

SOME NEGLECTED ISSUES IN THE ECONOMIC ANALYSIS
OF AGRICULTURAL PROJECT MANAGEMENT IN GHANA

by

Seth Kenneth Larney Addo, BSc (Hons) Agric.

A dissertation submitted in partial fulfilment
of the requirements for the degree of
Master of Agricultural Development Economics
in the Australian National University

August 1978

D E C L A R A T I O N

Except where otherwise indicated, this dissertation is my own work.

August 1978

Seth Ken'L. Addo

ACKNOWLEDGEMENTS

I wish to express my sincerest thanks to the Agricultural Development Bank, my employers, and the Government of Ghana for their respective nomination and approval to enable me to undertake this course in Australia. To the Australian Government for their generous scholarship, I owe a debt of gratitude.

Mr William Tetteh, my colleague of the Agricultural Development Bank, and Dr J. Brian Hardaker of the University of New England were instrumental in initiating my interest in risk analysis. I am grateful to them.

I am greatly indebted to my supervisor, Dr Nihal Amerasinghe, whose invaluable suggestions, criticisms, comments and guidance greatly inspired me to enable me to complete my research work. Dr Dan Etherington and Dr Mark Saad also contributed immensely through their suggestions and advice.

To Alison Davis, who helped tremendously in writing the Monte Carlo Simulation program, I am forever thankful.

Mrs Bridget Boucher was more than an editor in shaping up this thesis, and I am more than grateful.

To my wife Belinda, for her understanding, patience and moral support, I can hardly express the extent of my gratitude.

And finally, to Mrs Marianne Henderson who typed the manuscript, and to all friends and colleagues, who contributed in diverse ways to this study, but too numerous to mention here, I am thankful.

ABSTRACT

The Agricultural Development Bank (ADB) is an important financial organisation and is the main source of credit for agricultural projects in Ghana. The purpose of this study is to examine the procedures and method of analysis in project planning and management adopted by the ADB with the main object of identifying some of the neglected issues and to suggest some methods for improvement.

Agricultural project planning and management by the ADB have been found to be plagued by a number of problems and inefficiencies in the areas of identification and selection, formulation, approval, implementation, supervision, monitoring and control. These areas are systematically examined and the main problems and bottlenecks are identified.

An examination of the current state of project appraisal methodology is undertaken. The main project appraisal procedures are also reviewed, bringing out the difficulties of economic cost-benefit analysis and offering a critique of the appraisal procedures.

Suggestions for improving project identification and selection, formulation, implementation and supervision in the ADB are made based on the writer's insights into and experiences of the various problems identified with the production process. Cues are also taken from recommendations made for developing countries by such organisations as the FAO, IBRD and USAID.

The major contribution of the study is the use of probability appraisal to analyse risk in a maize and pineapple project financed by the ADB. The Monte Carlo Simulation technique is adapted for use in this analysis. Results from this technique are compared with original results of the same projects obtained by the use of conventional cost-benefit analysis where single value estimations of costs and prices are made.

Results from the probability analysis indicate that the methodology enables us to provide management with more appropriate information for making the right decisions by recognising the variability of outcomes of projects in the face of risk and uncertainty. Mean values of three indicators of worthiness obtained under this technique are also thought to be more reliable and acceptable, especially since we do not have to fear any large variations around these values.

Limitations of the analysis and directions for future research are indicated.

CONTENTS

	<u>Page</u>
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF APPENDICES	xii
GLOSSARY	xiv

CHAPTER

1	INTRODUCTION	1
	1.1 Ghana - Physical Features	1
	1.1.1 Land Area	1
	1.1.2 Population	2
	1.1.3 Natural Resources and Ecological Zones	2
	1.1.4 The Economy	3
	1.2 Agricultural Credit in Ghana: 1918-1960	13
	1.3 The Agricultural Development Bank (ADB)	15
	1.3.1 Organisation and Functions	15
	1.3.2 Activities of the Bank	17
	1.4 Objectives and Scope of Study	20
2	PROJECT FINANCING AND MANAGEMENT IN THE ADB	25
	2.1 Project Identification and Selection	25
	2.2 Project Formulation (Appraisal and Feasibility Study Preparation)	30
	2.2.1 The Project Area	31
	2.2.2 Project Description	31
	2.2.3 Organisation and Management	32
	2.2.4 Pricing of Inputs and Outputs	32
	2.2.5 Indicators of Project Worthiness	34
	2.2.6 Sensitivity Analysis	36
	2.3 Project Approval, Implementation, Supervision, Monitoring and Control	36
	2.4 Project Completion or Termination and Evaluation	39
	2.5 Loan Recovery and Rescheduling	40

<u>CHAPTER</u>		<u>Page</u>
3	PROJECT EVALUATION METHODOLOGY	42
	3.1 A Review of the Main Project Evaluation Procedures	42
	3.1.1 Cost-Benefit Analysis	42
	3.1.2 The Origins of Cost-Benefit Analysis	42
	3.1.3 The Little and Mirrlees Approach	44
	3.1.4 The UNIDO Method	46
	3.1.5 The Squire/van der Tak Approach	47
	3.1.6 The World Bank Method	49
	3.2 The Difficulties of Economic Cost-Benefit Analysis	49
	3.2.1 The Definition of Equilibrium Prices	49
	3.2.2 The Definition of Welfare Function	50
	3.2.3 The Determination of the Effects of a Project	51
	3.3 A Critique of the Existing Methodologies	51
	3.3.1 Disagreement with the Basic Philosophy of the Methodologies Proposed	51
	3.3.2 Disagreement About the Usefulness of the Methodologies Proposed	52
	3.3.3 Disagreement About the Applicability of the Methodologies	52
	3.3.4 Disagreement About the Questions Addressed by the Proposed Methodologies	53
4	SUGGESTED IMPROVEMENTS IN PROJECT PLANNING AND MANAGEMENT	54
	4.1 Improving Project Identification and Selection	54
	4.1.1 Economic Setting of the Country and the Role of Agriculture	56
	4.1.2 Constraints Facing Overall and Agricultural Development	57
	4.1.3 Selection of Agricultural Priority Sectors	60

<u>CHAPTER</u>	<u>Page</u>
4.2 Improving Project Formulation	64
4.2.1 The Project Area	64
4.2.2 Project Description	67
4.2.3 Organisation and Management	71
4.2.4 Pricing of Inputs and Outputs	75
4.2.5 Indicators of Worthiness	77
4.2.6 Sensitivity Analysis	85
4.3 Improving Approval and Implementation Procedures	86
4.3.1 Monitoring of the Execution	86
4.3.2 Process Evaluation	86
4.3.3 Ex-Post Evaluation	87
5 PROBABILITY APPRAISAL OF SELECTED PROJECTS	91
5.1 Methodology of Probability Appraisal or Risk Analysis	91
5.2 The Analytical Approach	99
5.3 Comparative Study of Results from the Conventional Analysis with Results Obtained in the Probability Appraisal of the Pineapple Project	100
5.3.1 Results Based on the Conventional Appraisal Technique	100
5.3.2 Results Based on Probability Appraisal	102
5.3.3 Discussion of Results	104
5.3.4 Sensitivity Analysis	109
5.4 Comparative Study of Results from the Conventional Analysis with Results Obtained in the Probability Appraisal of the Maize Project	110
5.4.1 Results Based on the Conventional Appraisal Technique	110
5.4.2 Results Based on Probability Appraisal	110
5.4.3 Sensitivity Analysis	113

<u>CHAPTER</u>		<u>Page</u>
6	SUMMARY AND CONCLUSIONS	114
	6.1 Summary of Research Findings and Implications	114
	6.2 Limitations of the Analysis	119
	6.3 Directions for Future Research	120
APPENDICES		122
BIBLIOGRAPHY		186

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1.1	(a) Gross Output and Gross Domestic Product from Agriculture, Forestry and Fishing (at 1968 prices)	7
	(b) Gross Output and Gross Domestic Product from Agriculture, Forestry and Fishing (at current market prices)	7
1.2	Expenditure on Gross Domestic Product - Percentage Distribution	8
1.3	Percentage Distribution of Value of Exports of Domestic Produce	9
1.4	Type of Holding by Size of Holding	11
1.5	Total Loans and Advances to the Agricultural Sector	16
1.6	Loan Classification	23
5.1	Random Variables Included in Pineapple and Maize Projects	92
5.2	Summary of Financial Cost-Benefit Analysis of the Pineapple Project (Based on Single-Value Estimates of Costs and Benefits Figures)	101
5.3	Uncertainties in Probability Analysis	106
5.4	Summary of Financial Cost-Benefit Analysis of the Maize Project (Based on Single-Value Estimates of Costs and Benefits Figures)	111

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1.1	Project Planning and Management Cycle	22
2.1	Project Planning and Management Cycle in the Agricultural Development Bank	26
4.1	Logical Framework of a Project	89
4.2	Improved Project Planning and Management Cycle	90
5.1	Cumulative Probability Distributions of Three Indicators of Worthiness (Pineapple Project)	103
5.2	Cumulative Probability Distributions of Three Indicators of Worthiness (Maize Project)	107

LIST OF MAPS

<u>Map</u>	<u>Title</u>	<u>Page</u>
1.1	Simplified Land Use Map of Ghana, 1959, Showing Land Use Zones	4

LIST OF APPENDICES

<u>Appendix</u>	<u>Title</u>	<u>Page</u>
A.1	Map of Ghana Showing Vegetation Zones	123
A.2	Agricultural Development Bank Organisation Chart - 1977	124
A.3	Map of Ghana Showing Branches and Farm Loan Offices of the ADB and NIB	125
A.4	(a) Gross Domestic Product by Industrial Origin (at 1978 prices) Per Cent	126
	(b) Gross Domestic Product by Industrial Origin (at current market prices) Per Cent	127
A.5	(a) Gross Domestic Product by Industrial Origin (at 1968 market prices) ¢ million	128
	(b) Gross Domestic Product by Industrial Origin (at current market prices) ¢ million	129
A.6	Cocoa Purchasing Company Loans Approved and Repayment Classified by Purpose	130
A.7	ADB and NIB Loans as at December 1974	131
B.1	Feasibility Study Report - Pineapple Production Company - ADB	132
B.2	Maize Project - Detailed Financial Cost-Benefit Analysis	152
D.1	Divisions of Values of Uncertain Variables and their Assigned Probability Distributions (Pineapple Project)	160
D.2	Flow Chart for Probability Analysis (Monte Carlo Simulation)	161
D.3	(a) The Monte Carlo Simulation Program	162
	(b) User Documentation for Simulation on DEC10	176

<u>Appendix</u>	<u>Title</u>	<u>Page</u>
D.4	An Example of a Simulation Loop	179
E.1	Different Simulation Levels and their Corresponding Mean and Standard Deviation Values of their Cumulative Probability Distributions (Pineapple Project)	180
E.2	Different Simulation Levels and their Corresponding Mean and Standard Deviation Values of their Cumulative Probability Distributions (Maize Project)	181
E.3	Cumulative Probability Distribution of IRR (Pineapple Project) at Different Levels of Simulation	182
E.4	Cumulative Probability Distributions of NPV (Maize Project) at Different Levels of Simulation	184

GLOSSARY

ALB	Agricultural Loans Board
ADB	Agricultural Development Bank
NIB	National Investment Bank
GCB	Ghana Commercial Bank
UGFCC	United Ghana Farmers Cooperative Council
CPC	Cocoa Purchasing Company
FAO	Food and Agricultural Organisation of the United Nations
OECD	Organisation of Educational and Cultural Development
UNIDO	United Nations Industrial Development Organisation
IDA	International Development Association
NPV	Net Present Value or Worth
IRR	Internal Rate of Return
ROI	Return on Investment
B/C ratio	Benefit-Cost Ratio
DCF	Discounted Cash Flow
USAID	United States Agency for International Development
IBRD	International Bank for Reconstruction and Development

CHAPTER 1

INTRODUCTION

This study attempts to examine the economic analysis of agricultural project management in Ghana, with the particular objective of identifying some of the neglected issues, and to suggest some methods for improvement. In view of the fact that the bulk of the small scale agricultural projects (about 90 per cent) are financed by the Agricultural Development Bank (ADB) of Ghana, which is entirely public-owned and fully devoted to agricultural development and modernisation, this study will largely be related to its mode of operations with occasional reference to other allied institutions, both financial and technical, which are committed to agricultural development. This chapter is intended to provide some background material for the study.

1.1 Ghana - Physical Features

The Republic of Ghana lies in a central position in West Africa, between latitudes 4°45' North and 11°11' North. It extends in width from longitude 1°12' East to 3°15' West and shares common boundaries with the Republic of the Ivory Coast in the west, Upper Volta in the north, Togo in the east and is boarded on the south by the Gulf of Guinea.

1.1.1 Land Area

The total area of the country is 92,100 square miles. Of this area, a third is covered by the two lakes of the country -

the Volta Lake and Lake Bosomtwi. Excluding areas covered by the lakes, lagoons, rivers, mountains, villages, towns and cities, the estimated total land area available for arable cultivation is given as 75,000 square miles. The current estimate is that less than 30 per cent of the cultivable area is actively cultivated. The country is divided administratively into the Greater Accra, Ashanti, Volta, Eastern, Central, Western, Brong Ahafo, Northern and Upper Regions.

1.1.2 Population

Ghana has a population of 8.6 million based on the 1970 population census (a little over 9 million currently) of which 2.8 million or 31 per cent live in urban areas. The economically active population in the country is 3.5 million. Of this number, about 60 per cent are engaged in agriculture. Population density per square mile is 98. The annual population growth rate is estimated at 3.2 per cent whereas life expectancy at birth is 46 years.

1.1.3 Natural Resources and Ecological Zones

Ghana is endowed with rich natural resources of which gold, diamonds, manganese, bauxite and timber are predominant. The country is ecologically divided into a number of vegetation zones. The type of vegetation is influenced mainly by the climatic factors of temperature, rainfall, humidity, winds, length of photoperiod, insolation and cloudiness and lightning. Other influences are those of physiographic, edaphic, biotic and historic factors. The principal vegetation zones of Ghana with approximate areas are as follows:

High or closed forest	-	31,760 sq. miles
Savanna woodland	-	57,850 "
Coastal thicket	-	805 "
Coastal grassland	-	935 "
Strand and lagoon margin	-	493 "

Apart from the strand and lagoon vegetation zone, which is well defined, the boundaries of the other zones are not abrupt; they merge into each other and outliers of one vegetation type may be found within another zone owing to local climatic, soil or topographic conditions.

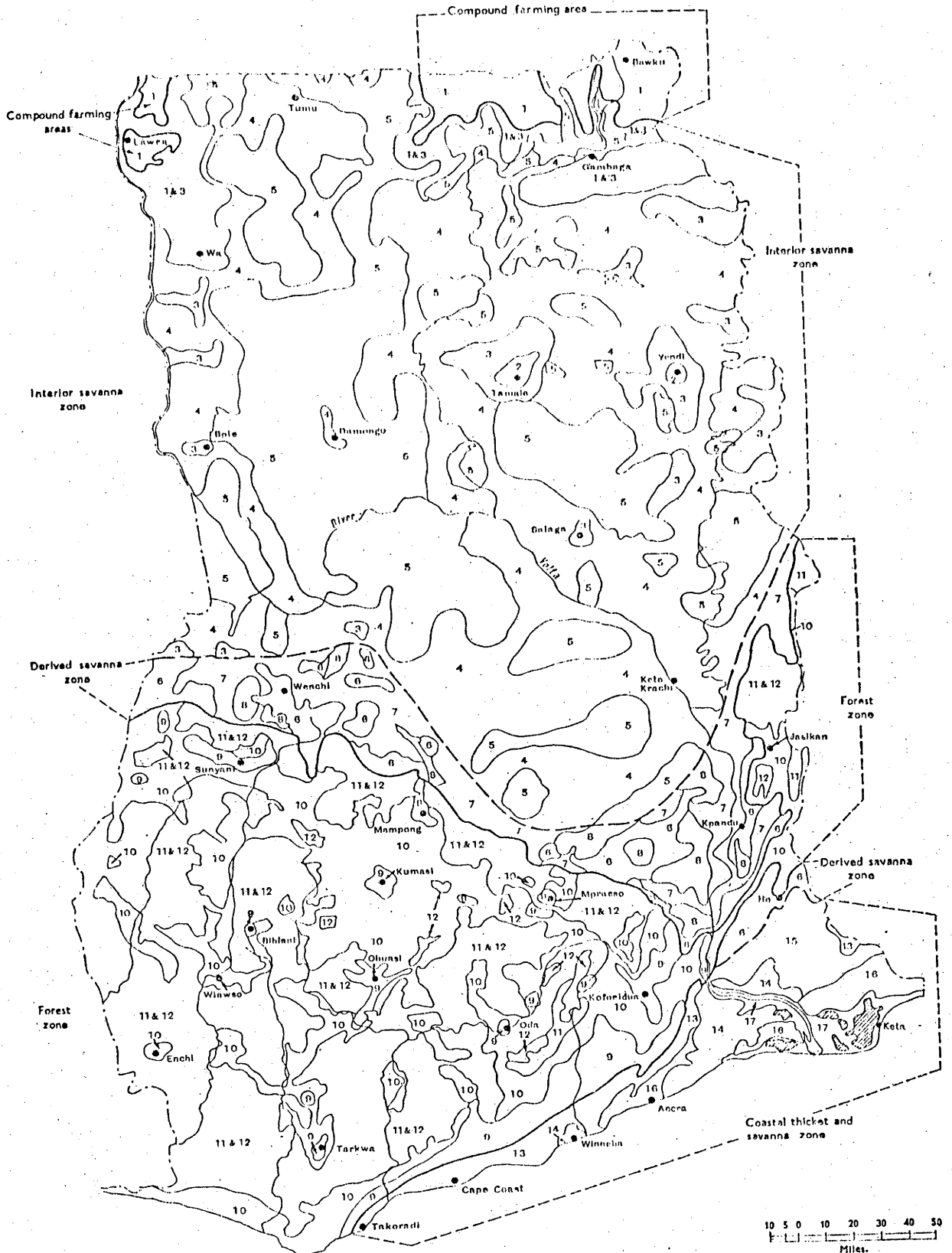
From an agricultural point of view, crop and livestock activities in the main ecological zones are determined, to a large extent, by the types of vegetation found in the zones. The vegetation formations thus permit the classification of five land use zones: compound farming zone; interior savanna; forest; derived savanna; coastal thicket and savanna. Each zone has a distinctive pattern of agricultural settlement and farming which characterises its subsistence economy and distinguishes it from other zones. Map 1.1 indicates Ghana's land use zones.

1.1.4 The Economy

The dominant feature of Ghana's economy is its large agricultural sector. This is evidenced by the extent of land resources utilised in production, the high proportion of labour engaged in farming, and the contribution which the agricultural industry makes to the gross national product and value added, especially food supply and exports. A considerable part of the land resources of the country is occupied by agriculture. The

MAP 1.1

SIMPLIFIED LAND USE MAP OF GHANA, 1959, SHOWING LAND USE ZONES



Source: Wills, 1962.

MAP 1.1 - KEY

1. Compound farming area.

Interior Savanna Zone

- 1.&3. Compound farming mixed with land rotation as in 3.
2. Grazed grassland with rare land rotation cultivation.
3. Land rotation with grazed tree savanna regrowth fallow.
4. Less intensive land rotation with sparsely grazed tree savanna regrowth fallow and scattered patches of 5.
5. Little-cultivated ungrazed tree savanna, including forest reserves.

Derived Savanna Zone

6. Land rotation with cocoa in forest outliers mixed with less intensive land rotation in more extensive patches of savanna.
7. Less intensive land rotation with tree savanna regrowth and some small cultivated forest outliers.
8. Little-cultivated, ungrazed tree savanna mixed with occasional patches of incompletely developed closed forest or secondary forest.

Forest Zone

9. Intensive land rotation with negligible forest remaining: area of most commercialised food cropping.
10. Land rotation with a small percentage of forest remaining: area of most extensive established cocoa, including areas of newest cocoa planting, especially in the north-west.
11. Less intensive land rotation with much forest remaining.
12. Little-farmed closed forest, including forest reserves: area (outside the reserves) of most active timber exploitation. (Owing to limitations of scale, 11 and 12 have been mapped together over much of the zone.)

Coastal Thicket and Savanna Zone

- | | |
|---------------------|--------------------------------|
| 13. Coastal thicket | 16. Savanna-thicket transition |
| 14. Grass savanna | 17. Lagoons and marshes |
| 15. Tree savanna | |

Ministry of Agriculture has estimated that about 56 million acres are available for agriculture.

