0.0000	6.2274	-0.0000	0.0000	0.0000
29	R.HBORO	L	0.0000	6.2274	-4.9345	0.0000	0.0000
30	R.POTATO	L	0.0000	5.8900	-0.0000	0.0000	INFINITY
31	FA.EX	G	0.0000	-32.6072	0.1733	1.0000	1.0067
32	T.R.CON	G	0.0000	-6.2274	10.0000	10.0000	14.9345
33	ANNUITY	G	0.0000	-20.0000	0.0000	1.0000	2.5365

Optimal Solution

Problem name : D(BEFORE)
Problem direction : MAX
Objective function value : 20.576406
Number of iterations : 25

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HLB.1	A	105.0000	0.0000	-0.1138	0.0000	0.0165
2	HLB.2	A	57.5000	0.0000	-0.0502	0.0000	0.0169
3	HLB.3	A	260.0000	0.0000	-0.1187	0.0000	INFINITY
4	OFA.1	Z	0.0000	0.0165	-INFINITY	0.0000	0.0165
5	OFA.2	Z	0.0000	0.0169	-INFINITY	0.0000	0.0169
6	OFA.3	Z	0.0000	0.1571	-INFINITY	0.0000	0.1571
7	BO.1	Z	0.0000	0.0698	-INFINITY	0.0000	0.0698
8	BO.2	A	2.6363	0.0000	-0.4029	0.0000	0.0635
9	BO.3	A	10.0000	0.0000	-1.0163	0.0000	INFINITY
10	IN.1	A	6.6250	0.0000	-0.1630	0.0000	0.0698
11	IN.2	Z	0.0000	0.0635	-INFINITY	0.0000	0.0635
12	IN.3	Z	0.0000	1.0463	-INFINITY	0.0000	1.0463
13	T.1-2	Z	0.0000	0.1630	-INFINITY	0.0000	0.1630
14	T.2-3	Z	0.0000	0.2116	-INFINITY	0.0000	0.2116
15	T.3-S	Z	0.0000	1.1163	-INFINITY	0.0000	1.1163
16	YE.SA	A	20.5764	0.0000	0.0000	1.0000	INFINITY
17	Jute	Z	0.0000	3.5623	-INFINITY	0.0000	3.5623
18	Pjute	D	0.0000	0.0000	-15.2949	0.0000	2.3591
19	LCBoro	A	0.5803	0.0000	-50.1871	0.0000	17.3436
20	HYVWht	Z	0.0000	13.7412	-INFINITY	0.0000	13.7412
21	Potato	Z	0.0000	27.0177	-INFINITY	0.0000	27.0177
22	Pulses	Z	0.0000	5.3809	-INFINITY	0.0000	5.3809
23	Oilseed	Z	0.0000	12.0991	-INFINITY	0.0000	12.0991
24	Onio	A	1.9123	0.0000	-8.6227	0.0000	INFINITY
25	BCAman	A	2.5000	0.0000	-3.5623	0.0000	INFINITY
26	Plcboro	Z	0.0000	6.2871	-INFINITY	0.0000	6.2871
27	Phyvwht	D	0.0000	0.0000	-4.6200	0.0000	7.3482
28	Ppot	D	0.0000	0.0000	-3.7500	0.0000	5.8607
29	Ppulses	D	0.0000	0.0000	-11.6800	0.0000	4.8044
30	Poils	D	0.0000	0.0000	-10.7500	0.0000	12.6032
31	Ponion	A	14.3231	0.0000	-1.1512	0.0000	INFINITY
32	Pbcaman	A	2.5289	0.0000	-1.8141	0.0000	5.0861
33	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	55.4822
34	CLBO	A	1.9789	0.0000	-14.7176	0.0000	5.0861
35	CBAM	A	3.2211	0.0000	-5.0861	0.0000	14.7176
36	MORT	A	1.0000	0.0000	-INFINITY	0.0000	25.0000

Optimal Solution

Problem name : D(BEFORE)
Problem direction : MAX
Objective function value : 20.576406
Number of iterations : 25

