

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

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

KAMAL UDDIN AHMAD

**A thesis presented in partial fulfilment
of the requirements for the degree of
Master of Philosophy in Agricultural Economics**

Massey University

1991

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

TABLE OF CONTENTS

<u>CHAPTER</u>	<u>DESCRIPTION</u>	<u>PAGE NO.</u>
	TABLE OF CONTENTS	(i)
	ACKNOWLEDGEMENTS	(vi)
	ABSTRACT	(viii)
I	MOTIVATION FOR THE STUDY	1
	1.1 Introduction	1
	1.2 Organisation of the dissertation	3
II	FLOODS AND FLOOD CONTROL IN BANGLADESH	4
	2.1 Floods in Bangladesh	4
	2.1.1 Frequency of floods	4
	2.1.2 Causes of floods	5
	2.1.3 Types of flood	7
	2.1.4 Extent of flood damage	7
	2.1.5 Flood protection measures taken to date	8
	2.2 Agriculture	9
	2.2.1 Crops	10
	2.2.2 Fisheries	10
	2.2.3 Forestry	11
	2.2.4 Livestock	11
	2.3 Agricultural inputs	12
	2.3.1 Land	12
	2.3.2 Labour	13
	2.3.3 Credit	13
	2.3.4 Water	14
	2.3.5 Irrigation	15
	2.3.6 Flood control	16
	2.3.7 Fertilizer	16
	2.3.8 Seed	17
	2.3.9 Pesticide	17
	2.3.10 Draft power	17
	2.4 Socio-economic conditions	18
	2.4.1 Land tenure system	18
	2.4.2 Farm size	19
	2.4.3 Farm families	20
	2.4.4 Food habits	21
	2.4.5 Farm budget	22
	2.4.6 Agencies involved in agricultural development	23

2.5	Agroecological conditions	23
2.5.1	Geographical location	24
2.5.2	Soils	24
2.5.3	Rainfall	26
2.5.4	Temperature	26
2.5.5	Flood depth	27
2.5.6	Climate	27
2.5.7	Environmental pollution	28
2.5.8	Cropping seasons	28
2.5.9	Crops grown	29
2.6	Conclusion	31
III	LITERATURE REVIEW	32
3.1	Introduction	32
3.2	Classification of flood mitigation measures	32
3.3	Types of decision frameworks	33
3.4	Distribution of flood losses	35
3.5	Non-structural measures	35
3.6	Flood plain land use planning	37
3.7	Operations research	37
3.8	Linear programming in Indo-Pak subcontinent	38
3.8.1	Linear programming used for optimal water use	38
3.8.2	Linear programming used for cropping pattern	42
3.9	Use of linear programming in Bangladesh	43
3.10	Scope of this study	45
3.11	Conclusion	45
IV	METHOD	46
4.1	Introduction	46
4.2	Development of linear programming	48
4.3	Solving procedure of linear programming	48
4.4	Different approaches of linear programming	49
4.4.1	Parametric programming	49
4.4.2	Inter-temporal programming (Dynamic programming)	50
4.4.3	Integer programming	50
4.4.4	Recursive programming	51
4.4.5	Goal programming	51
4.4.6	Risk programming (MOTAD)	52
4.5	Demerits of linear programming	53
4.6	Estimating model coefficients	54
4.7	Conclusion	55

V	FORMULATION OF THE MODEL	56
5.1	Introduction	56
5.2	Choice of the method	56
5.3	Steps taken in formulation	57
5.4	Considerations	58
5.5	Objective function	59
	5.5.1 Components of the objective function	60
	5.5.2 Merits of split in objective function	61
5.6	Overview of major constraints	62
5.7	Assumptions of the matrix	63
5.8	The matrix	65
5.9	Activities	67
5.10	Constraints	69
5.11	Solution of the problem	72
5.12	Conclusion	72
VI	SURVEY DATA AND FINDINGS	73
6.1	Introduction	73
6.2	Survey area	74
6.3	Questionnaire	74
6.4	Sample size	75
6.5	Nature of the data and definition	75
	6.5.1 Land	76
	6.5.2 Draft power	76
	6.5.3 Labour force	77
	6.5.4 Irrigation facilities	77
	6.5.5 Manure and fertilizer	78
	6.5.6 Capital	78
	6.5.7 Crop mix	79
	6.5.8 Living costs and family consumption	79
	6.5.9 Benefits of the project	80
	6.5.10 Demerits of the project	80
	6.5.11 Environmental impacts	81
6.6	Crop coefficients	81
6.7	Findings of the survey	84
VII	RESULTS AND DISCUSSIONS	90
7.1	Introduction	90
7.2	Output from the computer	90
	7.2.1 Shadow cost	93
	7.2.2 Shadow price	93
	7.2.3 Range analysis	93