Gross output from the agricultural sector (comprising cocoa, crops other than cocoa, livestock, forestry and fishery) in real terms constituted a share of 33.4 per cent, 31.9 per cent, and 31.6 per cent of total gross output of the economy in 1972, 1973 and 1974, respectively. Real gross domestic product originating from this sector (Appendix A.4(a)) formed 45.2 per cent in 1972, 43.1 per cent in 1973 and 43.3 per cent in 1974 (Table 1.1 shows gross output and GDP from Agriculture and Forestry & Fishing).

Other estimates provided by the economic survey 1972-74 indicated that between 1969 and 1974 an annual average of some $\text{¢}1,024 \text{ million}^1$ was spent on local food, out of an average total private consumption expenditure of $\text{¢}1797.7 \text{ million}$ or 57 per cent over the six year period. On the other hand, total private consumption expenditure amounted to about 75 per cent of the expenditure on gross national product within the same period. Private expenditure on local food was thus about 42 per cent of the expenditure on gross national product. Table 1.2 shows the percentage distribution of expenditure on GDP.

Ghana's main exports are cocoa, timber, gold, diamonds and bauxite. Exports of agricultural products (including forest products) account for about 70 per cent of total domestic exports. For the fiscal year 1974, cocoa alone accounted for $\text{¢}513 \text{ million}$ or

1 The exchange rate assumed for this study is $\text{¢}1.15 = \text{\$US}1.00$.

TABLE 1.1
GROSS OUTPUT AND GROSS DOMESTIC PRODUCT
FROM AGRICULTURE, FORESTRY AND FISHING
(a) (at 1968 prices)

	1969	1970	1971	1972	1973	1974
1. Gross Output: (Z million)						
1.1 Cocoa (Production and Marketing)	210	228	232	244	214	210
1.2 Crops other than Cocoa	439	482	506	520	565	624
1.3 Livestock	46	44	55	55	62	67
1.4 Forestry	70	70	72	72	81	75
1.5 Fishery	49	47	51	51	44	50
1.6 Total	814	871	916	916	966	1,026
2. Gross Domestic Product (Z million)						
2.1 Cocoa (Production and Marketing)	195	212	216	216	199	187
2.2 Crops other than Cocoa	424	466	490	490	546	603
2.3 Livestock	35	33	41	41	47	50
2.4 Forestry	67	67	69	69	78	72
2.5 Fishery	38	39	43	54	31	38
2.6 Total	729	817	859	895	901	950
3. Index Number of Production (1968 = 100)						
3.1 Cocoa (Production and Marketing)	106.1	115.2	117.2	123.2	108.2	106.1
3.2 Crops other than Cocoa	103.8	113.9	119.6	122.9	133.6	147.5
3.3 Livestock	100.0	95.7	119.6	115.2	134.2	145.2
3.4 Forestry	106.1	106.1	109.1	111.6	122.7	113.7
3.5 Fishery	188.5	180.8	196.2	246.2	169.2	192.6
3.6 Overall	107.2	114.8	120.7	126.0	127.3	135.2
4. Index Number of Gross Domestic Product (1968 = 100)						
4.1 Cocoa (Production and Marketing)	106.0	115.2	117.4	122.8	108.2	101.6
4.2 Crops other than Cocoa	103.7	113.9	119.8	123.0	133.5	147.4
4.3 Livestock	100.0	94.3	117.1	114.3	134.3	142.9
4.4 Forestry	106.3	106.3	109.5	114.3	123.8	114.3
4.5 Fishery	211.1	216.7	238.9	300.0	172.2	211.1
4.6 Overall	107.1	115.2	121.2	126.2	127.1	134.0

(b) (at current market prices)

	1969	1970	1971	1972	1973	1974
1. Gross Output: (Z million)						
1.1 Cocoa (Production and Marketing)	264	332	264	335	375	537
1.2 Crops other than Cocoa	544	616	729	844	1,129	1,596
1.3 Livestock	54	55	65	76	111	127
1.4 Forestry	73	77	74	90	136	175
1.5 Fishery	39	36	36	53	68	75
1.6 Total	974	1,116	1,168	1,398	1,819	2,510
2. Gross Domestic Product (Z million)						
2.1 Cocoa (Production and Marketing)	249	317	245	304	343	503
2.2 Crops other than Cocoa	529	600	711	824	1,100	1,556
2.3 Livestock	43	43	53	63	95	107
2.4 Forestry	70	74	71	86	128	164
2.5 Fishery	28	25	26	37	48	52
2.6 Total	919	1,059	1,106	1,314	1,714	2,382
3. Index Number of Production (1968 = 100)						
3.1 Cocoa (Production and Marketing)	133.3	167.7	133.3	169.2	189.4	271.2
3.2 Crops other than Cocoa	128.6	145.6	172.3	199.5	266.9	377.3
3.3 Livestock	177.4	119.6	141.3	165.2	241.3	276.1
3.4 Forestry	110.6	116.7	112.1	136.4	206.1	265.2
3.5 Fishery	150.0	138.5	138.5	203.8	261.5	288.5
3.6 Overall	128.3	147.0	153.9	184.2	239.7	330.7
4. Index Number of Gross Domestic Product (1968 = 100)						
4.1 Cocoa (Production and Marketing)	135.3	172.3	133.2	165.2	186.4	273.4
4.2 Crops other than Cocoa	129.3	146.7	173.8	201.5	268.9	380.4
4.3 Livestock	122.9	122.9	151.4	180.0	271.4	305.7
4.4 Forestry	111.1	117.5	112.7	136.5	203.2	260.3
4.5 Fishery	155.6	138.9	144.4	205.6	266.7	288.9
4.6 Overall	129.6	149.4	156.0	185.3	241.7	336.0

Source: Central Bureau of Statistics, 1977, p.78, p.79.

TABLE 1.2

EXPENDITURE ON GROSS DOMESTIC PRODUCT - PERCENTAGE DISTRIBUTION
(at current purchaser's value)

	1969	1970	1971	1972	1973	1974
1. Private Consumption Expenditure	73.0	73.8	76.6	74.4	74.8	77.0
2. Government Final Consumption Expenditure	14.2	12.8	13.0	12.7	10.9	12.2
3. Gross Fixed Capital Formation	9.8	12.0	12.4	8.7	7.6	11.9
4. Changes in Stocks	(+)2.0	(+)2.1	(+)1.7	(-)1.6	(+)1.4	(+)1.1
5. Domestic Expenditure	99.0	100.7	103.7	94.2	94.7	102.2
6. Export <u>Less</u> Import of Goods and Non-Factor Services	(+)1.0	(-)0.7	(-)3.7	(+)5.8	(+)5.3	(-)2.2
7. Expenditure on Gross Domestic Product	100.0	100.0	100.0	100.0	100.0	100.0

Source: Central Bureau of Statistics, 1977, p.147.

TABLE 1.3

PERCENTAGE DISTRIBUTION OF VALUE OF EXPORTS OF DOMESTIC PRODUCE

Commodity	1968	1969	1970	1971	1972	1973	1974
Cocoa	63.4	62.9	72.1	65.3	59.7	56.8	65.1
Kola Nuts	0.1	0.2	0.1	0.1	0.1	0.2	0.1
Timber	8.5	10.0	8.0	9.1	11.6	19.0	12.0
Bauxite	0.4	0.4	0.3	0.6	0.5	0.4	0.4
Manganese	3.2	1.8	1.6	1.8	1.8	1.0	1.2
Diamonds	5.2	3.5	3.1	3.2	3.4	1.9	1.7
Gold	8.6	7.6	5.6	7.8	9.2	10.0	11.0
Aluminium	-	-	6.9	8.2	10.3	6.5	3.9
Other	10.6	13.6	2.3	3.9	3.4	4.2	4.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Central Bureau of Statistics 1970; 1977, p.43.

65.1 per cent of total exports while timber accounted for about 12 per cent. Table 1.3 indicates percentage distribution of exports of domestic produce.

Owing to the fundamental importance of agriculture in the economy of Ghana, the problems facing the agricultural industry which have tended to retard its growth have also acted as constraints on the rate of growth of the entire economy. These problems have accounted principally for the prevalence and persistence of a low level of productivity in the country's agriculture. The main constraints derive from: the difficult nature of the environment; the outmoded farming practices and land tenure systems; the inefficient organisation of

marketing and extension; the underdeveloped infrastructure; and the restricted provision of agricultural credit and capital for the various requirements of a complex industry.

Ghana's agricultural population is predominantly composed of smallholders. In the 1970 Sample Census of Agriculture, it was estimated that there were 805,200 landholders in agriculture in Ghana of which 81 per cent were full-time holder/operators. The 805,200 households had an average size of 5.6 people resulting in an estimated farm population of 4.5 million people or roughly 50 per cent of the total population.²

Table 1.4 gives the size distribution of holdings. Thirty per cent of the holdings are less than two acres, 55 per cent less than four acres and 82 per cent less than ten acres. At the other extreme, less than 2 per cent of the holdings are greater than 50 acres. Unfortunately, the percentage of land by size of holding is not available. However, it is generally accepted that Ghana is not troubled with a land distribution problem at present.³

Very little additional information is available on the small farmer as a group but in 1970 of the 805,200 holders, 111,100 (14 per cent) were classified as producing for subsistence only, while 289,700 (36 per cent) were classified as 'mainly' subsistence and 404,400 (50 per cent) were operating mainly for sale.⁴ Table 1.4

2 Ghana's population was estimated by the 1970 census to be 8.5 million.

3 This is not to say that Ghana has no land tenure problem.

4 The definitions used for the classification were as follows: (a) operated for subsistence only - no cash crop cultivated and little or no sale of food crops, (b) operated 'mainly' for subsistence - no more than 50 per cent of produce intended for home consumption, and (c) operated mainly for sale - more than 50 per cent of produce intended for sale.

TABLE 1.4

TYPE OF HOLDING BY SIZE OF HOLDING

Region:	Western	Central	Eastern	Volta	Ashanti	Brong-Ahafo	Northern	Upper	All Ghana
Holdings ('000)	68.1	81.1	148.2	108.6	147.7	71.6	61.2	118.7	805.2
Subsistence Only %	5	7	2	9	6	5	22	54	14
% of which were:									
0-3.9 Acres	92	98	87	100	95	79	53	65	73
4.0-9.9	8	2	13	0	2	17	34	31	23
10+	0	0	0	0	3	4	13	4	4
Mainly Subsistence %	24	25	23	60	19	43	77	41	36
% of which were:									
0-3.9 Acres	59	93	82	82	92	53	46	30	65
4.0-9.9	28	6	16	16	5	37	46	43	27
10+	13	1	2	2	3	10	8	27	8
Mainly for Sale %	71	68	75	31	75	52	1	5	50
% of which were:									
0-3.9 Acres	32	57	56	45	34	27	75	8	43
4.0-9.9	30	26	28	38	28	30	0	0	29
10+	38	17	16	17	38	43	25	92	28

Source: Ministry of Agriculture, Economics and Marketing Division, 1970, pp.51-52.

summarises the available data with respect to production for market and farm size. If we consider 10 acres and less as small holdings, slightly over 40 per cent of the small cultivators in Ghana produce mainly for cash sale. Probably no more than half of these are cocoa farmers.⁵ Therefore, it is estimated that about 65 per cent of Ghana's farmers are small food crop farmers (cultivating less than 10 acres) of which some 20 per cent are producing only for subsistence, 50 per cent are producing a surplus no larger than their own consumption and the remaining 30 per cent are producing mainly for sale.

Apart from cocoa, cultivated crops are sometimes artificially divided into food and industrial crops. The former are those cultivated for direct human consumption; the latter provide raw materials for processing factories. The five main food crops are maize, rice, yam, cassava and plantain. Apart from cocoa, the other major industrial crops are pineapples, oil palm, citrus, tobacco, rubber, cotton and kenaf.

The foregoing indicates that agriculture is the major preoccupation of the people of Ghana. The introduction of cash crop production and modern husbandry practices has made it increasingly necessary for the farmer to obtain credit for his enterprise. Associated with credit is the whole spectrum of agricultural project management in Ghana which needs re-examination in some aspects to bring to the fore some of the neglected issues.

5 The average size of cocoa holdings in 1970 was estimated to be 12 acres (Ministry of Agriculture, Economics and Marketing Division, 1970).

1.2 Agricultural Credit in Ghana: 1918-1960

In this section, we shall review the state of agricultural credit in Ghana between 1918 and 1960. There is very little written information concerning the extent of indebtedness among farm people in Ghana and the facilities available for extending credit to them to relieve their indebtedness and improve agricultural production and marketing. No efforts were made officially to tackle the problem of agricultural indebtedness until the end of the First World War. The Colonial Government declined a petition presented to it in 1918 by the Chiefs of the Eastern Region for the establishment of an agricultural bank. A further attempt was made by a deputation of Ghanaian politicians in 1925 which resulted eventually in the adoption of a co-operative credit system. Co-operative societies granted loans to their members as a means of relieving indebtedness, and the ability of societies to make loans available to their members was as great an attraction for joining them as the possibility of the farmer sharing the returns from the bulk sale of produce.

The expansion of the co-operative movement, especially in the cocoa growing areas, was accompanied by an increased demand for credit. In the 12 years between 1944 and 1956, the co-operative societies issued more than two and a quarter million pounds in small loans to members. As at 31 March 1956, an amount of £290,579 was outstanding to the Co-operative Societies (Anyane, n.d.).

Attempts were made under an Agricultural Bank Ordinance in 1948 to establish an agricultural bank for the relief of indebtedness among farmers. The ordinance was unfortunately never applied

and no agricultural bank came into existence. More positive steps were taken in 1950 when the Agricultural Loans Board Ordinance was passed to provide for the establishment and management of a Loans Board to facilitate the issue of credit for agriculture in Ghana. In 1952, a 20 year loan for a quarter of a million pounds was made by government to the Agricultural Loans Board (ALB) at an interest rate of 2.5 per cent to enable it to undertake its functions. The responsibility for agricultural loans was transferred from the ALB to the Cocoa Purchasing Company (CPC) in 1953. The Company failed miserably owing to mismanagement. Out of 22,176 applications for loans (amounting to £6,582,461) made to the Company, 13,002 loans (or £3,227,845) were issued at a rate of interest of 10 per cent. By 1957 when the Company was dissolved, over £3 million was still owed by farmers with little prospect for its recovery.

The CPC gave way to the United Ghana Farmer's Co-operative Council (UGFCC) which was more of a political instrument for the government. It became the sole agency for organising the farming community and received an annual subvention from government for granting loans and advances to farmers.

Despite these earlier attempts at institutional credit, however, the bulk of agricultural credit in Ghana (prior to the 1960s) was provided by relatives, friends and money lenders. It was not until 1965 that an institutional base for agricultural credit was established.

1.3 The Agricultural Development Bank (ADB)

The ADB, which was originally known as the Agricultural Credit and Co-operative Bank, was established by an Act of Parliament in 1965 as a 'specialised Bank charged with the duty of providing adequate credit facilities on reasonable terms to agriculture, forestry, fishing, animal husbandry as well as to small-scale rural or cottage industries' (Brown, 1972). It had developed from the rural credit department of the Bank of Ghana. The ADB is currently the main source of credit to small farmers in Ghana (see Table 1.5). Large scale agricultural projects are financed by the National Investment Bank (NIB). The Ghana Commercial Bank (GCB), Standard Bank of Ghana and Barclays Bank, to a lesser extent, also grant credit facilities for farming in various parts of the country.

1.3.1 Organisation and Functions

The ADB was set up with four main objectives:

(1) The provision of credit facilities for the development and/or modernisation of agriculture and allied industries.

(2) The identification and promotion of agricultural enterprises in Ghana, whether singly or jointly with persons or institutions either local or foreign.

(3) The initiation of, or participation in, the conduct of research and training designed to promote agriculture in general.

TABLE 1.5

TOTAL LOANS AND ADVANCES TO THE AGRICULTURAL SECTOR, 1962-74

(¢'000)

Source	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
All													
Commercial Banks	2,500	18,100	7,000	10,000	13,800	3,200	3,800	10,000	9,048	16,154	16,048	21,673	37,946
NIB	-	750	224	290	405	353	1,233	769	692	3,433	7,583	7,535	9,572
ADB	-	-	-	-	1,071	392	1,215	3,070	4,530	8,622	28,469	17,823	14,661
Total	2,500	18,850	7,224	10,290	15,276	3,945	6,248	13,839	14,270	28,209	52,100	47,031	62,179

Source: Loans and Advances outstanding 31 December, 1974. Bank of Ghana Annual Reports for various years and Annual Report for NIB and ADB.

(4) The mobilisation of financial and human resources to meet the country's development needs in agriculture.

Management

The overall policy of the bank is determined by a seven-man board of directors with the Managing Director and the Executive Director as full-time employees of the bank. The bank's Act enjoins the board in discharging its functions to act on commercial considerations but with due regard to government policy on agriculture and cottage industries.

Organisation

The day to day activities of the bank are under the control of a Managing Director who is responsible to a Board of Directors. The Managing Director is appointed by the government for a period not exceeding five years and is eligible for re-appointment.

There are seven main departments of the bank: Operations, Administration, Research and Planning, Internal Audit, Legal, Commercial Banking and Finance. The departments are controlled by Chief Managers who are responsible to the Managing Director. Branch Offices are controlled by Area Managers.

The Organisational Chart of the bank is shown in Appendix A.1.

1.3.2 Activities of the Bank

Responsibility for increased agricultural production has in the past been concentrated in the public sector. While certain

large projects initiated in this sector may probably be desirable, the bank nevertheless lays emphasis on loans to the private sector as a means of accelerating the transition from subsistence to commercial agriculture. It is also the bank's policy to direct investments into the production of raw materials for existing factories and import substitutes, particularly food crops. The bank's ultimate objective is to help raise the living standards of farmers through increased production and productivity.

The bank has not lost sight of the three sectors in Ghana's economic development, i.e. the private, government-cum-private and the co-operative sectors. Thus the bank has directed its activities to all these sectors.

Types of Loans

Loans granted by the ADB may be categorised into short, medium and long term and this classification is normally based on the expected life of the project for which the loan is granted. Whether a particular investment is termed short, medium or long depends on the rate at which return from the particular project would be expected to pay off the loan. This, of course, depends also on the size of the project and the gestation period of the crop or livestock - the shorter the gestation period and, ceteris paribus, the shorter the loan term. Hence, the production and marketing of annuals such as rice, maize, yam, etc. qualify for short term loans not exceeding 18 months.

Medium term loans are granted for the purchase of farm machinery and equipment, livestock, land development and for setting up agro-business enterprises such as tractor-hiring services. These loans are normally repayable over a period not exceeding five years.

Projects with long gestation periods such as perennial crops (oil palm), or irrigation projects, fall within the category of long term projects and are committed for periods not exceeding 15 years.

Interest Rates on Loans

By a government directive, the ADB now charges between $8\frac{1}{2}$ and $12\frac{1}{2}$ percentum per annum on agricultural loans. In fixing interest rates within this range, however, the bank takes into consideration the financial prospects of the project to be financed, the length of the term of the loan and the degree of risks associated with it.

Hitherto, the banks have been charging a flat interest rate of 6 per cent per annum on all agricultural loans. The rationale behind the idea of lowering the rate was to make credit cheaper to the agricultural sector with a view to encouraging the public to increase their borrowing powers so as to invest in agriculture on a larger scale than before. The banks have been able to operate on this small rate of interest largely because they can borrow funds from the Central Bank or the government at a much reduced rate.

Securities on Collateral

The ADB requires that all loans should be secured. The following securities are normally accepted for agricultural loans:

Promissory Note: Here the customer signs a promissory note in favour of the bank for the loan amount approved. With customers who have low net worth in assets, the bank requires that the promissory note be countersigned by a person with good financial standing.

Landed Property: The customer may be required to secure the loan with immovable property.

Indemnity/Guarantors: Customers may be asked to provide persons with good financial standing to indemnify the bank in respect of loans.

Life Policy, Stocks and Bonds: These are also accepted by the bank as security. The bank also takes a hypothecation over the crops and livestock. The management competence of the customer, viability of the project and the associated risks are considered when determining the type of security to be offered by customers.

1.4 Objectives and Scope of the Study

It is evident from the foregoing that agriculture forms the basis of Ghana's economy. The development banks, especially the ADB, therefore, have a crucial role to play in the financing and development of the industry.

The main objective of this study is to examine the role of the ADB in its economic management of agricultural projects in Ghana and to bring into focus some of the neglected aspects of its methodological appraisal procedures and implementation of projects. An attempt will be made to offer some suggestions and approaches for overcoming these shortcomings.