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	10.2422	2.0585	2.5000	2.5000
2	LAND(2)AN	L	0.0000	0.0000	2.5000	2.5000	INFINITY
3	LAND(3)DM	L	0.0074	0.0000	2.4926	2.5000	INFINITY
4	LAB.1(AJ)	L	0.0000	0.0747	-15.0000	120.0000	136.1622
5	LAB.2(AN)	L	0.0000	0.0698	-62.5000	120.0000	137.2936
6	LAB.3(DM)	L	0.0000	0.1821	7.0326	120.0000	121.0913
7	HLB.1	L	135.0000	0.0000	105.0000	240.0000	INFINITY
8	HLB.2	L	182.5000	0.0000	57.5000	240.0000	INFINITY
9	HLB.3	L	0.0000	0.1187	86.5851	260.0000	261.1578
10	DP.1(AJ)	L	32.5000	0.0000	147.5000	180.0000	INFINITY
11	DP.2(AN)	L	180.0000	0.0000	0.0000	180.0000	INFINITY
12	DP.3(DM)	L	83.1968	0.0000	96.8032	180.0000	INFINITY
13	CAPI.1(AJ)	L	0.0000	2.4909	-13.3750	20.0000	20.4849
14	CAPI.2(AN)	L	0.0000	2.3280	-7.3637	0.0000	0.5188
15	CAPI.3(DM)	L	0.0000	2.1163	-9.7226	0.0000	0.5707
16	BORROW.1	L	10.0000	0.0000	0.0000	10.0000	INFINITY
17	BORROW.2	L	7.3637	0.0000	2.6363	10.0000	INFINITY
18	BORROW.3	L	0.0000	1.0163	-0.0000	10.0000	10.5707
19	YR.E.SAV	L	0.0000	1.0000	-20.5764	0.0000	INFINITY
20	WATER.3	L	985.8173	0.0000	1014.1827	2000.0000	INFINITY
21	R.JUTE	L	0.0000	15.2949	-0.0000	0.0000	0.0790
22	R.LBORO	L	0.0000	10.4971	-1.9602	0.0000	0.1151
23	R.WHEAT	L	0.0000	4.6200	-0.0000	0.0000	INFINITY
24	R.POTATO	L	0.0000	3.7500	-0.0000	0.0000	INFINITY
25	R.PULSE	L	0.0000	11.6800	-0.0000	0.0000	INFINITY
26	R.OILSEED	L	0.0000	10.7500	-0.0000	0.0000	INFINITY
27	R.ONION	L	0.0000	3.9500	-5.2092	0.0000	INFINITY
28	R.BAMAN	L	0.0000	10.4971	-1.9602	0.0000	0.1151
29	FA.EX	G	0.0000	-55.4822	0.9782	1.0000	1.3709
30	T.R.CON	G	0.0000	-10.4971	5.0849	5.2000	7.1602
31	ANNUITY	G	0.0000	-25.0000	0.0000	1.0000	1.8231

Optimal Solution

Problem name : D(AFTER)
Problem direction : MAX
Objective function value : 41.415331
Number of iterations : 38