7.3	Results of the model run	94
7.3.1	Recommended crop mix for Group A	94
7.3.2	Recommended crop mix for Group B	95
7.3.3	Recommended crop mix for Group C	96
7.3.4	Recommended crop mix for Group D	96
7.3.5	Recommended crop mix for Group R	97
7.3.6	Sensitivity of the recommended crop mixes	98
7.4	Conclusion	101
VIII	CONCLUSIONS AND RECOMMENDATIONS	102
8.1	Summary	102
8.2	Conclusions	104
8.3	Policy implications	105
8.4	Recommendations	107
8.5	Limitations	109
8.6	Scope for further research	110
8.6.1	Sustainability considerations	111
8.6.2	Environmental considerations	112
8.6.3	Equity considerations	113
APPENDICES		
APPENDIX I	The questionnaires used for data collection and survey	115
APPENDIX II	Summary of the findings of field survey	120
APPENDIX III	Results obtained through computer run of the model	134
REFERENCES		154

LIST OF TABLES

2.1	Farm size of Bangladesh	19
2.2	Farm budget for different crops in one hectare of land	22
2.3	Approximate farm budget for a season	23
2.4	Classification of land based on depth of flood	27
2.5	Acreage under different crops and their relative position	30
5.1	The model matrix showing interactions of the activities and constraints/input output coefficients.	66
6.1	Distribution of farms according to the size of cultivation area	74
6.2	Comparison of variables in different classes of farmers (without project condition)	82
6.3	Comparison of variables in different classes of farmers (with project condition)	83
6.4	Average resource endowments possessed by different groups of farmers in the Project area.	89
7.1	Summary of results obtained by model run	91
7.2	Optimal cropping pattern for different groups as received by model runs	92

LIST OF FIGURES

2.1	Food grain production trend in Bangladesh	6
2.2	Map of Bangladesh	25
3.1	Classification of flood mitigation measures	33
3.2	Types of decision frameworks for flood mitigation strategies	34

LIST OF TABLES - APPENDIX II AND III

II.1	Average resources endowments possessed by different groups of farmers in the project area	120
II.2	Distribution of farms according to the size of cultivation area	121
II.3	The input output coefficients of the crops grown before project implementation by Group A farmers	122
II.4	The input output coefficients of the crops grown before project implementation by Group B farmers	123
II.5	The input output coefficients of the crops grown before project implementation by Group C farmers	124
II.6	The input output coefficients of the crops grown before project implementation by Group D farmers	125
II.7	The input output coefficients of the crops grown before project implementation by an average farmer	126
II.8	The input output coefficients of the crops grown after project implementation by Group A farmers	127
II.9	The input output coefficients of the crops grown after project implementation by Group B farmers	128
II.10	The input output coefficients of the crops grown after project implementation by Group C farmers	129
II.11	The input output coefficients of the crops grown after project implementation by Group D farmers	130
II.12	The input output coefficients of the crops grown after project implementation by an average farmer	131
II.13	Comparison of variables in different classes of farmers (without project condition)	132
II.14	Comparison of variables in different classes of farmers (with project condition)	133
III	Optimal solutions for with and without project for different groups of farmers obtained through model run	134-153

ACKNOWLEDGEMENTS

Professor Anton D.Meister, Department of Agricultural Economics and Business, Massey University through his vast knowledge of the technical and economic aspects of the agriculture sector of developing countries, has contributed substantially to the development of this model for analysing flood control and irrigation benefits in Bangladesh. I express my profound respect and gratitude to him for his guidance.

I am indebted to **Dr. Jeffrey Weber** for his constant encouragement and suggestions for completing the work. He had to take a life risk for travelling in Bangladesh in a political unrest and declared emergency situation to judge the conformity of the model to the environment for which it was developed. He spared his valuable time to go through the draft and improved the mode of expression. Words are inadequate to express my profound gratitude for the assistance rendered by him.

The sympathetic reception to the Department of Agricultural Economics and Business from **Professor Allan N.Rae**, whose guidance has been valuable throughout my study, encouraged me for working after hours in the study room in the department. I express him my sincere thanks. **Dr. Doren D.Chadee** was generous in encouragement at a time when it was most needed. I have benefited from **Dr. Muhammad Ismail Ahmed**, Department of Marketing, **Dr. Phil Halverson** of the Department of Agricultural and Horticultural Systems, and other staff members at Massey.

It is not practicable to list all who aided by giving of their time and information. My special debt of gratitude must be to **Dr. A.S.M. Hamidur Rahman**, Chief, Research and Treatment, International Centre for Diaheadrial Disease Research, Bangladesh, **Dr.Frank Swarts**, Consultant to Agricultural Sector Review Committee, **Dr. Abdus Sabur**, Assistant Professor, Bangladesh Agricultural Research Institute, **Mr. Dilip Kumar Sinha**, Project Director, Meghna Dhonagoda

Irrigation Project, **Mr. Fazlur Rahim**, Assistant Chief, Planning Commission for their generous cooperation during data collection. I also wish to take the opportunity to express the deepest thanks to those who have contributed by suggestions to improve the methodology in data collection.

It is impossible to overestimate the assistance and encouragement I have received from **my wife** for continuation of the study by taxing her time and comfort of staying in touch of parents. Mention must be made of **MERT**, for without their cooperation and travel grant a study of this type would not have been possible. Finally grateful acknowledgement is made to **Mr. Mike Randall**, Student Support Coordinator, Ministry of External Relations and Trade, for his widespread helping hand through out the study, especially for arranging the trip for data collection.

Kamal Uddin Ahmad

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.