In this analysis, the ADB's operations will be examined in the context of a planning and management cycle as indicated in Figure 1.1. Each stage of the cycle will be analysed and, where necessary, methods for improvement suggested.

The main hypothesis of this study is that agricultural projects are risky and have uncertain outcomes and that it is imperative to take into account elements of risk and uncertainty if ex-post and ex-ante project performances are to be consistent. The main contribution of this study will, therefore, be an attempt to develop a suitable methodology for the incorporation of a measure of risk in two selected projects approved by the Agricultural Development Bank. This has been, hitherto, a neglected area. The Monte Carlo simulation technique will be modified for use in the form of probability appraisal. The use of discounted cash flow methods, accounting prices and shadow wage rates will also be looked into.

Pineapple and maize projects of the ADB's customers have been selected from the writer's loan portfolio for this exercise. The selection of projects for analysis in this study has largely been influenced by the greater emphasis placed by the bank on the projects' financing and development. (See Table 1.6 for loan portfolio by ADB to

FIGURE 1.1

PROJECT PLANNING AND MANAGEMENT CYCLE

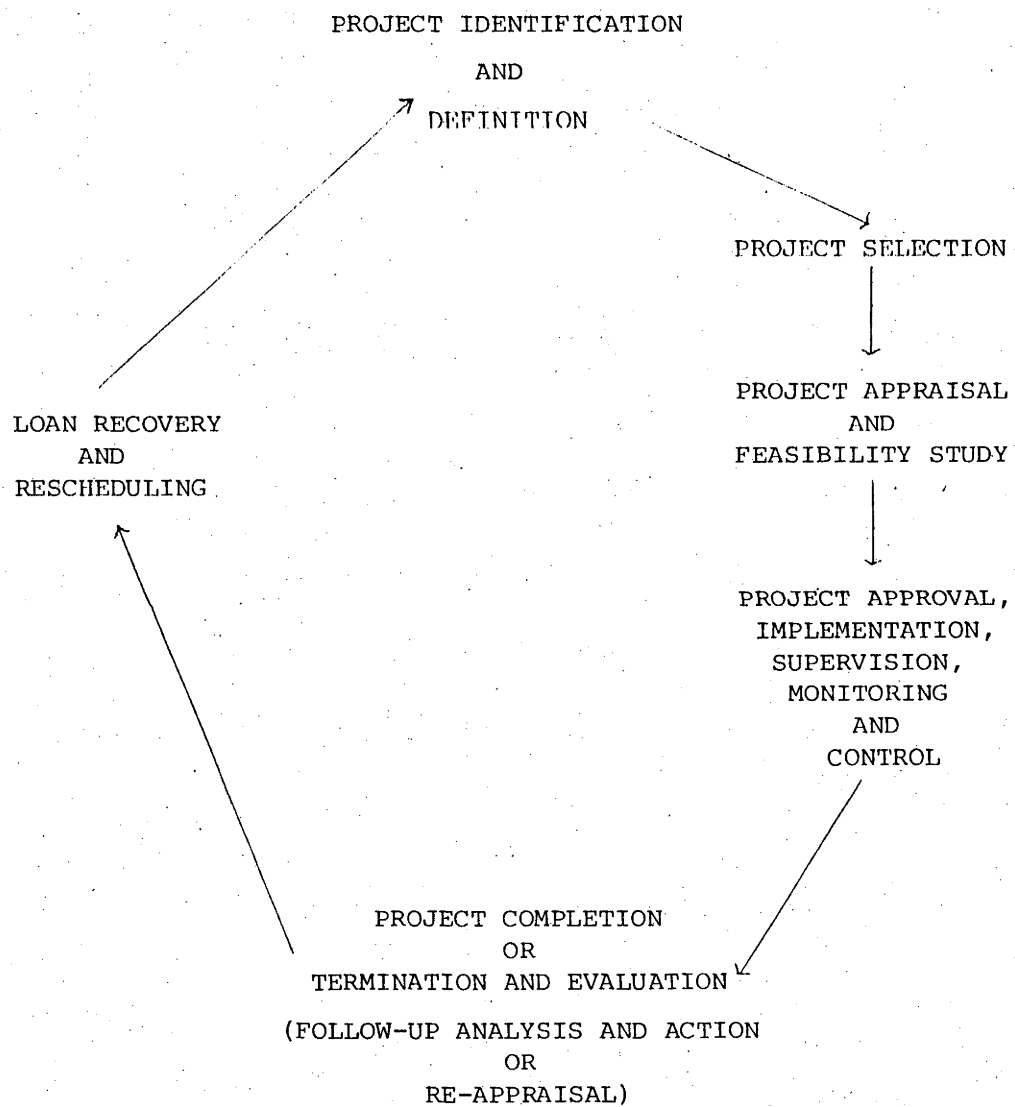


TABLE 1.6

LOAN CLASSIFICATION

The 1975 loan portfolio may be classified on sector basis as follows:

(%)

<u>Sector</u>	<u>Amount</u>	
Food Crops	4,475,726.25	
Livestock	828,020.00	
Industrial Crops	1,763,249.00	
Fishing	1,080,298.85	
Agro-Business	1,272,824.00	
Sub-Total		9,420,118.10
<u>Schemes</u>		
Maize	4,683,474.00	
Yam	2,578,490.00	
Rice	241,405.00	
Cassava	251,516.00	
Cotton	300,000.00	
Shallot	21,200.00	
Groundnuts	110,790.00	
Guinea Corn/Beans/Millet	41,820.00	
Sub-Total		8,228,695.00
Cocoa Rehabilitation	1,468,518.80	
Special Projects	1,952,492.23	
Sub-Total		3,421,011.03
Grand Total		21,069,824.13

Source: ADB 1975, p.14.

the various sectors.) However, the unavailability of adequate data has constrained the choice of projects for study. Despite this shortcoming, it is hoped that the methodology developed will be useful and will provide the basis for future research work. The application of this type of analysis in project analysis will also train management to appreciate that projects can be risky and that a mistake in committing resources to very risky projects might be very costly. In effect, management will be provided with more appropriate information for making the right decisions by recognising the likelihood or variable outcome of projects in the face of risk and uncertainty.

CHAPTER 2

PROJECT FINANCING AND MANAGEMENT IN THE ADB

This chapter highlights project financing and management in the ADB. It also attempts to identify some of the neglected issues and problems which have characterised the Bank's operations. The main aspects of planning and management covered are depicted in Figure 2.1.

2.1 Project Identification and Selection

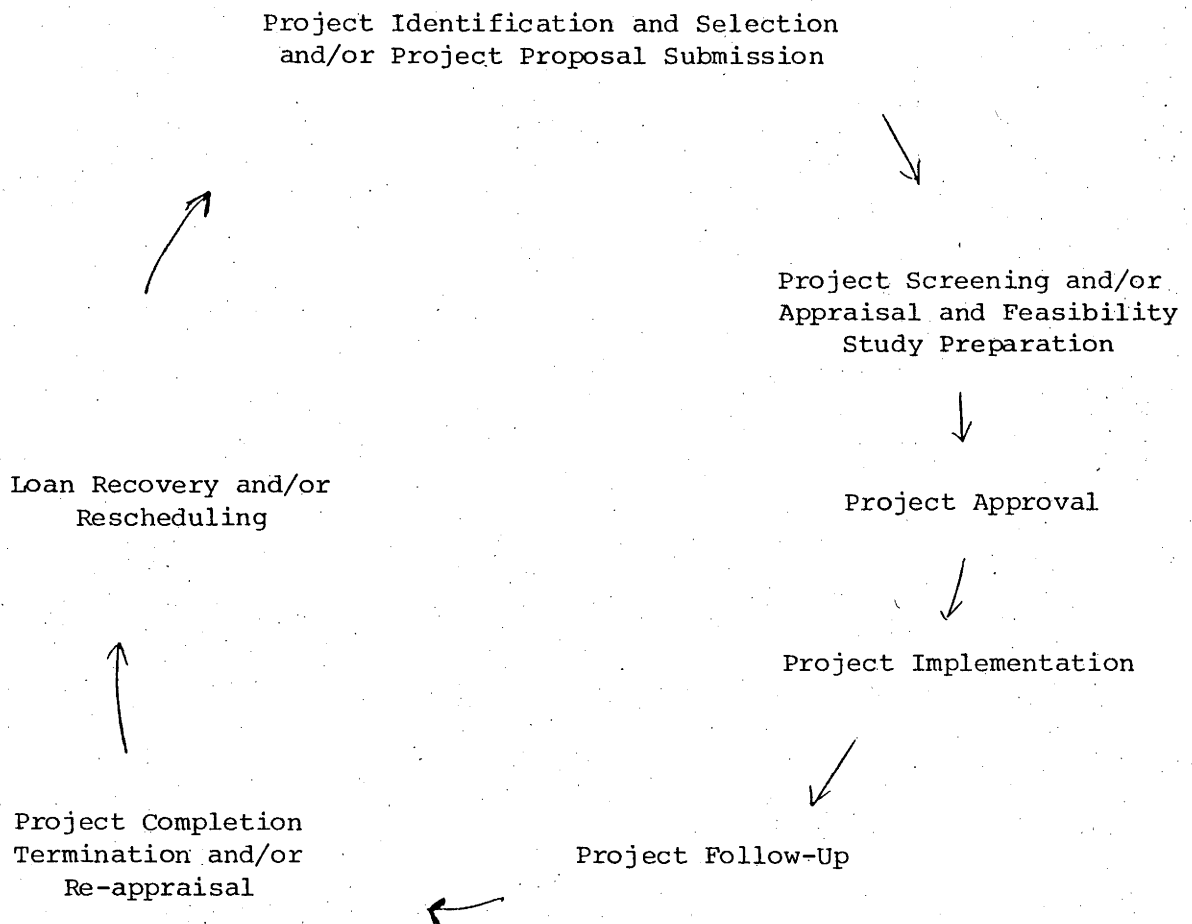
One major objective of the ADB is the identification and promotion of agricultural enterprises in Ghana, whether singly or jointly, with persons or institutions either local or foreign.

Ghana's economy, like most development economies, is faced with constraints. However, development opportunities still exist. The constraints are numerous, powerful and entrenched, while the development opportunities, although numerous, are less apparent. Investment projects are, therefore, planned with a view to exploiting the most promising areas of the economy.

In carrying out the above-mentioned objective, the ADB looks at the country's agricultural potential needs and targets as embodied in the national development plan. The purpose of the development plan is to determine general guidelines that should lead to the fulfilment of overall development goals.

FIGURE 2.1

PROJECT FINANCING AND MANAGEMENT CYCLE
IN THE AGRICULTURAL DEVELOPMENT BANK



In trying to meet the criterion set for project identification, the ADB attempts to observe the following conditions:

- (a) the project is subjected to an examination to ensure its priority for the economy and especially for the agricultural sector;
- (b) the project will yield a high rate of economic return to the society.

Potential projects identified by the ADB for financing are normally defined to conform with the alternative sectoral strategies that would lead to the achievement of the objectives specified by the policy planning exercise.

The ADB is bound by its objective to select any technically feasible and economically viable agricultural or agro-industrial project presented to it for financing. Thus the bank handles the bulk of institutional investment in the country's agricultural sector. Refer again to Table 1.5 for loan advances to the agricultural sector by the major financial institutions.

Despite the heavy demand on the ADB's resources, selection of projects for financing is frequently on the basis of total financial resources available to the bank for investment and this is quite often limited. The main sources of loanable funds for the credit institutions in Ghana are the Government of Ghana and the Central Bank. Funds from these sources are obtained by the credit institutions in the form of loans and equity subscription. External aid and loans to the agricultural sector have also been coming from the World Bank through the

International Development Association (IDA) and also the African Development Bank.

Apart from a project's viability, a farmer's eligibility to receive credit from the ADB depends on his management competence and his ability to provide some sort of security or collateral.

Apart from projects identified, selected and financed by the ADB, an intending customer of the bank normally lodges an application for a loan and, on its receipt, he is invited to an interview. If from the discussion it becomes evident that the project has a chance of success, the applicant is given an official application form to complete and return, giving more details of the proposed project. The technical officer in charge of the project in question verifies the information furnished by the applicant by visiting the project site. He then assembles the initial data necessary to enable proper assessment of the applicant's credit needs and the profitability of the project to be determined. The technical officer then submits a pre-appraisal report to a screening committee for consideration prior to final appraisal and consideration by a loans committee and/or Board of Directors.

Despite the strong efforts made by the ADB in identifying and selecting agricultural production projects, a number of serious deficiencies arise in this direction.

The process of identification begins with the search for an idea with a development potential and ends with a specific project. In between lie a number of steps which need to be undertaken systematically until the final project is evolved. This gradual build-up

from a development-oriented idea to a specific project is achieved through a process of successive approximations and calls for a number of preparatory and analytical phases involving use of supporting data, the participation of many experts in various disciplines, as well as close co-operation between various government agencies and departments. However, the machinery for such a thorough exercise falls short of expectation as a result of lack of a proper compendium of essential statistics for the economy and the agricultural sector, including an analytical presentation of the structural indicators of the economy and the agricultural sector, with particular emphasis on the inter-relationship between the two.

Some problems also arise in the co-ordination of projects with the national development plan, despite attempts by the bank to relate project identification and selection with it. These include: the lack of strong political and administrative support for national plans among operating ministries responsible for project implementation; ineffective communication of plan goals to the bank and other allied organisations with investment resources; and the failure to specify projects required for plan implementation. The shortage of adequately trained planners and specialists in central planning agencies and operating ministries and the bank itself compounds the problem.

Other serious problems in this aspect of project planning and management are the promotion of 'pet projects' by individuals and groups within government agencies, the bank and even international assistance organisations. Development patterns are often distorted

through the imposition of funding agency priorities on recipient governments. Long lag periods in the processing of project proposals by government agencies and funding organisations have also caused problems.

2.2 Project Formulation (Appraisal and Feasibility Study Preparation)

Once a project has been selected as promising, the next major task is to formulate the selected investment proposal and to examine systematically and in some depth its essential features. These features will include a study of project area, purpose, size and location of project, description of major works and other project components, estimation of costs and their composition, proposed production pattern, volume and value of incremental output, project financing, organisational and management needs and finally the prospective financial returns of the project. Such a systematic examination amounts to undertaking the feasibility study of the selected investment proposal for the purpose of reaching a final decision.

In the detailed feasibility study of projects, the ADB examines their technical considerations, marketing, management, economic and financial aspects, collateral offered and repayment arrangements. A format depicting the bank's feasibility study of projects is shown in Appendices B.1 and B.2.

Project formulation, as pointed out earlier, forms a very important link in the project planning and management cycle and should provide sufficient information to the ultimate decision-making authority for the purpose of reaching a final decision. In spite of the

importance of this link, there are a number of deficiencies in the setting followed by the ADB which have tended to result in the making of recommendations for decision-making which are not based on sound and logical assumptions and facts. The most neglected issues are in the following steps in project formulation.

2.2.1 The Project Area

The success or failure of the project will primarily depend on the adequacy and quality of the physical and human resources of the area embraced by the project and its future economic prospects.

However, most analyses in this section have not been supported by the findings of surveys and other relevant data on physical resources, population and employment, economic and social infrastructure, institutions, economy of the project area and agriculture of the project area.

2.2.2 Project Description

Here certain essential features of the project have often been overlooked. In defining project objectives, secondary objectives, if any, have not been emphasised and there has not been structuring of primary objectives which is important from the point of view of defining various project activities and establishing the logical sequence between them.

The presentation of proposed major works and other essential components which ought to be established to bring the project to the stage of full development have not been fully detailed to provide a clear picture of their nature and scope and to enable the estimation of costs to be made with a fair degree of reliability.

2.2.3 Organisation and Management

The success of the project depends largely, apart from its technical and economic merits, on the effectiveness of the organisation or organisations and management responsible for its construction and operation. Without an efficient organisation, a sound and viable project may end in failure. This important aspect of the production process, however, has a number of deficiencies which need to be examined. These include insufficient capacity or incompetence of local contractors; difficulty in obtaining local resources and materials during construction; lack of proper operation and maintenance facilities at the on-going phase of the project; and most important of all, problems with farm services and other agrarian measures. Here research and extension have been lacking or inadequate, major input supply has been a hindrance, and marketing and processing have not been well handled. Land tenure problems resulting in protracted litigations have also disrupted a number of projects as a result of improper land reform.

2.2.4 Pricing of Inputs and Outputs

Project costs consist of all the expenditures on goods and services required for the various phases of the project: preconstruction, construction, operation and maintenance. At the formulation stage these costs are in the form of estimates and their degree of reliability depends on the extent to which various project actions are translated into appropriate work quantities and their corresponding justified unit rates. It is essential, also, that in the feasibility

study the various cost and price estimates be fairly reliable since they form the main basis for project funding and for calculating the financial and economic returns of the project.

It is regrettable, however, to note that as a result of inadequate and unreliable data and inflationary trends, cost and price estimates by the ADB and other financial institutions in Ghana have not been reasonably accurate and have more often than not deviated widely from the expected norm. This problem of incorrect costing has been compounded by the use of a single-valued estimation approach. Uncertainty usually affects most of the variables which are combined to obtain a cost estimate, an economic rate of return, a net present value, a financial return, or any of the other indicators which may be used to evaluate a project. Sometimes this uncertainty is dealt with by combining values for all input variables, chosen in such a way that they yield a conservative estimate for the result of the analysis. In other cases, the best estimate value is selected, that is, the value which it is thought is most likely to be achieved. Both these solutions imply a decision: first to look at the project with a conservative eye, and second to disregard the consequences of any variation around the best estimate value. Both can lead to biased decisions.

This has been recognised by Hertz (1964), Reutlinger (1970), Pouliquen (1970) and Jones (1972). For example, Pouliquen asserts that 'if we combine only conservative estimates of our variables, our final result is likely to 'over conservative'. On the other hand, by using only best estimate values of the variables we

fail to take into account that other values of the variables we combine might result in substantial variations in the final estimate; thus, by basing our decision on a single value of the decision variable we may be taking more risk than we intend.' (Pouliquen 1970, p.2).

2.2.5 Indicators of Project Worthiness

There are a number of indicators of worthiness of a project, some simple and some complicated. However, the common denominator of all indicators is the comparison of benefits and costs. A good indicator of worthiness should be comprehensive, i.e. it should take into calculation all the cost and benefit items brought about by the project and these should be appropriately valued. If these two prerequisites are not met, the value of the indicator is in serious doubt.

In the ADB, the most simple non-discounting methods are used in determining the worth of both small and large scale projects. These measures, although having their own inherent advantages, fail to take into account the consideration of time and could give misleading results.

One of the indicators, the pay-back period or recoupment method shows the number of years required for net benefits to equal the cost of the project. It has the advantage of being simple and is considered to be a useful criterion where the emphasis is on early recovery (break-even point) of capital

because of financial constraints. It could be particularly useful in the case of risky investments where risk is due to technological progress and commercial uncertainties. The main shortcomings of the indicator, however, are that it gives excessive weight to quick yields and ignores the importance of net benefits beyond the break-even point. Another disadvantage is that no allowance is usually made for taxation or for capital allowances (these may be very different for different projects). Even if some attempt is made to include these, the benefits of investment allowances may accrue over ten to fifteen years, or even more, and are therefore undervalued since they continue after the end of the pay-back period.

The other main indicator used is the return on investment or the peak profit method. The basis of this method is to take the level of profits in the best year and express it as a rate of return on the sum invested. The assumption behind this method is that the peak-profit rate of return is in some way a guide to the average profitability of the project. Hawkins and Pearce (1971, p.16) contend that this assumption is only valid if projects have similar lengths of life and similar profit streams. In practice, however, project lives vary enormously, as do profit patterns. Some projects have profits which are expected to build up slowly to a peak; others reach a peak early and then decline. A project with a relatively low peak profit, but which reaches its peak early, may be better than one which reaches a higher peak later in its life. The reason is that the high early profits can be re-invested. The peak profit method cannot allow for

this, neither can it deal adequately with the effects of capital allowance, which may differ from project to project.

2.2.6 Sensitivity Analysis

The rate of return of a project is likely to be affected by changes in value of some of its basic parameters. Sensitivity analysis can be undertaken by varying the value of each of the sensitive parameters by the same fixed percentage so as to determine which one is likely to have a greater impact on the rate of return if a range is assumed instead of a unique value. In this way, sensitive parameters are isolated and a series of rates of return calculated by assigning different values to the sensitive parameter. Despite the usefulness of this method in feasibility analysis, its use has largely been neglected in the ADB.