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HLB.1	A	147.5000	0.0000	-0.0808	0.0000	0.0263
2	HLB.2	A	360.0000	0.0000	-0.0554	0.0000	INFINITY
3	HLB.3	A	346.3953	0.0000	-0.0290	0.0000	0.0178
4	OFA.1	Z	0.0000	0.0263	-INFINITY	0.0000	0.0263
5	OFA.2	Z	0.0000	0.0744	-INFINITY	0.0000	0.0744
6	OFA.3	Z	0.0000	0.0178	-INFINITY	0.0000	0.0178
7	BO.1	A	1.3750	0.0000	-1.4245	0.0000	0.1488
8	BO.2	Z	0.0000	0.1391	-INFINITY	0.0000	0.1391
9	BO.3	Z	0.0000	0.1300	-INFINITY	0.0000	0.1300
10	IN.1	Z	0.0000	0.1488	-INFINITY	0.0000	0.1488
11	IN.2	A	21.9620	0.0000	-0.0212	0.0000	0.1391
12	IN.3	A	56.9576	0.0000	-0.0178	0.0000	0.1300
13	T.1-2	Z	0.0000	0.2290	-INFINITY	0.0000	0.2290
14	T.2-3	Z	0.0000	0.0749	-INFINITY	0.0000	0.0749
15	T.3-S	Z	0.0000	0.0700	-INFINITY	0.0000	0.0700
16	YE.SA	A	41.4153	0.0000	0.0000	1.0000	INFINITY
17	BCAus	A	2.5000	0.0000	-1.6667	0.0000	INFINITY
18	HYVAus	Z	0.0000	1.6667	-INFINITY	0.0000	1.6667
19	Pbcaus	A	9.3250	0.0000	-0.2008	0.0000	INFINITY
20	Phyvaus	D	0.0000	0.0000	-0.1206	0.0000	0.4065
21	HYVAman	A	2.5000	0.0000	-1.1823	0.0000	INFINITY
22	LCAman	Z	0.0000	1.1183	-INFINITY	0.0000	1.1183
23	Phyvaman	A	10.5250	0.0000	-0.1011	0.0000	INFINITY
24	Plcaman	D	0.0000	0.0000	-0.2723	0.0000	0.2998
25	LCBoro	Z	0.0000	3.3211	-INFINITY	0.0000	3.3211
26	HYVBoro	A	2.0930	0.0000	-0.4346	0.0000	3.6715
27	HYVWht	Z	0.0000	5.8723	-INFINITY	0.0000	5.8723
28	Potato	A	0.4070	0.0000	-3.6715	0.0000	0.4346
29	Pulses	Z	0.0000	9.9641	-INFINITY	0.0000	9.9641
30	Oilseed	Z	0.0000	8.8984	-INFINITY	0.0000	8.8984
31	Sugar	Z	0.0000	12.6188	-INFINITY	0.0000	12.6188
32	Plcboro	Z	0.0000	0.9038	-INFINITY	0.0000	0.9038
33	Phyvboro	Z	0.0000	0.8538	-INFINITY	0.0000	0.8538
34	Phyvwht	D	0.0000	0.0000	-5.3600	0.0000	2.0533
35	Ppot	A	1.9535	0.0000	-0.7649	0.0000	0.0905
36	Ppulses	D	0.0000	0.0000	-11.5000	0.0000	9.7687
37	Poils	D	0.0000	0.0000	-12.5000	0.0000	9.0800
38	Psugar	D	0.0000	0.0000	-0.7800	0.0000	0.2281
39	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	32.2990
40	CBAU	Z	0.0000	0.2008	-INFINITY	0.0000	0.2008
41	CHAU	Z	0.0000	0.1206	-INFINITY	0.0000	0.1206
42	CHAM	Z	0.0000	0.1011	-INFINITY	0.0000	0.1011
43	CLAM	Z	0.0000	0.2723	-INFINITY	0.0000	0.2723
44	CLBO	D	0.0000	0.0000	-0.9038	0.0000	1.0282
45	CHBO	A	9.0000	0.0000	-0.1011	0.0000	0.9038
46	MORT	A	1.0000	0.0000	-INFINITY	0.0000	30.0000

Optimal Solution

Problem name : D(AFTER)
Problem direction : MAX
Objective function value : 41.415331
Number of iterations : 38

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	12.5215	2.3436	2.5000	3.4812
2	LAND(2)AN	L	0.0000	0.0000	2.5000	2.5000	INFINITY
3	LAND(3)DM	L	0.0000	13.9259	2.0930	2.5000	2.5613
4	LAB.1(AJ)	L	0.0000	0.0550	27.5000	240.0000	274.3750
5	LAB.2(AN)	L	0.0000	0.1011	-169.4582	240.0000	240.0000
6	LAB.3(DM)	L	0.0000	0.0428	226.3953	240.0000	586.3953
7	HLB.1	L	212.5000	0.0000	147.5000	360.0000	INFINITY
8	HLB.2	L	0.0000	0.0554	0.0000	360.0000	360.0000
9	HLB.3	L	13.6047	0.0000	346.3953	360.0000	INFINITY
10	DP.1(AJ)	L	77.5000	0.0000	102.5000	180.0000	INFINITY
11	DP.2(AN)	L	65.0000	0.0000	115.0000	180.0000	INFINITY
12	DP.3(DM)	L	63.7791	0.0000	116.2209	180.0000	INFINITY
13	CAPI.1(AJ)	L	0.0000	1.3739	11.3750	20.0000	21.3750
14	CAPI.2(AN)	L	0.0000	1.1449	-21.9620	0.0000	INFINITY
15	CAPI.3(DM)	L	0.0000	1.0700	-38.7059	0.0000	INFINITY
16	BORROW.1	L	8.6250	0.0000	1.3750	10.0000	INFINITY
17	BORROW.2	L	10.0000	0.0000	0.0000	10.0000	INFINITY
18	BORROW.3	L	10.0000	0.0000	0.0000	10.0000	INFINITY
19	YR.E.SAV	L	0.0000	1.0000	-41.4153	0.0000	INFINITY
20	WATER.3	L	546.5116	0.0000	1453.4884	2000.0000	INFINITY
21	R.BAUS	L	0.0000	6.5946	-3.8128	0.0000	INFINITY
22	R.HAUS	L	0.0000	6.5145	-0.0000	0.0000	INFINITY
23	R.HAMAN	L	0.0000	6.4949	-6.3766	0.0000	INFINITY
24	R.LAMAN	L	0.0000	6.6661	-0.0000	0.0000	INFINITY
25	R.LBORO	L	0.0000	6.3938	-0.0000	0.0000	4.7000
26	R.HBORO	L	0.0000	6.3938	-1.7500	0.0000	4.7000
27	R.WHEAT	L	0.0000	5.3600	-0.0000	0.0000	INFINITY
28	R.POTATO	L	0.0000	5.3600	-1.9535	0.0000	INFINITY
29	R.PULSE	L	0.0000	11.5000	-0.0000	0.0000	INFINITY
30	R.OILSEED	L	0.0000	12.5000	-0.0000	0.0000	INFINITY
31	R.SUGER	L	0.0000	0.7800	-0.0000	0.0000	INFINITY
32	FA.EX	G	0.0000	-32.2990	0.8472	1.0000	1.9583
33	T.R.CON	G	0.0000	-6.3938	4.3000	9.0000	10.7500
34	ANNUITY	G	0.0000	-30.0000	0.0000	1.0000	2.3805

Optimal Solution

Problem name : R(BEFORE)
Problem direction : MAX
Objective function value : 12.756538
Number of iterations : 30

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	0.5000	0.0000	-1.5306	0.0000	INFINITY
2	HL.2	A	0.5000	0.0000	-1.5306	0.0000	7.0834
3	HL.3	A	0.5000	0.0000	-12.7829	0.0000	INFINITY
4	HLB.1	A	30.0000	0.0000	-0.0153	0.0000	0.0179
5	HLB.2	Z	0.0000	0.0168	-INFINITY	0.0000	0.0168
6	HLB.3	A	142.2082	0.0000	-0.0724	0.0000	0.0451
7	OFA.1	Z	0.0000	0.0179	-INFINITY	0.0000	0.0179
8	OFA.2	D	0.0000	0.0000	-0.0590	0.0000	0.0168
9	OFA.3	Z	0.0000	0.0458	-INFINITY	0.0000	0.0458
10	BO.1	Z	0.0000	0.0758	-INFINITY	0.0000	0.0758
11	BO.2	Z	0.0000	0.0708	-INFINITY	0.0000	0.0708
12	BO.3	A	5.0000	0.0000	-1.2611	0.0000	INFINITY
13	IN.1	A	6.4950	0.0000	-0.1768	0.0000	0.0758
14	IN.2	A	2.1497	0.0000	-0.1653	0.0000	0.0708
15	IN.3	Z	0.0000	1.2911	-INFINITY	0.0000	1.2911
16	T.1-2	Z	0.0000	0.1768	-INFINITY	0.0000	0.1768
17	T.2-3	Z	0.0000	0.1653	-INFINITY	0.0000	0.1653
18	T.3-S	Z	0.0000	1.3611	-INFINITY	0.0000	1.3611
19	YE.SA	A	12.7565	0.0000	0.0000	1.0000	INFINITY
20	Jute	Z	0.0000	3.1409	-INFINITY	0.0000	3.1409
21	Pjute	D	0.0000	0.0000	-16.3710	0.0000	2.0006
22	LCBoro	A	0.3869	0.0000	-25.8482	0.0000	16.6776
23	HYVWht	Z	0.0000	18.3485	-INFINITY	0.0000	18.3485
24	Potato	Z	0.0000	16.3792	-INFINITY	0.0000	16.3792
25	Pulses	Z	0.0000	13.8482	-INFINITY	0.0000	13.8482
26	Oilseed	Z	0.0000	16.0403	-INFINITY	0.0000	16.0403
27	Onio	A	1.1131	0.0000	-14.6311	0.0000	INFINITY
28	BCAman	A	1.5000	0.0000	-1.5306	0.0000	INFINITY
29	Plcboro	Z	0.0000	7.2014	-INFINITY	0.0000	7.2014
30	Phyvwht	D	0.0000	0.0000	-4.4000	0.0000	8.7374
31	Ppot	D	0.0000	0.0000	-3.8700	0.0000	3.4123
32	Ppulses	D	0.0000	0.0000	-10.0000	0.0000	13.0643
33	Poils	D	0.0000	0.0000	-10.1000	0.0000	17.0642
34	Ponion	A	6.9792	0.0000	-2.3335	0.0000	INFINITY
35	Pbcaman	A	0.7817	0.0000	-0.5877	0.0000	6.0208
36	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	25.0495
37	CLBO	A	1.0717	0.0000	-9.3315	0.0000	6.0208
38	CBAM	A	3.3283	0.0000	-6.0208	0.0000	9.3315
39	MORT	A	1.0000	0.0000	-INFINITY	0.0000	15.0000