2.3 Project Approval, Implementation, Supervision, Monitoring and Control

Following the appraisal of a project, a feasibility report is presented to a loans committee/board for their final decision. They assess the major aspects of the project, i.e. technical, commercial, organisational, financial and economic, with a view to making a judgement on its worthiness. In some cases, the technical officer presenting the report is invited to the meeting to defend certain aspects of the report which might not be apparently clear or convincing.

When a project is approved for financing, various formalities (signing of promissory note, execution of Heads of Agreement, etc.) are carried through and disbursements follow.

Adhering to the system of supervised credit, the ADB as a rule does not disburse its loans in cash or at one discrete period unless circumstances really demand that such a rule should be set aside in the best interests of the project being financed. When a loan is made under the system of supervised credit, the applicant is made to understand that he should utilise his loan mainly in kind and he should thus make his purchases with the consent of the bank. Payments are made on behalf of the bank upon receipt of pro forma invoices, statements or bills from the suppliers of the inputs or capital items purchased. If, for the payment of any item or, as is usually the case with regard to payment of wages for labour, cash disbursement is made, the bank would have to satisfy itself as to the bona fides of the customer's request so as to ensure that money is not diverted for other purposes.

Supervision, Monitoring and Control

Following the approval and disbursement of loans, follow-ups are made by the personnel of the bank to check on the progress of the project. On such visits, the officer's attention is focussed on items to which disbursements have been made and difficulties facing the customer. These follow-ups are carried out regularly and reports are compiled. The purpose of this monitoring system is to provide the necessary information for effective project management.

It tries to compare planned outputs, targets and purpose with the real levels achieved by the project.

Once a project is selected, its timely approval by the management of the financial institution and the ability to implement operation plans is a crucial determinant of ultimate success or failure. But the ADB and other financial institutions in Ghana face particular difficulties in activating, organising and implementing projects.

Among the most frequently encountered problems of initiation are:

- (1) delays in granting necessary approval for project activation, and procedural and bureaucratic delays at the management/board level;
- (2) difficulty in obtaining local and imported resources and materials during construction, leading to delays and cost over-runs.

Apart from the above difficulties, there have been several instances where unavailability and exorbitant prices of certain farm inputs at the times required appeared to have nullified the efforts of the credit institutions. Specific infrastructures which are considered necessary prerequisites for successful implementation of credit programmes have also not been easily available to farm operators. The situation is further worsened where a particular customer is found wanting in the management of his own project.

By the very nature and objectives of agricultural credit, more effective supervision, monitoring, control and ex-post evaluation are needed if the lending institution, the farmer, and society as a whole, are to benefit from the project. However, lack of managerial skills and technical competence, the severe shortage of trained administrators and technical staff and ineffective and inadequate extension services plague these aspects of agricultural credit programmes.

Problems of monitoring and control have tended to result in failure to properly re-design projects upon discovery of un-anticipated obstacles to implementation. They have also brought about frequent failures to collect and process feedback information required to indicate achievement of performance targets and to correct deviations from work schedules and specifications.

2.4 Project Completion or Termination and Evaluation

When the monitoring process does not reveal a deviation of the project from the set targets, purpose and planned outputs, the bank's involvement normally comes to an end after the loan has been fully amortised. Of course, if the bank directly holds a share in the project, then it continues to operate it through its economic life. A project would cease to be operational when it is abandoned by the customer as a result of improper management, destroyed by a natural hazard, or for some other reason.

With respect to on-going projects, the monitoring process would more often than not reveal that activities and resources are not

matched by the actual results because of inefficiency in several areas. Under such circumstances, an evaluation process is carried out. This process attempts to define why things have happened the way they have. An attempt is made to determine the effectiveness of resources and of planned activities. These activities are conducted in the pursuit of the project purpose and contribute to the realisation of the programme goal. In other words, given a set of project inputs (resources and activities) the evaluation exercise consists of determining whether the anticipated outputs were produced, whether these outputs, in fact, achieved the project purpose, and finally whether this made a significant contribution towards the achievement of programme goals.

2.5 Loan Recovery and Rescheduling

The customer is expected to repay his loan by following a repayment schedule given to him by the bank. The schedule is a table stating the specific dates for repayment of the instalments and the amount of the instalments. Periodic reminders and contacts with the customer are made when the repayment falls due but is not honoured.

In certain cases, it becomes necessary for a particular project to be re-appraised and the repayment revised and/or further investments made to correct loan imbalances and operational bottlenecks.

Loan rescheduling or further investments are made under the following circumstances:

- (1) positive fluctuations in input prices during the constructional stage of the project;
- (2) natural hazards resulting in low production;
- (3) low produce price at harvest; and
- (4) disabilities which prevent the project from achieving the targets and projections indicated in the original report.

An annual review on defaulters and delinquent customers is carried out in order to reschedule loans where there is a genuine case for re-adjustment. Requests for rescheduling of loan repayments go to the appropriate committee.

CHAPTER 3

PROJECT EVALUATION METHODOLOGY

This chapter examines the current state of project evaluation methodology. (Evaluation in this context means appraisal and it takes place before a project is approved. It includes ex-ante evaluation of anticipated benefits.)

In Section 3.1 the main project evaluation procedures are reviewed. Section 3.2 covers an examination of the difficulties of economic cost-benefit analysis. A critique of the methodologies reviewed is undertaken in Section 3.3.

3.1 A Review of the Main Project Evaluation Procedures

3.1.1 Cost-Benefit Analysis

There are various methodological frameworks to appraise projects by cost-benefit analysis. However, they are all based on the same concepts and as Lal (1974, p.xiv) has pointed out, '... any substantive differences among the alternative procedures are in large part dependent upon differing assumptions about the relevant aspects of the economic environment in which the investment decisions are being made'.

3.1.2 The Origins of Economic Cost-Benefit Analysis

Economic cost-benefit analysis has its origin in financial analysis. A private investor confronted with the choice of

alternative investments determines the profitability of the investments. Cost-benefit analysis assesses the benefits and costs of alternative investment possibilities and reduces them to a common denominator. The methodology provides a simple criterion for investment decisions. A project is accepted if its net benefits exceed those of the next best alternative course of action. The definition of costs and benefits is simple for a private investor: monetary expenditure is considered as costs and income as a benefit. Thus financial analysis which, according to Squire and Van der Tak (1975) 'identifies the money profit accruing to the project-operating entity', provides a private entrepreneur with the necessary criterion to choose among alternative investments.

Economic cost-benefit analysis differs from financial cost-benefit analysis in so far as the effects of the project are not evaluated according to their profitability to the operating entity but according to their impact on the society as a whole.

Thus economic cost-benefit analysis, sometimes referred to as social cost-benefit analysis in the literature, is similar in form to financial analysis: they both assess the profit of an investment. However, they differ in what they consider to be cost and what they consider to be a benefit, i.e. the concept of financial profit is not the same as economic profit. If private benefits would coincide with economic profits, there would be no need for two distinct analyses. However, for that to be the case, a host of assumptions proposed by Little and Mirrlees (1974, pp.19-24) concerning full employment, competition, marginality, consumer sovereignty, external effects and

income distribution have to be fulfilled. Since these assumptions are normally not justified in developing countries, economic cost-benefit analysis adjusts the financial analysis by:

- including (excluding) some costs and benefits which have been excluded (included) in the financial analysis (e.g. transfer payments, contingencies, sunk costs, externalities, multiplier effects, etc.);

- revaluing certain inputs/outputs according to shadow prices reflecting their real cost-benefit rather than their market value, e.g. rather than using the market price of labour, economic cost-benefit would calculate the opportunity cost, i.e. the marginal output of labour foregone elsewhere because of its use in the project. Squire and Van der Tak (1975, pp.19-25) discuss these factors which have to be excluded/included in economic cost-benefit analysis compared to financial analysis.

Thus traditional economic cost-benefit analysis has been evaluating projects according to a single objective, i.e. the increase of income to the society without giving sufficient attention to other social objectives a society may pursue. Most criticism against economic cost-benefit analysis is addressed to this type of analysis.

3.1.3 The Little and Mirrlees Approach¹

The raison d'etre of the OECD method proposed by Little and Mirrlees lies in the use of accounting prices as better guides

¹ Based on the writer's review of Little and Mirrlees (1974).

to project selection than actual market prices. They base project decisions on the social value of a project as measured by accounting prices.

Little and Mirrlees argue that, in view of distortions in prices, a project's anticipated receipts and expenditures cannot be relied upon to measure social benefits and costs in most developing countries. Therefore, there is a strong case for the use of cost-benefit analysis. In supporting the basic idea of economic cost-benefit analysis, however, they suggest that hypothetical rather than predicted actual prices must be applied when evaluating a project. The rate of discount may also not correspond to any actual interest rate. They attest further that 'these "shadow prices", as they are called, are chosen so as to reflect better the real costs of inputs to society, and the real benefits of outputs, than do actual prices.' (Little and Mirrlees 1974, p.36). Some of the shadow prices are, for example, that of foreign exchange and unskilled labour.

Little and Mirrlees concede that shadow prices cannot be exact reflections of social costs and benefits but are much better approximations of actual prices for many projects in many countries. They also do not claim that, 'the use of accounting prices is a very satisfactory method of dealing with distortions in prices. Many of the distortions can be fully dealt with only by removing them - that is, by adopting policies which lead to proper correspondence of prices and costs and benefits' (Little and Mirrlees 1974, p.37).

The numéraire in the Little and Mirrlees approach is world market price, and the components of a project are divided into three categories:

(1) Traded Goods and Services

- (a) Goods which are actually exported or imported (or their close substitutes actually exported or imported);
- (b) Goods that could be exported or imported had the country followed policies that would have resulted in optimum industrial development.

(2) Non-traded goods and services.

(3) Unskilled labour.

3.1.4 The UNIDO Method¹

The UNIDO (United Nations Industrial Development Organisation) guidelines for project evaluation proposed by Dasgupta, Marglin and Sen, like the Little and Mirrlees approach, are concerned with the use of cost-benefit analysis which expresses a social inventory in industrial projects' evaluation. However, it is felt that some of the basic issues would be relevant to the valuation of agricultural projects.

In the UNIDO approach of economic cost-benefit analysis, the numéraire is present aggregate consumption, that is, all items involved in a project are valued in terms of present aggregate consumption, which is sought to be maximised.

The basic feature involved in calculating the aggregate consumption benefits of a project is to measure the consumers'

¹ Based on the writer's review of Dasgupta, Sen and Marglin (1972).

willingness to pay for the 'net output' of the project. By net output of a project is meant the goods and services made available to the economy which would not have been available in the absence of the project. By the same token, 'costs' involved in a given project are measured by the maximum alternative benefits foregone as a result of using resources and services in this project.

Viewing it this way, the components of a given project are divided into the following broad categories (Dasgupta 1972):

- (1) Direct present benefits
 - (a) Consumer goods
 - (b) Producer goods
- (2) Direct present costs
 - (a) Producer goods
 - (b) Foreign exchange
- (3) Indirect future benefits and costs,
e.g. unskilled labour.

3.1.5 The Squire/Van der Tak Approach¹

Squire and Van der Tak subscribe to the main principles of the cost-benefit approach for economic analysis of projects. However, they propose that 'in assessing the merits of different projects, the objectives of any particular society clearly must be taken into account. That is, project costs and benefits must be measured against the extent to which they detract from, or contribute to, achievement of that society's objectives' (Squire and Van der Tak

1 Based on the writer's review of Squire and Van der Tak (1975).

1975). They define two basic objective characteristics of all countries, viz. to increase total national income, the growth objective, and to improve the distribution of national income, the equity objective.

Generally, they assert that projects should be assessed in relation to their net contribution to both of these objectives, but this has not always been the practice of the World Bank or of other lending institutions.

The methodology outlined in the Squire and Van der Tak approach deviates in some essential respects from traditional analytical practice. In particular, they recommend a more systematic and consistent estimation and application of shadow prices than has been done in the past. Again, in contrast to past practice, they favour the calculation of rates of return that take explicit account of the impact of the project on the distribution of income, both between investments and consumption and between rich and poor.

The authors recommend that as a numéraire, or unit of account, the value of real resources that are freely available to the public sector be used, or put more simply, that the numéraire be public income. They define their numéraire as 'uncommitted public income measured in convertible currency', which they refer to as 'free foreign exchange'. They use a series of weights to convert values of, for instance, increase in public consumption, into the numéraire.

3.1.6 The World Bank Method

The method used by the World Bank, like the UNIDO method, adopts the domestic price as the numéraire. Here, non-traded goods are expressed in terms of domestic prices, therefore the prices of imports and exports have to be adjusted to the domestic price level (which is usually higher). Higher domestic price levels lead to higher net present worth when the domestic price numéraire is used.

3.2 The Difficulties of Economic Cost-Benefit Analysis

3.2.1 The Definition of Equilibrium Prices

According to Squire and Van der Tak (1975, p.26), shadow prices are no longer defined as the equilibrium prices that would prevail in a distortion-free economy. They 'are determined by the interaction of the fundamental policy objectives and the basic resource availabilities' (Squire and Van der Tak 1975, p.16). Thus the calculation of shadow prices, as seen by Imboden (1978), implies that there exists an intrinsic value for inputs and outputs (for a given welfare function and resource basis) and that this intrinsic value can be determined. Some authors¹ contest the existence of such intrinsic values, or if they accept their existence, consider that it is impossible to determine those values with any precision.

1 See, in particular, Charles Prou, 1973, p.6.

3.2.2 The Definition of Welfare Function

The process of shadow pricing presupposes 'a well defined social welfare function, expressed as a mathematical statement of the country's objectives ...' (Squire and Van der Tak 1975, p.49; Little and Mirrlees 1974, p.89). However, Imboden (1978, p.36) argues that, 'there exists no objective development function: objectives and their relative weights cannot be determined objectively. The definition of a welfare function thus depends on the characteristics of those making the valuation. There exists, therefore, not one welfare function, but as many as there are different value sets present in the society. Since shadow prices used in social cost-benefit analysis depend on the welfare function chosen, there are as many shadow prices as there are value sets represented in the society. Therefore, a social cost-benefit analysis does not provide an unambiguous, unique criterion for project appraisal'.

The exactitude of the shadow prices depends on how well the economist translated the subjective welfare function of the decision-makers. On the other hand, the decision-maker can only appreciate the value of the economic cost-benefit analysis if he understands the different factors that have been taken into account in calculating the various costs and benefits. Economic cost-benefit analysis, therefore, requests a close dialogue between decision-makers and economists. The inclusion of different objectives into one figure, however, does not facilitate this dialogue. The shadow wage rate, for example, includes, in one figure, four different values: the economic efficiency cost (opportunity cost of labour),

the valuation of leisure (reservation wage), the valuation of additional present consumption compared with future consumption (inter-temporal distribution) and the valuation of additional consumption according to the agent who receives it (inter-personal distribution).

3.2.3 The Determination of the Effects of a Project

Before putting a value on costs and benefits of a project, we have to identify the effects the project has on its environment: 'In order to affix dollar values to the benefits of a programme, first there has to be some evaluative evidence of what kinds and how much benefit there has been' (Weiss 1972, p.84). How much time one spends on the identification of effects compared with their valuation depends on what we know about the potential effects. Putting high emphasis on valuating the contribution of a project to a country's socio-economic development objectives, according to Imboden (1978, p.38) 'is justified if we can predict those contributions with a reasonable degree of accuracy. If the effects of a project cannot be predicted with confidence - which is often the case with so-called social projects - the emphasis has to be shifted from the valuation of effects to their identification. In such cases, social cost-benefit analysis, which assumes that the effects of a project have been identified, may be of little interest.'

3.3 A Critique of the Existing Methodologies

3.3.1 Disagreement with the Basic Philosophy of the Methodologies Proposed

The administrators in developing countries often feel that the specific management methods proposed do not take into account

sufficiently their own objectives. They feel that many of the underlying assumptions of specific methodologies have been derived from a traditional western approach and are not justified in the developing country environment.

3.3.2 Disagreement About the Usefulness of the Methodologies Proposed

Developing administrations are often not convinced that the proposed analytical methods lead to better decision-making and management. They often consider appraisal methods as window dressing to make predetermined decisions acceptable to some foreign donor, and proposed monitoring systems as a means of hidden controls imposed by foreign interest groups. Since management systems are mostly proposed and often imposed by foreign donors, they are considered as just another means of control used by foreign powers.

3.3.3 Disagreement About the Applicability of the Methodologies

It is contended that most methodologies proposed are not taking into account the institutional and organisational aspects of the countries concerned and often misjudge the decision-making structure. The methods are analytically complex and are too demanding in terms of data and planning capacity. They do not take into account the realities of staffing, time pressure and data availability in developing countries.

3.3.4 Disagreement About the Questions Addressed by the Proposed Methodologies

According to developing country administrators, the proposed methodologies put too much emphasis on predicting the effects of projects and not enough on the problems of execution and implementation. Moreover, the proposed methodologies concentrate on choices among alternative actions, while developing countries' major concern is to identify those actions. The methodologies attempt to identify optimal solutions to given problems, while developing country administrations are concerned with identifying problems and finding satisfying solutions to them.

All these criticisms concern the questions addressed by the proposed analytical systems and the lack of adaptation of the methodologies proposed to the real world situation.

CHAPTER 4

SUGGESTED IMPROVEMENTS IN PROJECT PLANNING AND MANAGEMENT

In the previous chapter, a review was made of the existing methodologies in project evaluation. In the following chapter, suggestions for improving project planning and management in the ADB are discussed. The stages covered include project identification and selection, project formulation and implementation procedures.

4.1 Improving Project Identification and Selection

Economic and social development are long term processes involving many activities on a wide front. The choice of projects in this process is of strategic importance in that, if the selection is good, the momentum of development can increase rapidly. On the other hand, if the selection is poor, the growth of the economy will remain slow, and additional development efforts may be severely handicapped. A pre-condition for rapid development is the achievement of greater efficiency in the use of resources. This is especially important in Ghana and other developing countries where critical resources are in short supply and where the need for accelerated development and structural changes is most urgent. Consequently, in each sector, priority should be given to those projects which can utilise existing and new resources more efficiently and which can have the maximum catalytic effect in promoting further development. A careful approach to project analysis makes it possible to identify such promising opportunities for development

and to exercise rational choices among alternatives. Hence the need for improved methods of project identification, selection, formulation and appraisal.

Good identification ensures that the project selected will serve the needs of the economy, that it is of high priority and consistent with the development targets of the sector concerned and that it ranks high among competing alternatives.

From the point of view of project identification and selection, the criterion of exploiting the most promising areas of the economy implies the observance of at least four cardinal conditions suggested by the FAO (1971). Projects should:

- (1) be subjected to a rigorous examination to ensure their priority for the economy and especially for the sector to which they are related;
- (2) neutralise or minimise the inhibiting effects of the constraints facing the development of the sector or sub-sector;
- (3) make the optimum use of scarce factors in the economy; and
- (4) yield a high rate of economic return to the society.

In the identification and selection of agricultural production projects, the major steps to be considered are: the economic

setting of the country and the role of agriculture; constraints facing overall and agricultural development; selection of agricultural priority sectors; the identification of the project; the choice of alternatives and selection; and, finally, a brief summary of the project itself.

Of course the Ghana National Development Plan is supposed to have sorted out all these preparatory steps necessary for the identification of potential investment proposals. However, lack of proper co-ordination of certain activities, as pointed out earlier, enjoins the project planner of the ADB and allied institutions to look more seriously into them.

4.1.1 Economic Setting of the Country and the Role of Agriculture

Every investment proposal put forward for consideration should be capable of making a contribution to the socio-economic betterment of the country; otherwise its purpose will remain in doubt and there will be less justification for allocating scarce resources for its implementation. Therefore, prior to the formulation of a specific investment proposal, a sound diagnosis of the country's economy has to be made, including a thorough analysis of the agricultural sector and its potential contribution to the future growth of the economy. Such a diagnosis, if undertaken with care, will reveal the constraints on the economy and the agricultural sector and will single out those segments of agriculture which are capable of rapid development through additional investment. Thus, the purpose of the analysis is to gain a better understanding of the agricultural

sector with a view to identifying the most rewarding investment proposals.

In the agricultural sector, the diagnosis will include the study of trends in agricultural production, yields of crops and livestock and products, farm prices and income, changes in the supply of agricultural requisites (fertilisers, machinery, etc.) and the behaviour of agricultural exports and imports. It would also include a review of the agricultural resources (land, forestry, fisheries and water supply) and explain any newly discovered resources which might affect the future productive capacity.

The FAO (1971, p.8) suggests that the best way of undertaking such a diagnosis is to prepare a compendium of essential statistics for the economy and the agricultural sector, including an analytical presentation of the structural indicators of the economy and the agricultural sector, with particular emphasis on the inter-relationship between the two. Obviously, the depth of the exercise will depend on the availability of data and vital statistics.

4.1.2 Constraints Facing Overall and Agricultural Development

From the analysis of the economy and the agricultural sector, it should be possible to single out the major constraints which are likely to affect, in one form or another, the formulation and implementation of agricultural production projects. The understanding of constraints is vital for project identification and

selection as they focus attention on the scarcities of physical and financial resources and highlight various institutional and policy shortcomings which need to be carefully considered in the selection and preparation of projects. Of course, it is not necessary to list all the constraints; one need only mention those which are likely to prove critical in the construction and/or operational phase of investment proposals. It is advisable to review the critical constraints in a time perspective, as they are likely to change in the course of project implementation, and to indicate the extent to which they could inhibit, individually and collectively, the progress of the project at various stages. For convenience, the various constraints can be grouped into four separate categories:

- (a) Resource
- (b) Infrastructure
- (c) Institutional and Policy
- (d) Technical

(a) Resource Constraints

These include the limitations on agriculture such as the shortage for good arable land, soil deficiency, inadequate rainfall, lack of irrigation water at critical periods and shortage of labour at peak seasons. The most important resource constraints may often be the shortages of foreign exchange and skilled labour. Any government policies related to the amelioration of these two critical factors should be studied in depth.

(b) Infrastructure Constraints

These will include the limitations and defects in the existing productive facilities, e.g. water structures, farm building, storage, workshops, transport facilities (main and feeder roads, railways and waterways), power, and facilities related to marketing and processing.

(c) Institutional and Policy Constraints

These will include the main defects in the agrarian setting such as land tenure, tenancy conditions and land fragmentation and the lack of receptivity of the farmer/farmers to various technological and organisational changes and improvements. The constraints on demand arising from large disparities in income distribution will also be highlighted. Most important of all will be the shortcomings in agricultural policies, government services (extension and other technical services), lack of inter-departmental co-ordination, weaknesses in farm organisation and the managerial ability of producers.

(d) Technical Constraints

These will cover a variety of technical weaknesses affecting farm production and productivity, e.g. soil erosion, salinity, defective productive practices and land use patterns, inability to organise and conduct research, lack of disease and pest control practices, etc.

4.1.3 Selection of Agricultural Priority Sectors

The assessment of agricultural development priorities related to the technical, economic and institutional aspects of agriculture will pave the way for specific investment opportunities in the various sub-sectors of agriculture and in different regions of the country.

For the purpose of project identification, the various agricultural priorities are translated into specific development opportunities as listed below:

- (1) Selection of agricultural commodities which are in great demand or those which are in short supply; selection of promising regions where expansion in output can be effected in the shortest time possible and at minimum cost;
- (2) identification of areas where expansion in productive capacity is most urgently needed, e.g. irrigation, land reclamation, etc.;
- (3) selection of sub-sectors and regions where certain technical measures could have the maximum impact on output in the shortest time possible, e.g. new varieties, improved cultural practices, crop diversification, improvement in extension services and farmers' training;
- (4) identification of sub-sectors and regions in which production can be increased through the use of additional purchased inputs or through the rational use of existing farm capital and labour;

(5) selection of sub-sectors and regions where various economic measures could yield rewarding results in terms of production and productivity, e.g. price incentives, subsidies and expansion in farm credit;

(6) identification of regions in which institutional measures could quickly benefit farm production and income, e.g. reform of land tenure system, creation of co-operatives and the strengthening of public services assisting the rural sector;

(7) selection of agricultural regions suffering from low income, greater unemployment or underemployment and suggested remedies for improvement;

(8) selection of crops and livestock products with encouraging prospects for processing and export;

(9) identification of development opportunities arising from newly discovered resources, e.g. groundwater;

(10) identification of sub-sectors and regions in which development prospects can be improved by undertaking resource surveys and feasibility studies.

Finally, it should be borne in mind that one potential source in the identification of production projects is the farming community itself. Through their intimate knowledge of agriculture, the farmers and their prospective organisations are sometimes well-equipped to come up with sound investment proposals. Consequently, it is necessary for public agencies and project identification teams to solicit the views of farmers and their associations.

An investment proposal is unlikely to be conceived in only one form: in many cases, there will be alternative ways for its planning and implementation. One essential aspect of project identification is to examine the technical and economic merits of various alternatives for an investment proposal and to select the one which, on balance, is best suited to the needs and conditions of the country. This implies a comparison among alternatives which may or may not be compatible with one another.

There are no hard and fast rules for choosing among alternatives. It is a painstaking process requiring a persistent effort in weighing the merits of one proposal against another. The process invariably involves making choices related to products, production processes, technology, scale, location, costs and returns, time of completion, etc. The alternatives are then ranked to help select the one which, on balance, is likely to prove the most favourable. In brief, one is forced by circumstances to undertake a preliminary feasibility analysis of various alternatives. In order to anticipate some of the major points which influence the final choice, the various alternatives for a single proposal can be subjected to a series of preliminary tests related to their technical, financial, economic and management feasibility as recommended by the FAO (1971, p.11), i.e.:

(1) From the technical point of view, which of the alternatives has:

- (a) the fewest technical complications;
- (b) the greatest chance of acceptability by farmers;
- (c) the greatest adaptability to factor endowment in the country.

(2) From the financial point of view, which of the alternatives has:

- (a) the lowest unit costs;
- (b) the smallest foreign exchange component;
- (c) the most desirable cash flow;
- (d) the maximum financial returns.

(3) From the economic point of view, which of the alternatives has:

- (a) the potential of giving quick results;
- (b) the shortest capital recovery period;
- (c) the highest rate of return on capital;
- (d) the widest impact on the economy.

(4) From the management point of view, which of the alternatives has:

- (a) the least cumbersome management organisation;
- (b) the smallest demand on skilled staff needed for operation and management;
- (c) the greatest chance of being accepted and supported by a large number of producers.

It should be emphasised that the above tests are undertaken for the sole purpose of establishing a ranking among alternatives. Although the tests may be crude in many respects, they do serve the useful purpose of clarifying to the project planner and the decision-maker the advantages and disadvantages of each alternative and thus make the final choice much easier.

The results of the work on identification and selection should be presented in a brief summary of the main features of the recommended investment project which is being considered for further detailed study. The purpose of this brief summary is to enable the authority and/or financing agency concerned to decide whether to go ahead with the feasibility study of the project.

4.2 Improving Project Formulation

The formulation stage of the project analysis entails a systematic and an in-depth examination of its essential features for the purpose of reaching a final decision. The main areas to examine are the following:

4.2.1 The Project Area

As already indicated, the success or failure of the project will primarily depend on the adequacy and quality of the physical and human resources of the area embraced by the project and its future economic prospects. The purpose of this section should be to describe the base from which the project starts, including its existing state of development. The analysis should be supported by findings of surveys and other relevant data so as to establish the suitability of the physical and human resources called for by the project.

(a) Physical Resources

This will include the study and evaluation of those natural characteristics of the project area which may have a direct bearing on

the production process, e.g. topography of terrain, suitability of climate, soil capability, adequacy of water supply, etc.

(b) Population and Employment

This will involve analysis of the present size and age structure of the population in the project area and, as appropriate, of its surrounding areas. Attention should be drawn to such particulars as population density, urban and rural distribution of population, rates of migration and the projected rate of population growth. It will also indicate the magnitude of the current and projected labour force in the project area, share of agriculture in such labour force, seasonal pattern of agricultural employment, and the degree of unemployment and underemployment in the project area.

(c) Economic and Social Infrastructure

This will include an assessment of transport facilities and other means of communication in the project area and its links with other parts of the country, including access to major urban centres and main port outlets. The possible impact of other infrastructure and productive facilities on the growth of agriculture in the project area will also be assessed, e.g. power supply and agricultural processing industries. Special attention will be given to the analysis of social infrastructure, with emphasis on the structure of rural communities and level of literacy.

(d) Institutions

This will give a brief description of the functions, organisation, staffing and effectiveness of existing government and private institutions operating in the area which are likely to be of concern to the project.

(e) Economy of the Project Area

This will include an analysis of the main economic characteristics of the project area, such as the level and composition of its gross product, disparity in per capita income between agricultural and non-agricultural occupation, the level and pattern of present consumption, the magnitude of savings and investment, the pattern of the project area's trade with other areas of the country and its share in the country's foreign trade.

(f) Agriculture in the Project Area

This section will make analysis in depth of the agricultural situation:

- relationship of present land use to soil capability as established under (a);
- present water usage in relation to the availability of surface and groundwater as established under (a), especially at times of peak demand;
- extent of the agricultural area and the pattern of its utilisation, the intensity of land use and the influence of

irrigation on the pattern of its utilisation and on the pattern of farming, crop yields and livestock output;

- volume and gross and net values of agricultural production from the project area to be used as a base for measuring incremental benefits;

- land ownership and tenure system, including land fragmentation and the importance of share cropping;

- pattern and level of agricultural inputs used in the project area and any obstacle in the promotion of their use, e.g. high transport costs, inadequacy of credit arrangements and lack of distribution facilities;

- market outlets and the pattern of market organisation in the project area, storage facilities, transport costs, processing facilities, the price structure of agricultural produce in the project area and an indication of the prices received and paid by farmers;

- extent of agricultural services in the project area such as co-operatives, farmers' associations, extension, credit and training facilities.

It is possible that the project area may be part of a much larger agricultural region undergoing rapid change. If this is the case, the information and data about the project area mentioned above should be reviewed within the framework of similar information and data about the region as a whole.

4.2.2 Project Description

The feasibility study of the project should be prepared in sufficient detail to warrant serious consideration for approval and

financing. The degree of detail depends on the availability of data and information and on the depth of analysis required. However, under no circumstances should certain essential features of the project be overlooked. Some of these essential features are discussed below:

(a) Purpose

This section should give an adequate description of the primary objectives of the proposed project. If there are any important secondary objectives, they should also be defined. The primary objectives should be subsequently disaggregated into a number of narrowly defined sub-objectives, e.g. the achievement of specific major output targets, reclamation of a certain area, etc. This structuring of primary objectives is important from the point of view of defining various project activities and establishing the logical sequence between them.

(b) Choice of Location, Production Process and Size

Decisions on these three items are made at the identification stage. In the formulation phase, the relevant factors in support of each decision are further crystallised. Numerous factors will determine the choice of project location of which the most important ones are the availability and quality of essential inputs, the vicinity of the potential market for the produce of the project and the transport costs for both inputs and outputs. Location may also be influenced by the existence of external economies in a specific locality or sometimes by social and political considerations,

e.g. priority may be given to a socially depressed area despite other disadvantages. The choice of production process will be dictated mainly by the natural conditions and supply of production factors in the project area and by specific technical considerations. The choice of size is basically a problem of arriving at an optimum scale for the project which will maximise the rate of return on investment. Such an optimum scale in turn will depend on the volume of future demand for the produce of the project, the geographical extent of the market, the proposed technology of production and, finally, on the capability of project management.

(c) Project Major Works and Other Components

The aim of this section should be to describe the proposed major works and other essential components which ought to be established to bring the project to the stage of full development. The presentation of major works and other components should be in sufficient detail to provide a clear picture of their nature and scope and to enable the estimation of costs to be made with a fair degree of reliability. With due consideration for possible variations among projects in different sub-sectors, the proposed works and activities could be classified under five main headings:

(1) Major Works: Based on the preliminary design, this item will describe all the major works necessary to achieve the desired production capacity. The preliminary designs ought to be based on proper technical surveys and investigations and should be fairly precise so that any alterations at a later design stage are kept to a minimum.

(2) Farm Development Works: This item will describe the nature and scope of the necessary on-farm engineering works. Such on-farm works should be based on proper topographic surveys and land classification and the estimates derived from model designs prepared for different farm sizes envisaged in the project area.

(3) Ancillary Works and Buildings: This item will describe the various ancillary works and buildings required by the project, i.e. workshops, warehouses, pilot or experimental farms, nurseries, etc.

(4) Equipment: This item will list the type and quantity of equipment needed by the project.

(5) Support Services: This item will include at least the following components:

(i) institutions needed to improve agrarian structure i.e. changes in land tenure and land settlement, measures of land consolidation and the setting up of co-operatives;

(ii) organisations for the provision of essential farm inputs and services, i.e. production requisites, research, extension and marketing; and

(iii) administrative machinery needed to implement various incentive measures contemplated by the project.

(d) Phasing of Works and Activities and Special Problems
of Execution

Phasing entails the scheduling of all project works and activities with a view to determining the length of time required and the inputs needed to complete the project. This is done in order to estimate project cost over the pre-construction, construction and operation phases of the project and to raise the efficiency of implementation. The scheduling of activities and their costs will also help determine the disbursement pattern of loans.

For simple agricultural projects the phasing need not raise any difficult problems. However, for major project works involving a magnitude of activities, the phasing may be a complex task and can best be handled through a network analysis.

It is unlikely that the project will be executed without special problems arising from time to time. To avoid possible delays, it is advisable to identify such special problems in advance and to adjust project operations accordingly.

4.2.3 Organisation and Management

The form of organisation and management for the project has to be clearly established since the success of the project depends largely, apart from other technical and economic considerations, on their effectiveness. The nature and scope of project activities and the broad setting in which the project is expected to operate are also likely to be influenced by them. Moreover, the

requirements of organisation and management are likely to undergo radical changes as the project advances from the construction to the full development phase.

The section on organisation should clearly specify the entity or entities responsible for project construction and operation and the manner in which the entity is expected to perform these functions. This should apply to large public or private projects. With small farmer projects, the managerial competence and capacity of the farmer to organise and manage his own project should be well examined.

The section on management for large projects should explain the qualifications and experience of such key managerial staff. If there is any need for expatriates to assist management in the early phase, this should be stated.

Apart from key managerial staff, the needs of the project for technical and administrative personnel should be assessed. It is advisable to undertake this assessment for each entity and for specific categories of staff. The measures necessary to fulfil the requirements to each entity for various technical and administrative personnel should also be spelled out, including possible arrangements for training.

The specific aspect of organisation may be presented in the following form as suggested by the FAO (1971, p.21).

(1) Construction: Here one will identify the unit within the entity which is responsible for the design, construction and supervision of major works, ancillary project works and facilities

and the planning and implementation of on-farm development. The arrangement for completing such works should also be explained, e.g. by sub-contracting or on-farm development by farmers themselves or by the project authority.

(2) Operation and Maintenance: Here one will identify the units within the entity responsible for:

- (i) operation and control of major and ancillary works;
- (ii) repair and maintenance of works and facilities falling under the direct control of the project authority;
- (iii) collection of charges paid by farmers, i.e. water rates.

(3) Farm Services and Other Agrarian Measures: Here one will list the various organisations responsible for the implementation of agricultural policy measures and for assisting farmers to achieve full production in the project area. It is possible that these organisations form part of the project entity. However, in most cases they may have their own independent or semi-independent status. Whatever the case is, it is essential to describe the organisations' structure, assess their capabilities in terms of staff, equipment and financial resources and stipulate the measures needed for their effective co-ordination under the umbrella of the project authority. The specialised organisations responsible for farm services and agrarian measures are likely to include many of the following:

(1) Research and Extension: The organisational structure and responsibilities of the units in charge of research and extension should be mentioned, with particular emphasis on the qualification and experience of senior staff, number of field staff required, the level of their training and arrangements for field staff supervision; any measures necessary to ensure the availability of funds, equipment and physical facilities to these organisations should be stipulated.

(2) Supply of Inputs: An assessment of the functions and responsibilities of the organisation charged with the provision of agricultural requisites in the project area should be made with special emphasis on their financial strength, methods of procurement and distribution and coordination with the credit agency, farm co-operative or associations and the extension service.

(3) Marketing and Processing: A description should be given and an evaluation made of the institutions responsible for the marketing of farm production. In addition, there should be an assessment of market channels; identification of market rigidities and proposals for their amelioration. Factors affecting the pricing of farm produce, e.g. possible monopoly practices, market dues and commission charged, should be studied. Reference should also be made to the adequacy of transport facilities. The inclusion of agricultural processing industries in the project area and their production capacities, pricing policies, and methods of procurement and collection should be stated including any special arrangements of processing organisations with farmers, e.g. forward contracting, credit advances.

(4) Co-operatives and Farmers' Associations: A description of the legal and administrative structure of the existing or proposed co-operatives and farmers' associations in the project area should be mentioned. Attention should be drawn to their responsibilities vis-a-vis producers and their relationships with the project authority and other entities servicing farmers. The extent of participation of farm co-operatives and associations in policy decisions by the entity should be highlighted. If the farm co-operatives and associations have any past experience, it should be critically appraised.

(5) Land Reform: The organisational structure and responsibilities of the entity charged with land tenure and land distribution should be clearly stated, with particular emphasis on the proposed legislation and administrative measures necessary to improve the existing pattern of land ownership in the project area. Adequate coverage could be given to policies affecting new settlement (size of farms, conditions of occupation and selection of settlers), extent of land reform or land settlement agency with other organisation providing financial and technical assistance to farmers.

4.2.4 Pricing of Inputs and Outputs

At the formulation stage, project costs and prices are in the form of estimates and it is essential that in the feasibility study the various cost and price estimates be fairly reliable since they form the basis for project funding and for calculating the financial and economic returns of the project.

In most cost-benefit analyses, costs and prices are presented as single-valued estimates and, for the most part, project benefits are still estimated and reported in terms of one single outcome which does not take account of, or record, valuable information about the extent of uncertainty of project related events. This issue of uncertain outcomes is generally recognised, but is usually not explicitly considered in otherwise detailed cost-benefit analyses of investment projects. Application of contingency allowances and sensitivity analyses have been used as partial remedies.

Hertz (1964), Reutlinger (1970), Pouliquen (1970) and Jones (1972) et al. recommend that the best available judgements about the various factors underlying the cost and benefit estimates of a project be recorded in terms of probability distributions and that these distributions be aggregated in a mathematically correct manner to yield a probability distribution of the rate of return or net present worth of the project.

This procedure in no way eliminates the problem of making judgements about events and relationships in the face of limited and incomplete information, nor does it suggest a unique and simple formula for choosing among projects or project strategies with varying degrees of riskiness. However, this type of analysis would ensure and encourage that available information about events affecting the outcome of the project would be more fully utilised and correctly transformed into information about uncertain project results. Project-related decisions could be made more easily and more intelligently if returns on projects were reported not in terms of a single rate, or a wide

range of possible returns with undefined likelihoods of occurrence but in terms of a probability distribution. Allowance for this is made in the improved project cycle given at the end of this chapter although detailed discussion of the methodology of probability appraisal is left to the next chapter.

4.2.5 Indicators of Worthiness

(a) The Concept of 'Cash Flow'

The cash flow of a project expresses the financial requirements and balances for each year over the life of a project. In preparing the cash flow, all cash payments are considered as costs and all cash receipts as benefits. The annual cash flows are necessary in order to know the magnitude of expected cash deficits during the construction and development phases and for which short, medium and long term financing have been arranged. Similarly, at full development the appearance of cash surpluses will indicate the repayment capacity of the project.

Apart from expressing the financial liquidity of the project and its beneficiaries, cash flows are considered to be the basic ingredients for measuring the various indicators of worthiness (financial or economic), both for the project as a whole and for its various beneficiaries,

(b) Indicators of Project Worth

As pointed out earlier, the ADB uses the most simple non-discounting methods (pay-back period and peak-profit method) in indi-

cating the worth of its projects. The pros and cons of these indicators have been discussed and it is felt that in every serious project evaluation, discounted measures should rather be used.

In the computation of discounted measures of project worth, the rate of discount or 'interest rate' becomes an important consideration. Economists generally explain 'interest' as arising from two reasons:

(1) If we lend money to someone else we are deferring until the future the possibility of using that money for present pleasures. If we do this we are entitled to a reward and interest is that reward;

(2) Another closely related but better explanation is that interest is related to current income foregone. If the farmer lends money to his neighbour, the farmer is passing by the opportunity to use that money for productive purposes - say to increase his fertiliser use. On the other hand, his neighbour is gaining the money to put to a productive purpose perhaps. It is therefore only reasonable that the lender be compensated for the income foregone and that the borrower pays something for the use of the lender's money.