Optimal Solution

Problem name : R(BEFORE)
Problem direction : MAX
Objective function value : 12.756538
Number of iterations : 30

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	9.1098	0.7000	1.0000	1.0000
2	LAND(2)AN	L	0.0000	7.0834	1.0000	1.0000	1.5000
3	LAND(3)DM	L	0.0000	15.7829	0.4294	1.0000	1.1864
4	HRL.1(AJ)	L	0.0000	1.5306	0.2000	0.5000	0.5000
5	HRL.2(AN)	L	0.0000	0.0000	0.5000	0.5000	INFINITY
6	HRL.3(DM)	L	0.0000	12.7829	0.0000	0.5000	0.6864
7	LAB.1(AJ)	L	0.0000	0.0811	53.0327	120.0000	150.0000
8	LAB.2(AN)	L	0.0000	0.0590	120.0000	120.0000	269.2744
9	LAB.3(DM)	L	0.0000	0.0708	23.7368	120.0000	244.3953
10	HLB.1	L	210.0000	0.0000	30.0000	240.0000	INFINITY
11	HLB.2	L	240.0000	0.0000	0.0000	240.0000	INFINITY
12	HLB.3	L	97.7918	0.0000	142.2082	240.0000	INFINITY
13	DP.1(AJ)	L	4.5000	0.0000	55.5000	60.0000	INFINITY
14	DP.2(AN)	L	60.0000	0.0000	0.0000	60.0000	INFINITY
15	DP.3(DM)	L	6.4344	0.0000	53.5656	60.0000	INFINITY
16	CAPI.1(AJ)	L	0.0000	2.7032	9.9910	12.0000	15.2596
17	CAPI.2(AN)	L	0.0000	2.5264	-2.1497	0.0000	3.4877
18	CAPI.3(DM)	L	0.0000	2.3611	-5.4028	0.0000	3.7319
19	BORROW.1	L	5.0000	0.0000	0.0000	5.0000	INFINITY
20	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
21	BORROW.3	L	0.0000	1.2611	0.0000	5.0000	8.7319
22	YR.E.SAV	L	0.0000	1.0000	-12.7565	0.0000	INFINITY
23	WATER.3	L	1404.7544	0.0000	595.2456	2000.0000	INFINITY
24	R.JUTE	L	0.0000	16.3710	-0.0000	0.0000	0.5382
25	R.LBORO	L	0.0000	11.4514	-1.1140	0.0000	1.0549
26	R.WHEAT	L	0.0000	4.4000	-0.0000	0.0000	INFINITY
27	R.POTATO	L	0.0000	3.8700	-0.0000	0.0000	INFINITY
28	R.PULSE	L	0.0000	10.0000	-0.0000	0.0000	INFINITY
29	R.OILSEED	L	0.0000	10.1000	-0.0000	0.0000	INFINITY
30	R.ONION	L	0.0000	4.9800	-2.5616	0.0000	INFINITY
31	R.BAMAN	L	0.0000	11.4514	-1.1140	0.0000	1.0549
32	FA.EX	G	0.0000	-25.0495	0.6482	1.0000	1.3147
33	T.R.CON	G	0.0000	-11.4514	3.3451	4.4000	5.5140
34	ANNUITY	G	0.0000	-15.0000	0.0000	1.0000	1.8504