Undiscounted measures of project worth fail to take into account the consideration of time and could give misleading results. To overcome this problem we have to use discounting. Basically, this is a technique by which one can 'reduce' future benefit and cost streams to their 'present' worth. Using the discounted cash-flow procedures (DCF) we can compute:

- (a) Benefit-Cost Ratio (B/C ratio);
- (b) Net Present Value (NPV);
- (c) Internal Rate of Return (IRR).

For the purposes of this analysis, the NPV, IRR and ROI are highlighted.

(i) Net Present Value (NPV)

This is the most straightforward discounting cash flow measure of project worth. It is simply the present worth of the cash flow stream. The major problem in the use of the net present value is the choice of discount rate. All projects with a positive NPV are theoretically acceptable.

The formal selection criterion for the NPV measure of a project is to accept all projects with a positive NPV when discounted at the opportunity cost of capital. An obvious problem of the NPV measure is that the selected criterion cannot be applied unless there is a relatively satisfactory estimate of the opportunity cost of capital. No ranking of acceptable alternative projects is possible with the NPV criterion, which is a serious drawback to its use. This is because the NPV is an absolute and not a relative measure. A small highly attractive project will have a smaller NPV than a larger marginally acceptable project and would, therefore, be excluded if only this criterion was used.

$$\text{Net Present Worth} = \sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t}$$

where

B_t = benefits in each year

C_t = costs in each year

t = 1, 2, ... n

n = number of years

i = interest (discount) rate

(ii) Internal Rate of Return (IRR)

Another way of using the discounted cash flow procedure for measuring the worth of a project is to find the discount rate which makes the NPV of the cash flow equal to zero. This discount rate is termed the Internal Rate of Return and, in a sense, represents the average earning power of the money used in the project over the project life. The IRR is the most commonly used measure by the World Bank in both economic and financial analysis. To avoid confusion in terminology, the IRR in financial analysis is referred to as the Internal Financial Return, while the same criterion in economic analysis is called the Internal Economic Return.

The IRR for a project can be defined as the rate of discount (r) which equalises the discounted benefits (X) with the discounted costs (C), i.e. the relationship $X - C = 0$.

Gross Value of Output (X) = Net Benefits (B) + Current Expenses (E)

Costs (C) = Capital Costs (K) + Current Expenses (E)

Alternatively, it can be expressed as the rate of discount (r) which will equalise the stream of net benefits (B) and the stream

of capital costs (K), that is to say, the rate of discount which will satisfy the relationship $B - K = 0$.

The formal selection criterion for the IRR measure is to accept all projects having an internal rate of return above the opportunity cost of capital. Projects are ranked in order of the value of the IRR. The lowest acceptable IRR is termed the 'cut-off rate' and is often set above the opportunity cost of capital.

The procedure for calculation:

- from a quick examination of positive and negative benefits of the project, one could infer whether the project is very profitable or modestly profitable;
- a discount rate is chosen which has the possibility of exceeding the earning power of the project. If the guess is correct, the sum of the discounted benefits will turn out to be negative: upper limit;
- a similar trial is carried out with a larger rate of discount, in which the sum of the discounted benefits will be positive: lower limit;
- the IRR will lie somewhere between the lower and upper discount rates and will be obtained through interpolation.

The following formula will be useful in estimating the IRR after the above procedure has been adopted:

$$\text{IRR} = \text{Lower Discount Rate} + \frac{\text{Difference Between the Discount Rate}}{\text{Absolute difference}^1 \text{ between the present worth of the cash flow and the two discount rates}}$$

(Present worth of cash flow at the lower discount rate)

¹ Absolute difference is here defined as the sum of the two values ignoring the sign which is attached to them.

The formal mathematical statement of this measure of project worth is:

$$\sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t} = 0$$

In practice, it is best not to try to interpolate between a spread wider than about 5 percentage points. The IRR should always be rounded to the whole percentage point since the underlying projections cannot justify the implication of greater precision. It is also important to emphasise that, after 30-40 years, all the discounted values become so negligible that they have no significant bearing on the balance between costs and benefits.

The IRR rate of return has been preferred by many organisations. Its distinctive quality is that it avoids the difficult task of selecting a suitable discount rate and being expressed in the form of a rate of return, it can be compared with the prevailing interest rates.

Criticisms made regarding the IRR are that:

(1) The rate has no relationship with the opportunity cost of capital, i.e. the earning power of the marginal project. Consequently, those who advocate the opportunity cost of capital as a true reward of capital regard the IRR as an illusory rate.

(2) The method of computation is cumbersome and there are always some complications when more than one solution exists. Multiple solutions exist when, following a period of positive cash flows, there is a sizeable period in which there are negative cash flows. Under these circumstances, there may be more than one discount

rate which will bring the cash flow of the project down to zero.

(3) Another criticism of the IRR is that there is an implicit assumption that all returns from the project will be reinstated at the IRR. This will, in fact, not be the case. Instead, the IRR is currently interpreted as the rate of return on capital outstanding per period which is invested in the project. Returns withdrawn from the project may be reinstated at any other rate or consumed without affecting the IRR of the project.

(iii) Return on Investment (ROI)

This indicator of project worthiness - defined usually as expected profit after allowing for depreciation, but before tax, as a percentage of the investment involved. In some cases the initial investment is taken; in other cases, the average investment over the life of the project. In some cases the profit is 'peak' profit; in other cases average profit over the expected life. The assumptions, merits and criticisms behind the peak-profit rate of return have been discussed earlier in this study.

The average-profit method is the only major traditional method that takes account of profits over the whole of the project's life. The project's average profit level is expressed as a rate of return on the initial investment. The calculation is done after tax and including all capital allowances.

Although the average profit method is seen by Hawkins and Pearce (1971) as probably the best of the traditional methods of appraising capital investment, it does not allow for the fact that

surplus profits can be re-invested. It also does not allow for differing project lives and differing time patterns of profits.

(c) Choice of Discount Rate

In the NPV approach to investment appraisal it is necessary for the decision-maker to have some predetermined discount rate, r_0 . This same rate is used as the minimum acceptable rate of return which projects must earn to meet the IRR decision rule. In the context of the IRR rule, it also appears in the literature as the 'cut-off rate' and the 'hurdle rate'. This rate is what is referred to as the 'opportunity cost of capital', i.e. that rate which will just result in all the capital in the economy being invested if all possible projects were undertaken which yielded that much or more return. If set perfectly, the rate, according to Gittinger (1972), would just reflect the choice made by the society as a whole between present and future returns, and, hence, the amount of total income the society is willing to save.

There are practical problems in establishing this rate by banks and in practice the rate chosen is a rule of thumb: 12 per cent seems to be a popular choice and almost all countries seem to think it lies somewhere between 8 per cent and 15 per cent. The bank rate for Ghana lies between $8\frac{1}{2}$ and $12\frac{1}{2}$ per cent depending on prevailing economic circumstances and, therefore, for our purposes, an average rate of 10 per cent has been chosen.

4.2.6 Sensitivity Analysis

This method of analysis is used to measure the impact of changes in the value of basic parameters on the project's rate of return. To undertake a sensitivity analysis is to vary the value of each of the sensitive parameters by the same fixed percentage so as to determine which one is likely to have a greater impact on the rate of return if a range is assumed instead of a unique value. In this way, the most sensitive parameters are isolated and a surveillance kept on them.

Sensitivity analysis is a straightforward means of dealing with the questions of risk and uncertainty in project analysis. It is a normal practice in project appraisal and in agriculture there are four main kinds of sensitivity analysis which should be considered:

- (1) Prices: alternative assumptions regarding future prices of products; shadow wage rates; foreign exchange.
- (2) Delays in implementation.
- (3) Cost over-run;
- (4) Yield variability.

The weakness of sensitivity analysis is that the effect on the NPV of a number of variables changing simultaneously is not undertaken. The assumption of ceteris paribus is made. It does not show the combined effect of changes in all variables or the likelihood of various changes occurring together. A more appropriate method for considering risky parameters is discussed in Chapter 5.

4.3 Improving Approval and Implementation Procedures

Once selected, projects should be approved for timely start up and implementation since the ability to do this is a crucial determinant of ultimate success or failure.

The implementation phase implies the following tasks:

4.3.1 Monitoring of the Execution

The purpose of a monitoring system is to provide the necessary information for effective project or programme management. It consists of accounting, auditing and reporting. It tries to compare planned outputs, targets and purpose with the real levels achieved by the project. Monitoring is supposed to determine what has happened, not why it has happened. What to include into a monitoring system depends on the management level concerned: a project manager is requested to monitor inputs and outputs; the programme manager's targets and purpose; the sector manager's purpose and objective; and the planning agency's objectives and goals.

4.3.2 Process Evaluation

This is the task of adapting a project, programme or sector plan during implementation, when the monitoring information shows that such changes are indicated. It attempts to define why things happen the way they do.

4.3.3 Ex-Post Evaluation

The purpose of ex-post evaluation is to provide the necessary feedback of the lessons learned to the planning stage. It is supposed to provide better information for the analysis and planning. Ex-post evaluation validates or invalidates the assumptions on which the planning exercise was based, or, if programmes have not been defined in a rigorous way, ex-post evaluation permits one to delimit the problems in a more precise way (formative evaluation).

Among the various national and international development assistance organisations, USAID probably has been the most active in the formulation of standardised methodologies for project planning and evaluation.

In the USAID view, planning, implementation and evaluation are all integral parts of programme management, and procedures for one part cannot be developed without consideration of the others. Project design (or planning) and project evaluation are intimately related because of their respective functions of prediction and verification. Critical design elements should include an explicit statement of project purposes, the pre-conditions for achieving these purposes, the significance of the purposes and of the causative linkages leading to these purposes and to higher goals. The design must also incorporate key evaluation elements such as the collection of base-rate key evaluation elements and base-line data, the formulation of specific progress indicators, and possibly the use of both control and experimental areas.

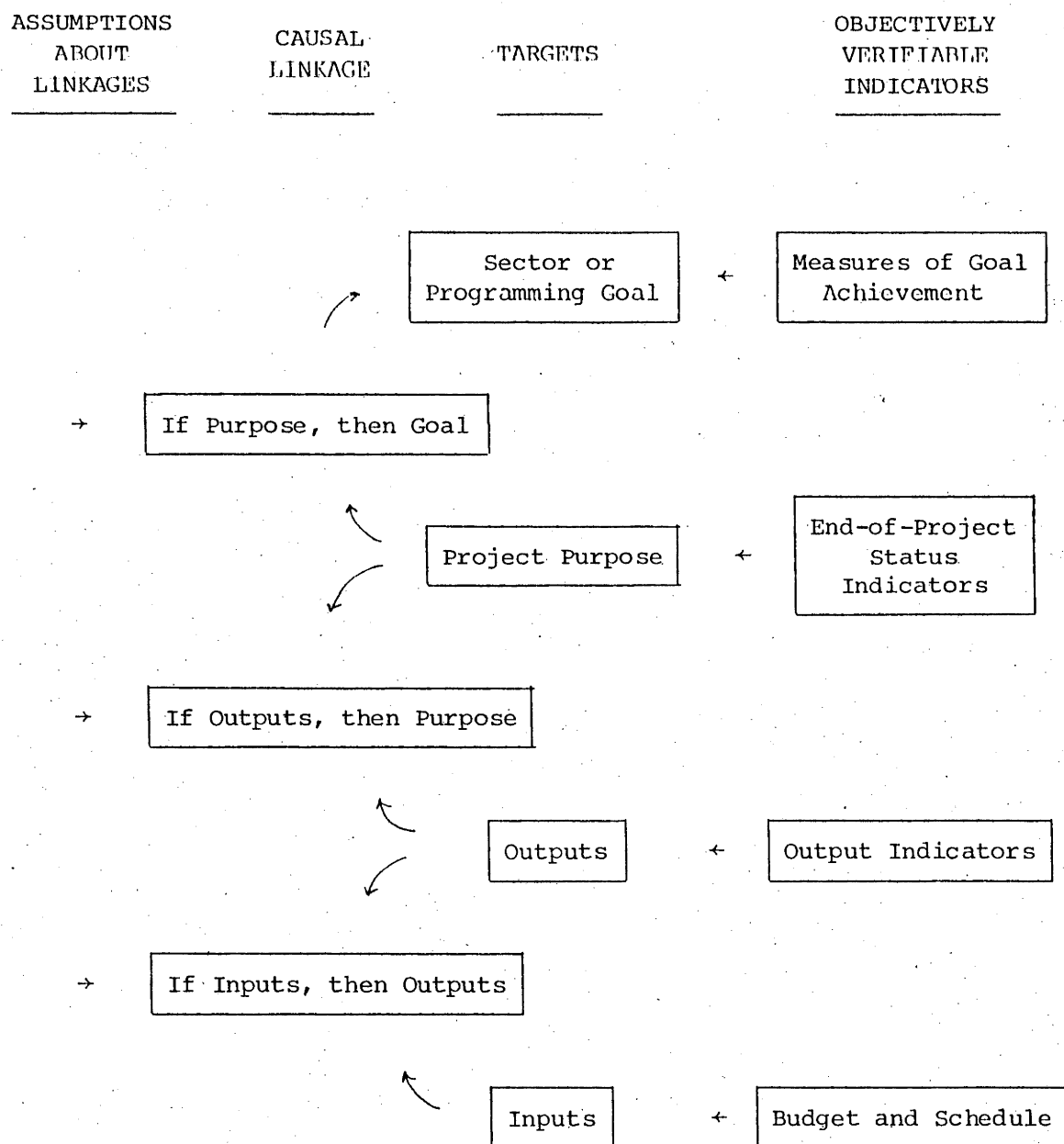
Evaluation is defined by USAID as the retrospective analysis of experience to determine what happened and why. It is intended to answer three basic questions:

- (1) Effectiveness: Were the planned targets achieved?
- (2) Significance: Did they make a substantial contribution to development?
- (3) Efficiency: Did the benefits justify the costs?

For all on-going technical assistance projects, USAID requires missions to conduct an annual project review intended to assess progress along the lines indicated in the Logical Framework in Figure 4.1 and to facilitate any necessary replanning.

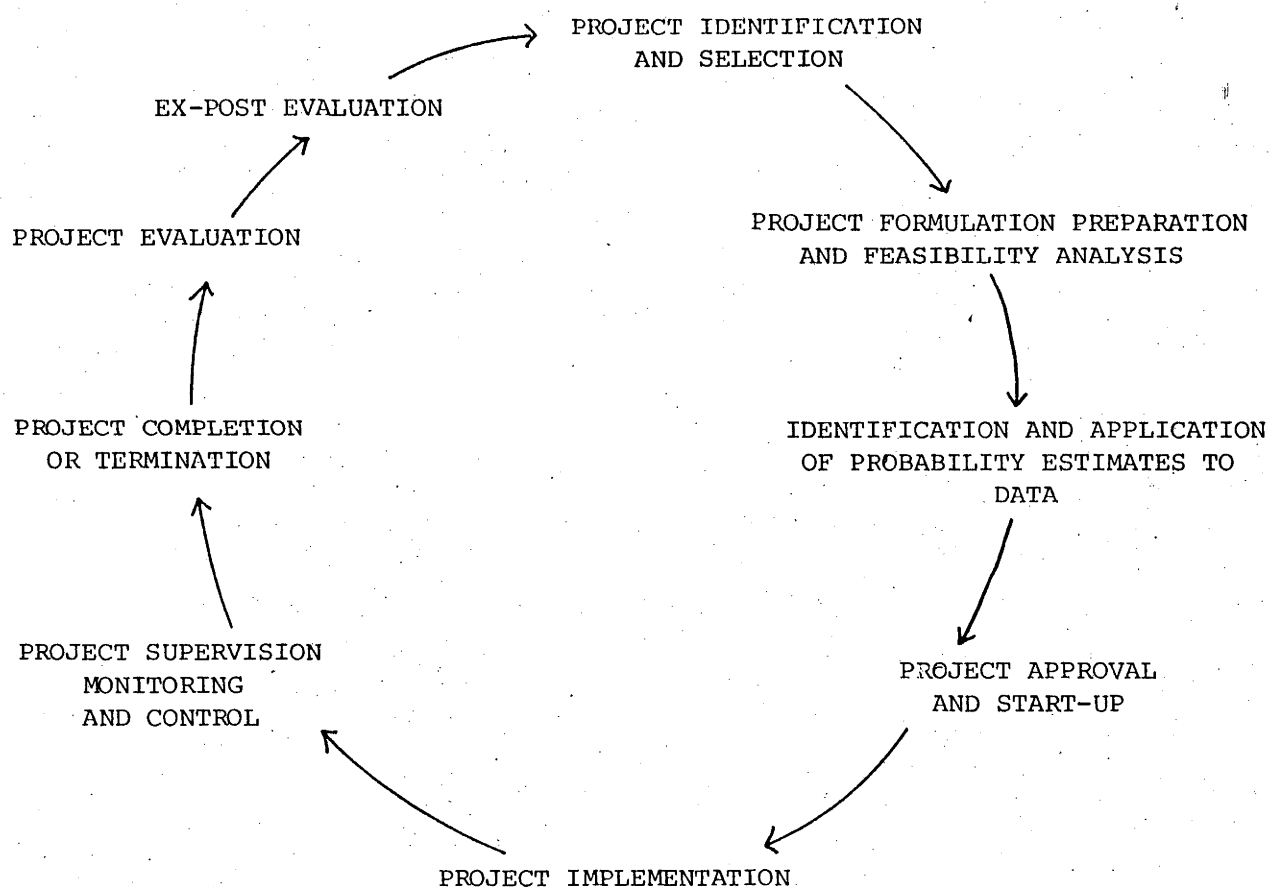
From the foregoing the following improved cycle is, therefore, recommended for project planning and management in the ADB (Figure 4.2).

FIGURE 4.1
LOGICAL FRAMEWORK OF A PROJECT



Source: USAID, cited in Amerasinghe (1978).

FIGURE 4.2
IMPROVED PROJECT PLANNING
AND MANAGEMENT CYCLE



CHAPTER 5

PROBABILITY APPRAISAL OF SELECTED PROJECTS

In this chapter the methodology of risk analysis and the results from the probability appraisal are discussed. The application of probability analysis to two selected projects (pineapple and maize) financed by the ADB are compared with original results of the same projects obtained by conventional analysis.

5.1 Methodology of Probability Appraisal or Risk Analysis

The purpose of risk analysis is to eliminate the need for restricting one's judgement to a single pessimistic, optimistic, or 'best' evaluation, by carrying throughout the analysis a complete judgement on the possible range of each variable and on the likelihood of each value within this range. At each step of the analysis, these judgements are combined at the same time as the variables themselves are combined. As a result, the product of the analysis is not just a single value of the decision variable, but is a judgement on the possible range of the decision variable around this value, and a judgement on the likelihood of each value within this range.

These judgements take the form of probability distributions. That is to say, each possible value of each variable is associated with a number between 0 and 1, such that for each variable the sum of all these numbers or probabilities is equal to 1. The probabilities, which are called subjective probabilities because they represent some degree of subjective judgement¹, follow all the rules of traditional probability theory. From a mathematical point of view, risk analysis,

1 All 'subjective' judgements that we are likely to obtain from experts are based on some sort of 'objective' experience. For example, usually the past record of similar events leads the expert to attach more importance to one outcome than another.

therefore, consists of aggregating probabilities. If it is thought, for instance, that X , Y and Z are independent events (that is, that their outcomes are in no way correlated), then the probability calculus tells us that the probability of encountering a combination of the most unfavourable outcomes of all three events is the product of the probabilities of the most unfavourable outcome of each event. If the most unfavourable outcomes are X_1 , Y_1 and Z_1 , and the respective probabilities are p_1 , p_2 and p_3 , then $p(X_1 Y_1 Z_1) = p_1 \cdot p_2 \cdot p_3$. Of the various ways in which this can be done, the one which, according to Pouliquen (1971, p.3), seems best fitted to risk analysis is the Monte Carlo simulation technique - sometimes referred to as stochastic simulation.

The idea underlying the Monte Carlo technique is quite simple. When we say that a project has a 40 per cent chance of earning a 10 per cent return, we mean that if we had a great number of similar projects we would expect about 40 per cent of them to earn a 10 per cent return. Conversely, if we had a great number of projects and if 40 per cent of them earn a 10 per cent return, we could say that the probability of a 10 per cent return is 40 per cent. Hence the simplest application of the Monte Carlo simulation is to build a great number of projects with the characteristics of the one we are interested in, and see how many of them earn 10 per cent, 15 per cent, 20 per cent, etc. In practice, the value of each of the uncertain variables is chosen by random selection, and the rate of return or some other decision variable is computed for the project defined by these values.

(a) Formulation of Anticipations

The first step of risk analysis is to select the uncertain variables and to assign to each variable a probability distribution. From either 'objective' experience, 'subjective' judgements or sensitivity analysis, we would have found out that the variation of the rate of return or some other indicator of worthiness was essentially explained by the variations of these variables or uncertain events.

The second step is to split up the values of the uncertain variables into divisions. Here, we determine the possible range of values for each variable, i.e. values that they are unlikely to exceed; values that they are unlikely to fall below; the most probable value; etc. We then assign a probability to the value of each division according to its chance of occurring. (In this particular analysis, each uncertain variable was assigned five divisions, each division being 10 per cent greater or less than the next division and the probability values being different for each division according to their likelihood of occurrence. Refer to Appendix D.1 for the divisions and their assigned probabilities.)

(b) The Simulation

This step in the proposed approach is to determine the returns that will result from random combinations of the factors involved in the cost-benefit analysis of the project. Random combinations or sampling is done by the use of pseudo-random numbers. These are numbers which are generated by the computer in such a way that any number has as much chance of occurring as any other number in that

there is no bias of any sort favouring one number against any other. Random values for each of the parameters varied in the analysis are combined to compute the rates of return and the process is repeated until enough values are obtained (10,000 times in this case) to give the observed distribution of the result. The computer is then further instructed to print the result in a cumulative probability distribution of the rate of return.

Appendix D.2 illustrates a flow chart for use in the Monte Carlo simulation for risk analysis. The Monte Carlo Simulation Program appears in Appendix D.3 and Appendix D.4 depicts an example of a simulation loop.

In a simulation, the random numbers, once they have been generated, are 'associated' with the relative probabilities of the factor being simulated in such a way that the more probable values of the factor are picked appropriately more often.

(c) The Choice of Probability Distribution

The Step Rectangular Distribution in its discrete form has been identified by Pouliquen (1970) as one of the most attractive and reliable distributions for use in this type of analysis. It has, therefore, been adopted for use in this exercise. A number of reasons are attributed to its usefulness. In the first place, it takes explicit advantage of the fact that the quantification of subjective probability judgements, in both theory and practice, is based on preference ranking. It also has the advantage that it can be drawn up by the appraiser himself. He has the freedom to choose whatever intervals or ranges he wants. This complete freedom of initiative,

which he lacks in the case of most other distributions, seems to help him considerably in the expression of his judgement.

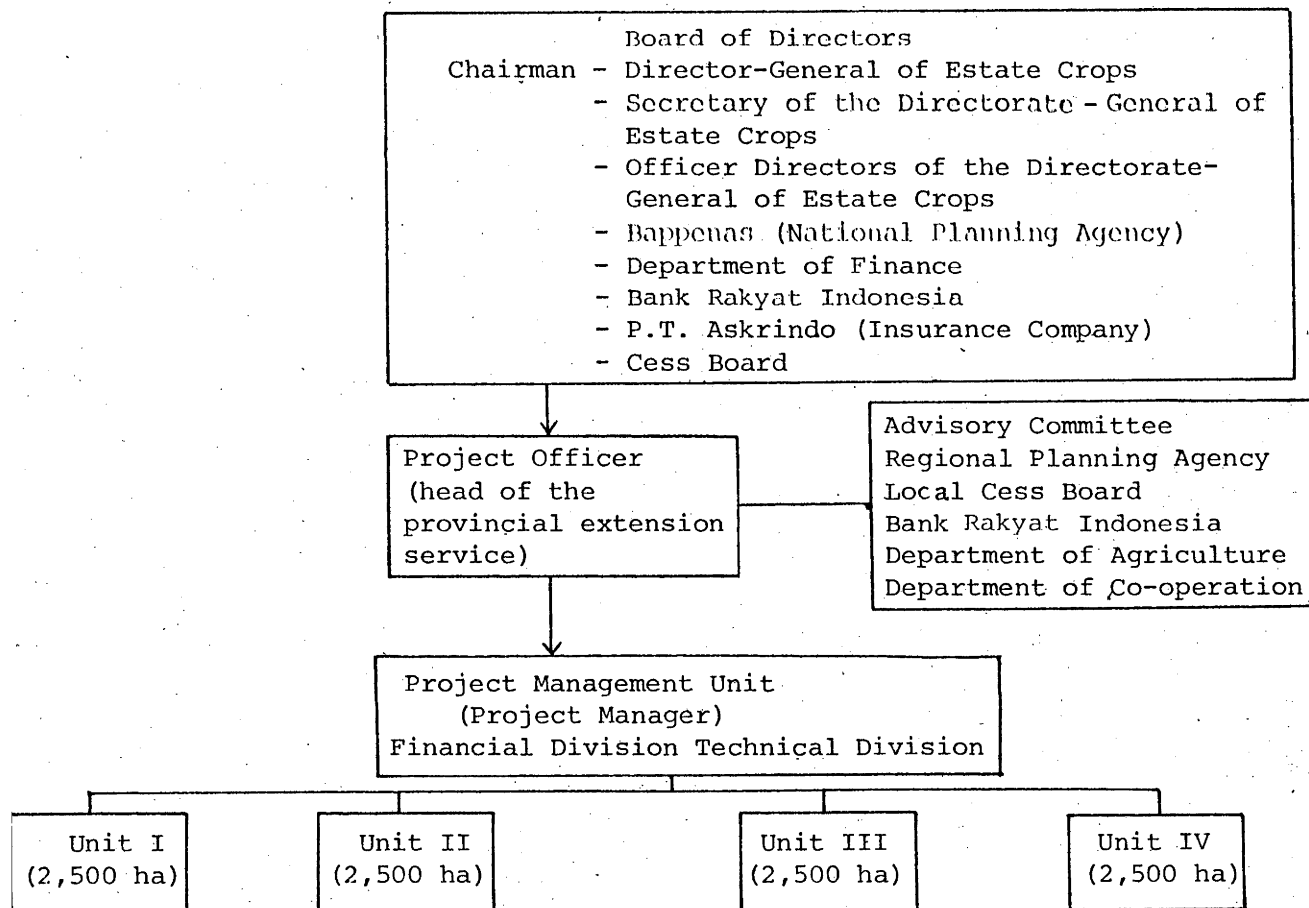
In use, this distribution has proven to be reliable. When the data generation process has been repeated for several distributions after a period of time, it has usually come up with the same or a very similar result. It is also a distribution which fits well with the rule of using all the information available but not requiring more. If the appraiser thinks that he can express more accurately a judgement he has just made, he can sub-divide intervals one step further and create a more detailed distribution. If, on the contrary, he thinks that he will be guessing to say that one value in an interval is more probable than another, he may stop sub-dividing. Furthermore, this distribution lends itself to some minor adjustments to give it a final polish.

Other distributions which have been tested for this type of analysis by Pouliquen (1970) are the Beta, uniform and normal distributions. The Beta distribution was tested to fill the gap between the step rectangular distribution, for which detailed information is needed, and the uniform distribution, for which minimal information is needed. Use of the Beta distribution was suggested by the wide use made of it in the PERT system (Program Evaluation and Review Technique). The Beta distribution is entirely defined if, in addition to its range, one fixes two parameters. The literature on PERT¹ suggests use of the mode and a standard deviation equal to

1 See, for example, Malcom, Roseboom, Clark and Fazar (1959).

FIGURE 4.2

ORGANIZATIONAL CHART FOR PROJECT MANAGEMENT UNITS



They have only used it on one occasion when the availability of an exceptional amount of data permitted a statistical analysis, and it turned out in the analysis that a Normal distribution was a good choice. But, except in rare cases, they feel that there is probably no justification for expressing a subjective judgement by a Normal distribution.

In his analysis of monthly rubber prices, Allen (1969), cited in Etherington (1977), found a close conformity of the prices to a log-normal distribution which, Allen suggests, reinforces 'the point that price is determined by a large number of independent factors (market forces)'. This further goes to prove the assumption that it is 'unrealistic to develop 'econometric models' which purport to predict single valued prices. Any realistic forecast would need to take account of probabilities, which means that one must forecast not only mean prices but also the scatter. This would be a formidable exercise and it is by no means certain that there is any rational procedure for carrying it out'. The Monte Carlo technique used in this analysis is a rational procedure for generating such a scatter of prices.

(d) Data for this Analysis

Two agricultural projects (pineapple and maize) selected from the ADB's loan portfolio have been used in this study (copies of the feasibility reports on the pineapple and maize projects are found in Appendices B.1 and B.2).

(e) The Uncertain Variables

Eleven uncertain variables are identified but they differ somewhat between the two projects. These are shown in Table 5.1.

TABLE 5.1

RANDOM VARIABLES INCLUDED IN THE PINEAPPLE AND MAIZE PROJECTS

Item	<u>Projects</u>	
	Pineapple	Maize
1. Labour cost for establishment	1	0
2. Cost of planting material	1	0
3. Farm maintenance cost	1	1
4. Fertilizer cost	1	1
5. Flower induction	1	0
6. Harvesting costs	1	1
7. Salaries and wages	1	1
8. Running costs of tractor	1	1
9. Yield	1	1
10. Price of produce	1	1
11. Vehicle running costs	1	0
Total Number of Random Variables	11	7

Note: 1 stands for inclusion and 0 for the use of a dummy variable because the variable is irrelevant in the project.

In view of the market distortions, inappropriate government price policies and inflationary trends, values of the variables identified have tended to vary widely from expected values and any attempts to assign 'best' estimates to them would, therefore, be inappropriate.

The life of the projects has not been considered in the analysis in view of its medium term nature, i.e. less than six years in each case.¹

¹ The pineapple and maize projects' lives should actually go beyond the 5 and 4 year periods respectively used in the analysis. However, these years have been used as a result of the ADB's special emphasis on their pay-back periods. Their salvage values are also not considered for the same reason. The effect of this analysis is that benefits have been under-estimated.

5.2 The Analytical Approach

The Monte Carlo Simulation technique was adapted for use in the probability appraisal. In this analysis, the eleven uncertain variables listed in Table 5.1 whose variations have essentially explained variations of the rate of return were first identified for each project. The identification of these variables was based on the author's objective experience and subjective judgements on their wide variations from expected values in view of market distortions, inappropriate government price policies and inflationary trends in Ghana. The values of the uncertain variables were split up into divisions by determining the possible range of values for each variable, i.e. values that they are unlikely to exceed, values that they are unlikely to fall below, the most probable value, and so on. Each of the values was then assigned with a probability according to its chance of occurring (the various divisions, range of values and their assigned probability distributions for the pineapple project are depicted in Appendix D.1).

The next step in the proposed approach was to determine the returns that would result from random combinations of all the factors involved in the financial cost-benefit analysis of the project. Random sampling was achieved by the use of pseudo-random numbers generated by the computer. Here random values for each of the parameters varied in the analysis were combined to give the observed distribution of the result. The computer was then further instructed to plot the results in cumulative probability distributions of the IRR, NPV and ROI which are used for the comparative discussion that follows later in this chapter.

In this analysis, 10,000 simulations were generated to ensure that, with the large enough samples, chances were high that the sample distributions would nearly approximate the 'true' distribution. In fact it appears from results of different numbers of simulations indicated in Appendices E.1 and E.2, that the minimum number of simulations which gives the expected mean and standard deviation is 100. However, the cumulative probability distribution curves for this and other low numbers of simulations are not smooth enough and cannot be used for proper interpretation of likelihoods of occurrence. They can only be used when they are smoothed with the program subroutine meant for that purpose. The minimum number of simulations which gives an ideal smooth curve without the use of the subroutine appears to be 5000. This is evidenced by a comparative study of the different numbers of simulations done for the two projects and which appear in Appendices E.3 and E.4.

In the conventional analysis, single-valued estimates of all the project variables were used in a financial cost-benefit analysis to arrive at a cash flow; that is, the variables were not classified as certain and uncertain and a 10 per cent contingency allowance was included as a buffer fund. Single-values of the IRR, NPV and ROI were then calculated for use as indicators of the project's worth.

5.3 Comparative Study of Results from the Conventional Analysis with Results Obtained in the Probability Appraisal of the Pineapple Project

5.3.1 Results Based on the Conventional Appraisal Technique

Table 5.2 below shows a summary of the financial cost-

benefit analysis of the pineapple project based on the use of single value costs and benefits estimates.

TABLE 5.2
SUMMARY OF FINANCIAL COST-BENEFIT ANALYSIS OF THE PINEAPPLE PROJECT
(BASED ON SINGLE-VALUED ESTIMATIONS OF COSTS AND BENEFITS)

	Year 1	Year 2	Year 3	Year 4	Year 5
A. CAPITAL INVESTMENT	447300	112200	149600	-	-
B. DIRECT PRODUCTION COSTS					
Total	16500	37620	64240	70400	70400
C. INDIRECT PRODUCTION COSTS					
Total	284360	387260	388990	390620	392250
TOTAL COSTS (A + B + C)	748160	537080	602830	461020	462650
TOTAL INVESTMENT (ie Costs less Depreciation and Interest)	629240	418160	483910	342100	343730
Cumulative Investment	629240	1047400	1531310	1873410	2217140
BENEFITS	-	360000	720000	1200000	1200000
NET PROFIT/LOSS (Benefits-Costs)	(748160)	(177080)	117170	738980	737350
Cumulative Net Profit/Loss	(748160)	(925240)	(808070)	(69090)	668260
CASH FLOW (Net Profit/Loss + Depreciation)	(697290)	(126110)	168040	789850	788220
Cash Flow Discounted at 10%	(633836)	(104167)	(136198)	539468	489485

NPV at 10% = 417,148

ROI (Average) = 30.14 per cent

IRR = 27 per cent

Footnotes:

- 1 Negative figures in parentheses.
- 2 Capital Investment - These cover all the expenditure on land development, cost of establishment, machinery and tools, buildings, office equipment and planting material which has been capitalised in this case.
- 3 Direct Costs - These cover operating expenses and include such items as farm maintenance costs, fertiliser costs, flower induction costs and harvesting expenses.
- 4 Indirect Costs - Indirect costs constitute the expenditures on salaries and wages, overhead expenses such as interest, insurance, depreciation, maintenance of buildings, running costs of tractors and vehicles, postage and stationery and land rent.
- 5 Benefits - They constitute sales from pineapple harvests.
- 6 Cost and benefit figures in cedis.
- 7 Depreciation is based on the expected lives of the capital items involved.

The values of three indicators of worthiness obtained in the analysis are presented below:

NPV at 10 per cent = £417,148

IRR = 27 per cent

ROI = 30.14 per cent

A verification test carried out on the conventional analysis with the computer to check the validity of the program used for probability analysis however, indicated the following results:

NPV at 10 per cent = £433,984.0

IRR = 28 per cent

ROI = 31.53 per cent

The verification results¹ appear reasonably close to the actual results used by the ADB. The slight differences are due to errors in rounding. To all intents and purposes, therefore, the program is valid.

5.3.2 Results Based on Probability Appraisal

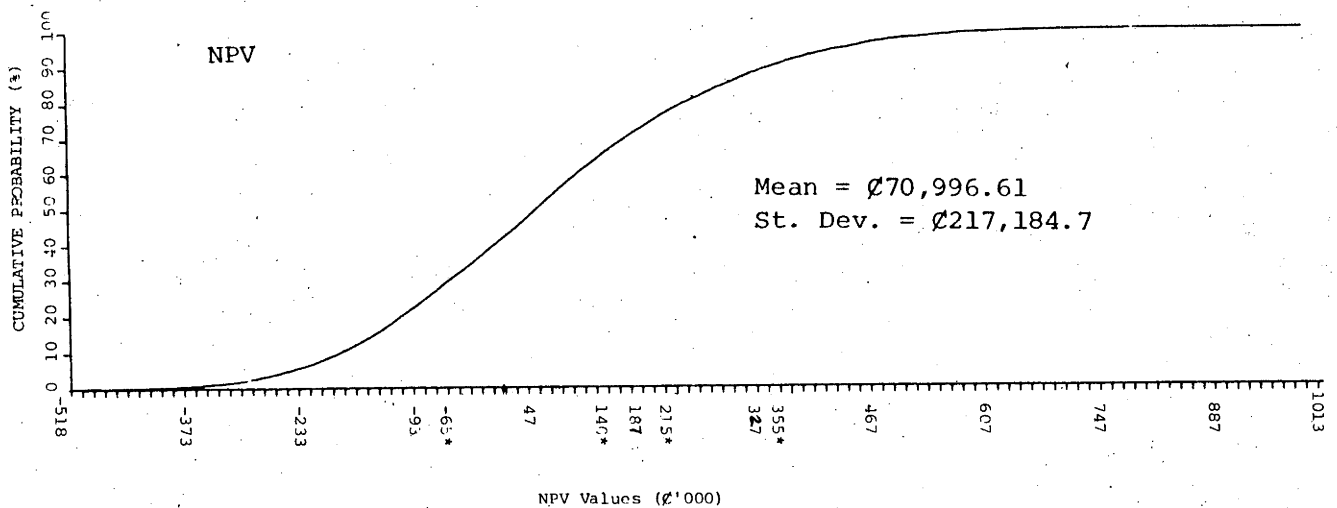
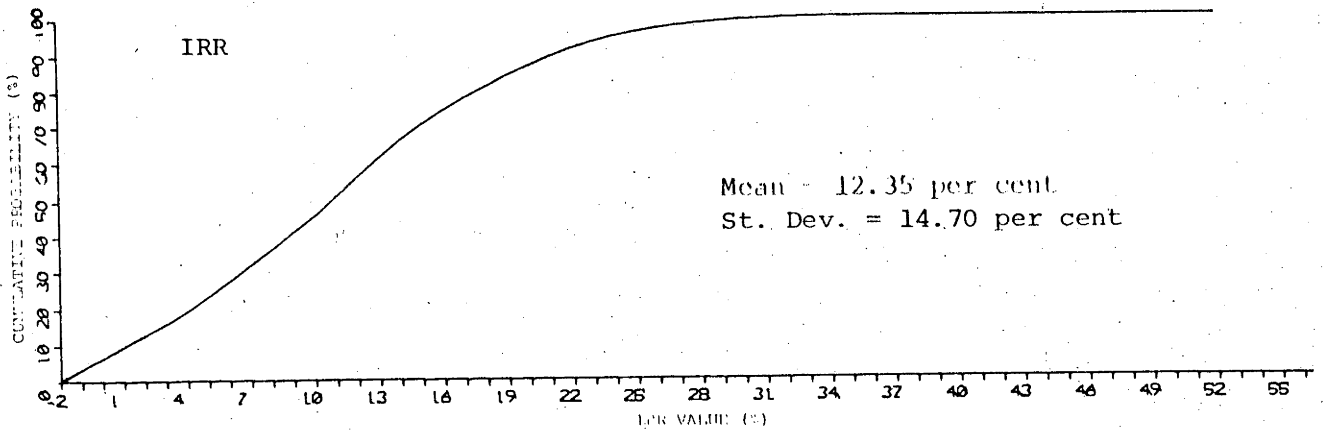
The overall results of the probability analysis for the IRR, NPV and ROI calculations derived from 10,000 simulations in each case are summarised by the cumulative probability distributions in Figure 5.1

The observed distributions fit fairly closely to the theoretical normal distribution. Therefore, normal distribution tables

¹ These results are used in the comparative study.

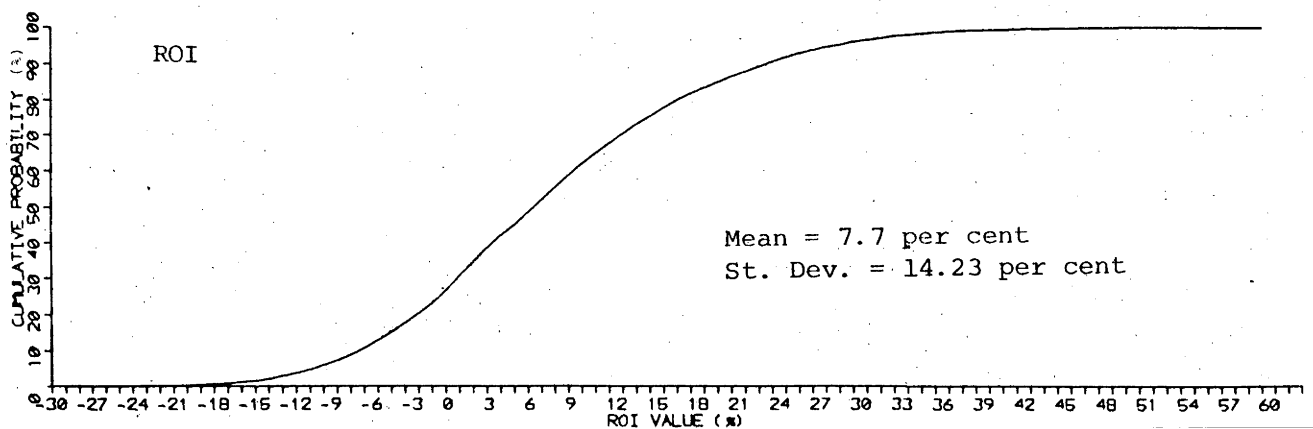
CUMULATIVE PROBABILITY DISTRIBUTIONS OF THREE INDICATORS OF WORTHINESS
(PINEAPPLE PROJECT)

Number of Simulations = 10,000



The difference between two intervals = €14,000

* Values illustrated in results.



can be used in these cases for making statements on the extent to which uncertainties surrounding the project translate into uncertainties about the realisable rates of return or net present value.