Optimal Solution

Problem name : R(AFTER)
Problem direction : MAX
Objective function value : 13.474731
Number of iterations : 44

Activities

No	Name		Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	HL.1	A	0.5000	0.0000	-4.9011	0.0000	INFINITY
2	HL.2	A	0.5000	0.0000	-8.3285	0.0000	INFINITY
3	HL.3	A	0.5000	0.0000	-8.3158	0.0000	INFINITY
4	HLB.1	A	67.5000	0.0000	-0.0239	0.0000	0.0218
5	HLB.2	A	72.0000	0.0000	-0.0221	0.0000	0.0190
6	HLB.3	A	98.7646	0.0000	-0.0368	0.0000	0.0178
7	OFA.1	Z	0.0000	0.0218	-INFINITY	0.0000	0.0218
8	OFA.2	Z	0.0000	0.0190	-INFINITY	0.0000	0.0190
9	OFA.3	Z	0.0000	0.0178	-INFINITY	0.0000	0.0178
10	BO.1	A	0.5700	0.0000	-0.3691	0.0000	0.0343
11	BO.2	Z	0.0000	0.0321	-INFINITY	0.0000	0.0321
12	BO.3	Z	0.0000	0.0300	-INFINITY	0.0000	0.0300
13	IN.1	Z	0.0000	0.0343	-INFINITY	0.0000	0.0343
14	IN.2	A	19.2562	0.0000	-0.0053	0.0000	0.0321
15	IN.3	A	5.0238	0.0000	-0.0049	0.0000	0.0257
16	T.1-2	Z	0.0000	0.1145	-INFINITY	0.0000	0.1145
17	T.2-3	Z	0.0000	0.0749	-INFINITY	0.0000	0.0749
18	T.3-S	Z	0.0000	0.0700	-INFINITY	0.0000	0.0700
19	YE.SA	A	13.4747	0.0000	0.0000	1.0000	INFINITY
20	BCAus	Z	0.0000	2.0258	-INFINITY	0.0000	2.0258
21	HYVAus	A	1.5000	0.0000	-2.0258	0.0000	INFINITY
22	Jute	Z	0.0000	6.7622	-INFINITY	0.0000	6.7622
23	Pbcaus	D	0.0000	0.0000	-0.0301	0.0000	0.6452
24	Phyvaus	A	5.9400	0.0000	-0.1102	0.0000	INFINITY
25	Pjute	D	0.0000	0.0000	-10.0064	0.0000	3.6356
26	HYVAman	A	1.5000	0.0000	-1.2837	0.0000	INFINITY
27	LCAman	Z	0.0000	1.2837	-INFINITY	0.0000	1.2837
28	Phyvaman	Z	0.0000	0.2050	-INFINITY	0.0000	0.2050
29	Plcaman	Z	0.0000	0.1515	-INFINITY	0.0000	0.1515
30	LCBoro	Z	0.0000	4.5256	-INFINITY	0.0000	4.5256
31	HYVBoro	A	0.2354	0.0000	-0.1290	0.0000	0.6500
32	HYVWht	Z	0.0000	6.5520	-INFINITY	0.0000	6.5520
33	Potato	A	1.2646	0.0000	-0.6500	0.0000	0.1290
34	Oilseed	Z	0.0000	6.8067	-INFINITY	0.0000	6.8067
35	Plcboro	Z	0.0000	1.0773	-INFINITY	0.0000	1.0773
36	Phyvboro	Z	0.0000	0.8673	-INFINITY	0.0000	0.8673
37	Phyvwht	D	0.0000	0.0000	-5.3600	0.0000	2.2909
38	Ppot	A	6.2343	0.0000	-0.1318	0.0000	0.0262
39	Poils	D	0.0000	0.0000	-12.2700	0.0000	6.1322
40	FA.EX	A	1.0000	0.0000	-INFINITY	0.0000	17.4375
41	CBAU	Z	0.0000	0.0301	-INFINITY	0.0000	0.0301
42	CHAU	Z	0.0000	0.1102	-INFINITY	0.0000	0.1102
43	CHAM	A	6.3900	0.0000	-0.2050	0.0000	INFINITY
44	CLAM	D	0.0000	0.0000	-0.1515	0.0000	0.3566
45	CLBO	D	0.0000	0.0000	-1.0773	0.0000	1.4741
46	CHBO	A	1.0100	0.0000	-0.0301	0.0000	0.1515
47	MORT	A	1.0000	0.0000	-INFINITY	0.0000	25.0000
48	HDP1	A	3.0000	0.0000	-0.1167	0.0000	0.0630
49	HDP2	A	10.5000	0.0000	-0.1772	0.0000	0.0572
50	HDP3	A	0.9417	0.0000	-0.0322	0.0000	0.0535

Optimal Solution

Problem name : R(AFTER)
Problem direction : MAX
Objective function value : 13.474731
Number of iterations : 44

Constraints

No	Name		Slack	Shadow Price	Lower Lim	Limit	Upper Lim
1	LAND(1)AJ	L	0.0000	9.4807	0.9571	1.0000	1.2857
2	LAND(2)AN	L	0.0000	12.6085	0.7766	1.0000	1.0957
3	LAND(3)DM	L	0.0000	12.3158	0.9765	1.0000	1.3482
4	HRL.1(AJ)	L	0.0000	4.9011	0.4571	0.5000	0.7857
5	HRL.2(AN)	L	0.0000	8.3285	0.2766	0.5000	0.5957
6	HRL.3(DM)	L	0.0000	8.3158	0.4765	0.5000	0.8482
7	LAB.1(AJ)	L	0.0000	0.0504	133.2919	240.0000	254.2500
8	LAB.2(AN)	L	0.0000	0.0458	122.6210	240.0000	312.0000
9	LAB.3(DM)	L	0.0000	0.0428	114.4045	240.0000	338.7646
10	HLB.1	L	172.5000	0.0000	67.5000	240.0000	INFINITY
11	HLB.2	L	168.0000	0.0000	72.0000	240.0000	INFINITY
12	HLB.3	L	141.2354	0.0000	98.7646	240.0000	INFINITY
13	DP.1(AJ)	L	0.0000	0.0630	48.0000	60.0000	63.0000
14	DP.2(AN)	L	0.0000	0.0572	55.5000	60.0000	70.5000
15	DP.3(DM)	L	0.0000	0.0535	45.9417	60.0000	60.9417
16	HDP1	L	12.0000	0.0000	3.0000	15.0000	INFINITY
17	HDP2	L	4.5000	0.0000	10.5000	15.0000	INFINITY
18	HDP3	L	14.0583	0.0000	0.9417	15.0000	INFINITY
19	CAPI.1(AJ)	L	0.0000	1.2594	7.7317	12.0000	12.5700
20	CAPI.2(AN)	L	0.0000	1.1449	-4.6952	0.0000	INFINITY
21	CAPI.3(DM)	L	0.0000	1.0700	-5.0238	0.0000	INFINITY
22	BORROW.1	L	4.4300	0.0000	0.5700	5.0000	INFINITY
23	BORROW.2	L	5.0000	0.0000	0.0000	5.0000	INFINITY
24	BORROW.3	L	5.0000	0.0000	0.0000	5.0000	INFINITY
25	YR.E.SAV	L	0.0000	1.0000	-13.4747	0.0000	INFINITY
26	WATER.3	L	617.7156	0.0000	1382.2844	2000.0000	INFINITY
27	R.BAUS	L	0.0000	6.5374	-0.0000	0.0000	INFINITY
28	R.HAUS	L	0.0000	6.6175	-0.8123	0.0000	INFINITY
29	R.JUTE	L	0.0000	10.0064	-0.0000	0.0000	INFINITY
30	R.HAMAN	L	0.0000	6.5073	-2.0707	0.0000	1.0100
31	R.LAMAN	L	0.0000	6.5073	-0.0000	0.0000	1.0100
32	R.LBORO	L	0.0000	6.5073	-0.0000	0.0000	1.0100
33	R.HBORO	L	0.0000	6.5073	-2.0707	0.0000	1.0100
34	R.WHEAT	L	0.0000	5.3600	-0.0000	0.0000	INFINITY
35	R.POTATO	L	0.0000	5.6300	-2.3934	0.0000	INFINITY
36	R.OILSEED	L	0.0000	12.2700	-0.0000	0.0000	INFINITY
37	FA.EX	G	0.0000	-17.4375	0.8914	1.0000	1.3083
38	T.R.CON	G	0.0000	-6.5073	6.3900	7.4000	9.4707
39	ANNUITY	G	0.0000	-25.0000	0.0000	1.0000	1.5390

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