The following mean values under probability analysis were obtained:

$$\text{NPV} = \text{£}70,996.61$$

$$\text{IRR} = 12.35 \text{ per cent}$$

$$\text{ROI} = 7.7 \text{ per cent}$$

The mean values are those observed from the random sample of 10,000 simulations. If, for instance, $x_1, x_2, \dots, x_n$ represent a random sample of size n , then the sample mean has the value:

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

The mean values constitute the mid-point of the probability distributions.

5.3.3 Discussion of Results

Results from the probability analysis indicate that the expected (mean) figures of the NPV, IRR and ROI are considerably less than estimated by the conventional analysis for the pineapple project: about one sixth of the NPV estimate; about half the IRR result and about one quarter of the ROI figure. This is an indication that highly optimistic single-valued estimates had been used in the conventional analysis whereas in the probability analysis a range of values had been used; it also reflects the fact that each value in

the range has been weighted by the chances of its occurrence. In fact, the general result of carefully weighing the information available is to indicate the true nature of an otherwise seemingly very satisfactory investment proposal. The new analysis may thus help management to avoid an unwise investment.

In addition, let us examine the implications of the detailed knowledge the simulation method gives us. Under the conventional analysis, using single expected values, the values of £417,148 NPV, 27 per cent IRR or 30.4 per cent ROI are presented to management for a decision on the project (which, from all indications, are not right unless there is no variability in the various input factors - a highly unlikely event). On the other hand, with the probability analysis, the uncertainties are clearly portrayed in Table 5.2.

Values in the table have been obtained from the cumulative probability distributions indicated in Figure 5.1. From the table we find, for example, that there is a 6.5 per cent probability that a zero rate or less of IRR will be achieved, a 55 per cent chance that an NPV of £70,000 or less will be achieved and a 96 per cent probability that an ROI of 30 per cent or less will be achieved. Alternatively, we can say that there is a 54.5 per cent probability that the IRR will exceed 10 per cent, a 9 per cent probability that the NPV will exceed £215,000 and a 38 per cent chance that the ROI will exceed 10 per cent.

The cumulative probability distributions can also be used to determine the probability that the rate of return on NPV will fall within a given range: we take the difference along the ordinate of the two extreme points of the range. For example, we find from the

TABLE 5.3
UNCERTAINTIES IN PROBABILITY ANALYSIS

Indicator of Worthiness	Probability of Achieving Return Shown or Less	Probability of Exceeding Return Shown (%)
IRR (%)		
0	6.5	93.5
5	19.5	80.5
10	45.5	54.5
20	86.5	13.5
25	95.5	4.5
30	99.0	1.0
NPV (¢) *		
(65,000) **	29.0	71.0
0	41.0	59.0
70,000	55.0	45.0
140,000	78.5	21.5
215,000	91.0	9.0
355,000	98.0	2.0
ROI (%)		
0.0	17.0	83.0
5.0	45.0	55.0
10.0	62.0	38.0
20.0	86.5	13.5
25.0	92.0	8.0
30.0	96.0	4.0

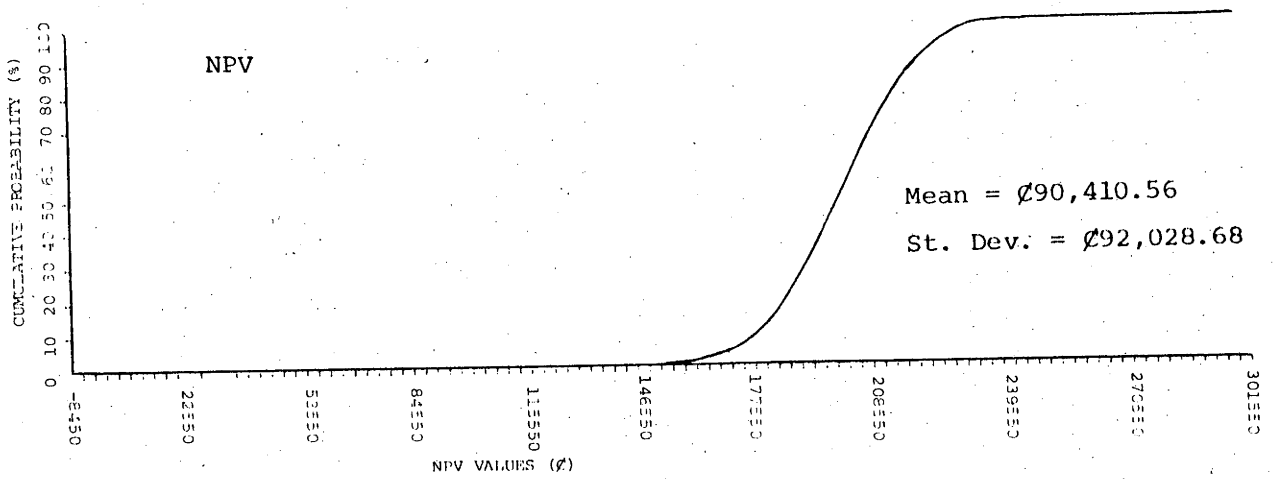
* NPV figures in cedis.

** Negative figure in parenthesis.

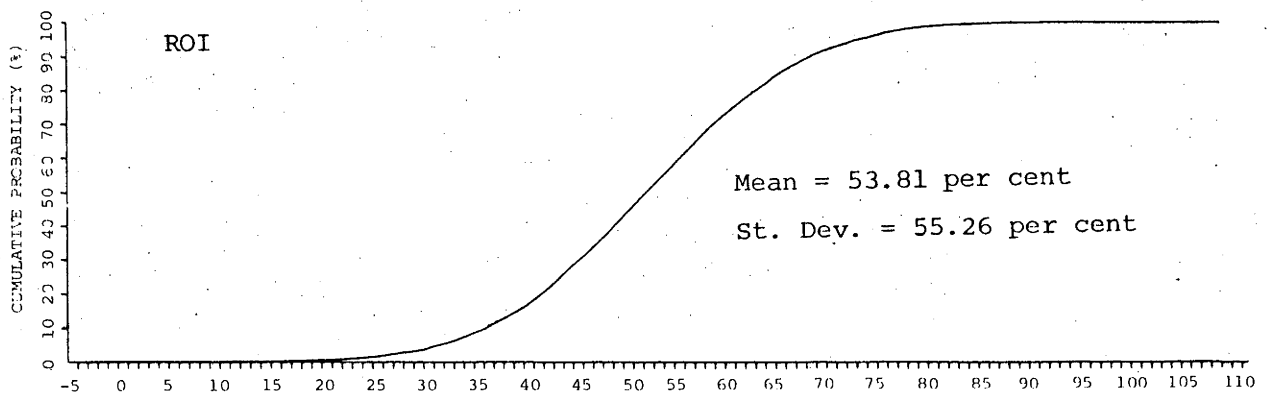
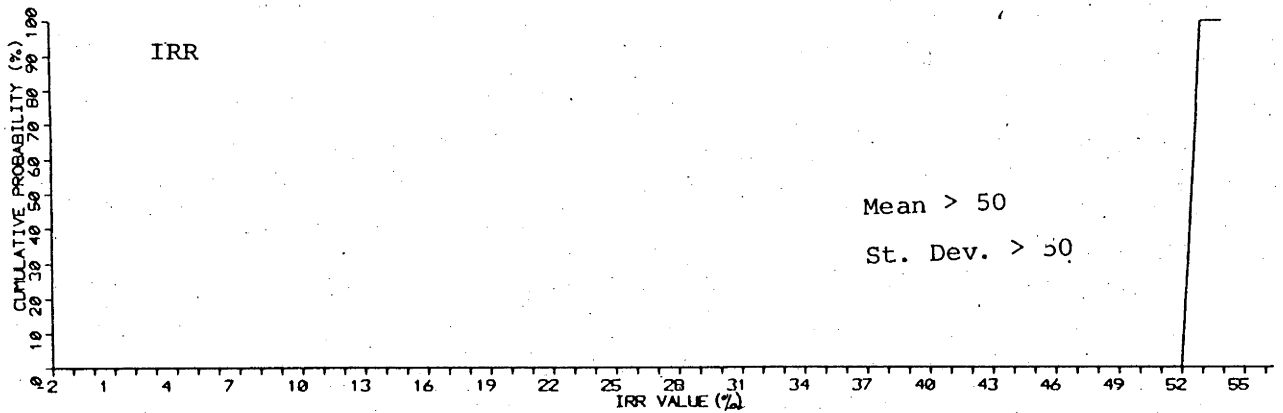
CUMULATIVE PROBABILITY DISTRIBUTIONS OF THREE INDICATORS OF WORTHINESS

(MAIZE PROJECT)

Number of Simulations = 10,000



The difference between two intervals = €3,100



IRR distribution that there is about an 88 per cent chance that the rate of return will be between 20 and 25 per cent. The figure also shows that the probability of getting a return inferior to 27 per cent, the IRR we obtained in the conventional analysis using best estimates for each variable, is 98 per cent, but the probability of getting more is only 2 per cent. So, at first glance, the results of this risk analysis seem to indicate that doubts about the likelihood of the 27 per cent rate of return were fully justified.

The probability analysis thus gives us a complete picture of the project and enables quantification of project risk - not, of course, the 'true' risk, but the risk as it appeared to the project analyst. The probability distributions of the IRR, NPV and ROI, or whichever indicator of worthiness is opted for, summarises this risk; one could say that it represents the complete judgement of the project analyst.

The mean rate of return is particularly helpful. It indicates that, on balance, we could expect the project to yield an IRR of 12.35 per cent; this is thought to be acceptable since the average discount rate has been estimated at about 10 per cent. On the basis of this, the project could be recommended for financing. However, despite this acceptable mean value, the standard deviation is high (14.70 per cent in this case) so that, in fairness, the project could be thought to be still risky. The probability of getting lower rates of return is apparent.

In presenting this decision, management is being presented all the information necessary to check this recommendation, and possibly to over-rule it. If we had presented the 27 per cent IRR found in the best estimates calculation, the situation would have been quite different.

Management would have been acting in the dark. In fact, it would not have been possible for anybody but the project analyst to evaluate the risk of the project. We would have been recommending the financing of a project earning a 27 per cent IRR after having already decided that the risk of the project was acceptable. This is seen by Poulliquen (1970) to be 'a dangerous mixing of analysis and decision-making'.

5.3.4. Sensitivity Analysis

A sensitivity analysis on the pineapple project was done with six of the uncertain variables which are considered most critical, viz. salaries and wages, farm maintenance costs, running costs of vehicles, running costs of tractor, yield and price of produce, to see the effect on the overall results obtained with eleven uncertain variables. The procedure adopted was to consider the five other uncertain variables as certain by assigning a probability of one to the base figure for each of them. The six most critical uncertain variables were assigned the same probabilities as before and two hundred simulations were run to obtain the following results:

IRR(%)		NPV(¢)		ROI(%)	
Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
15.37	17.15	143,638	245,081	11.91	16.78

Results obtained with two hundred runs for the eleven uncertain variables are also indicated as follows:

IRR(%)		NPV(¢)		ROI(%)	
Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
12.28	14.66	70,397	215,199	7.69	14.06

5.4 Comparative Study of Results from the Conventional Analysis with Results Obtained in the Probability Appraisal of the Maize Project

5.4.1 Results Based on the Conventional Appraisal Technique

Table 5.4 gives a summary of the financial cost-benefit analysis of the maize project based on the conventional method.¹

Results from a verification process are indicated as follows:

NPV at 10 per cent = 64,045.46

ROI = 38.90 per cent

IRR > 50 per cent

5.4.2 Results Based on Probability Appraisal

The following Figure 5.2 indicates summaries of the overall results of the probability analysis for the NPV, IRR and ROI calculations derived from 10,000 simulations. Here the observed distributions for the NPV and ROI figures again fit fairly closely to the theoretical normal probability distribution. The IRR distribution appears like a single point in view of the fact that all the values are over 50 per cent.

The following mean values under probability analysis were obtained:

1 Any discrepancies with ADB's results are due to errors in rounding.

TABLE 5.4

SUMMARY OF FINANCIAL COST-BENEFIT ANALYSIS OF THE MAIZE PROJECT
(BASED ON SINGLE-VALUED ESTIMATIONS OF COSTS AND BENEFITS)

	Year 1	Year 2	Year 3	Year 4
A. CAPITAL INVESTMENT				
Total	63960	-	-	-
B. DIRECT PRODUCTION COSTS				
Total	10260	10260	10260	10260
C. INDIRECT PRODUCTION COSTS				
Total	32251	20751	20751	20751
TOTAL COSTS (A + B + C)	106471	31011	31011	31011
TOTAL INVESTMENT				
(Less Interest, Depreciation and Commitment Fee)	93820	23260	23260	23260
Cumulative Investment	93820	117080	140340	163600
BENEFITS	62400	62400	62400	62400
NET PROFIT/LOSS				
(Benefits-Costs)	(44071)	31389	31389	31389
Cumulative Net Profit/Loss	(44071)	(12682)	18707	50096
CASH FLOW	(36320)	39140	39140	39140
Cash Flow Discounted at 10%	(33014.88)	32329.64	29394.14	26732.62

NPV at 10% = 255441.52

ROI (Average) = 30.62 per cent

IRR = >50 per cent

Footnotes:

- 1 Negative figures in parentheses.
- 2 Capital Investment - Items under this include cost of machinery and implements, farm shed and buildings.
- 3 Direct Costs - These include expenses for seed, fertiliser, herbicides, harvesting and handling.
- 4 Indirect Costs - They constitute wages and salaries, maintenance of machinery and equipment, land rent, fuel and lubricants, insurance and licensing, depreciation and interest.
- 5 Benefits - Constitute revenue from sale of maize harvest.
- 6 Cost and benefit figures in cedis.
- 7 Depreciation is based on the expected lives of the capital items involved.

NPV = ₦90,410.56

IRR >50 per cent

ROI = 53.81 per cent

5.4.3 Sensitivity Analysis

A similar sensitivity analysis to that undertaken for pineapple was undertaken for the maize project. Here the original seven random variables (see Table 5.1) were reduced by a further two (fertiliser cost and harvesting costs) to leave five random variables for this analysis. Again the same probabilities were assigned as in the original, but only 200 simulations were run. The following results were obtained:

Number of Random Variables	IRR(%)		NPV(₦)		ROI(%)	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
7	50	50	90,778	92,250	54.34	55.67
5	50	50	94,295	95,833	57.85	59.22

The direction of the movement here is the same as in the pineapple case, that is to say both means and standard deviations increase, although the extent of the increase here is very much less. This suggests that the inclusion of a large number of random variables has a dampening effect on the variability (somewhat similar to the idea of "countervailing oversimplifications" (Kulp, 1970, p.221) and the fact that only a few variables might end up as truly random provides little cause of comfort. It becomes increasingly critical that more detailed analysis be undertaken of the individual key variables.

A comparative analysis of the two sets of results indicate substantial increases in the mean and standard deviation figures as a result of the sensitivity analysis. This goes to strengthen the fact that in the cost-benefit analysis, some of the variables have uncertain outcomes and they critically affect the overall results of projects. It becomes necessary, therefore, to identify these variables and to use them in a probability appraisal for more meaningful and better judgement.

It is interesting to note from the results that in the probability analysis for this (maize) project, the expected (mean) results of the NPV and ROI are about one and a half times those obtained under the conventional analysis. The indication is that, unlike the conventional analysis of the pineapple project in which highly optimistic estimates were used, very conservative estimates were used in this case, hence the very high mean values of the results under probability analysis. (The current extremely high market price of maize in Ghana lends credence to this indication. Maize price has more than tripled since the original report was prepared about four years ago.) There is no means for comparing the IRR values in both the conventional and probability analyses since in each case the mean value is over 50 per cent. However, the over 50 per cent IRR attained in each case indicates that the project is highly viable and a decision based on that indicator alone could have been taken irrespective of the method of analysis used. The probability analysis, however, as already discussed, gives a better indication of investment risk.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Summary of Research Findings and Implications

The first part of the study highlights the importance of agriculture in Ghana's economy. However, despite the ADB's major responsibility and efforts in this all important facet of the economy, there are a number of serious problems and deficiencies which need to be handled properly for better project planning and management.

A careful examination of the project planning and management cycle of the ADB has unearthed some serious flaws in project identification and selection, formulation, project approval, implementation, supervision, monitoring and control procedures.

The identification and selection stages have not been well executed because of a lack of supporting data and a proper compendium of essential statistics for the economy and the agricultural sector, including an analytical presentation of the structural indicators of the economy and the agricultural sector, with particular emphasis on the inter-relationship between the two. Some problems also arise in the coordination of projects with the national development plan and they include: lack of strong political and administrative support for national plans among operating ministries responsible for project implementation; ineffective communication of plan goals to the Bank and other allied organisations with investment resources; and the failure to specify projects required for plan implementation. Shortage

of adequately trained planners and specialists in central planning agencies and operating ministries and the Bank itself compounds the problem.

Other bottlenecks have been the promotion of 'pet projects' by individuals and groups within government agencies, the ADB, and even international assistance organisations. Long lag periods in the processing of project proposals by government agencies and funding organisations have also caused problems.

In the formulation of projects, most analyses have not been supported by the findings of surveys and other relevant information on physical resources, population and employment, economic and social infrastructure, institutions, economy and agriculture of the project area. In defining project objectives, secondary objectives, if any, have not been emphasised and there has not been structuring of primary objectives which is important from the point of view of defining various project activities and establishing the logical sequence between them. The presentation of proposed major works and other essential components which ought to be established to bring projects to the stage of full development have not been fully detailed to provide a clear picture of their nature and scope and to enable the estimation of costs to be made with a fair degree of reliability.

Management and organisation which form an important link in the success of projects have also been plagued by a number of deficiencies. The most important of these have been connected with farm services and other agrarian measures. Here research and extension have been lacking or inadequate, major input supply has been a

hindrance, and marketing and processing have not been well handled. Land tenure arrangements resulting in protracted litigations have also disrupted a number of projects due to improper land reform.

At the feasibility study stage, it is recognised that various cost and price estimates should be fairly reliable since they form the main basis for project funding and for calculating the financial and economic returns of the project. However, in view of inadequate and unreliable data and inflationary trends, cost and price estimates by the ADB and other financial institutions have not been realistic and have more often than not deviated widely from expected figures. The use of a single-valued estimation approach for costing and pricing without due regard for risk and uncertainty has compounded this problem.

In the ADB, the most simple non-discounting methods are used in determining the worth of both small and large scale projects. These measures, although having their own inherent advantages, fail to take into account the consideration of time and could give misleading results for decision-making.

Despite the usefulness of sensitivity analysis, its use has largely been neglected in the ADB.

Project approval and implementation have also had their share of the problems. Among the most frequently encountered problems of initiation are: delays in granting necessary approvals for project activation, and procedural and bureaucratic delays at the Management/Board level of the ADB; difficulty in obtaining local and

imported resources and materials during construction, leading to delays and cost over-runs.

Inefficient monitoring and control procedures have tended to result in failure to properly re-design projects upon discovery of unanticipated obstacles to implementation. They have also brought about frequent failures to collect and process the feedback information required to indicate achievement of performance targets and to correct deviations from work schedules and specifications.

An attempt has been made to suggest possible ways and methods for improvement of the planning and management exercise as depicted in the improved cycle [see Figure 4.2]. The suggested improvements which seek to overcome the problems and bottlenecks outlined include a systematic and an in-depth approach to the whole production process. This is based partly on my understanding, judgments, experiences of and insights into the problems. These experiences and insights have been acquired in the course of my work with the ADB and during my training at the ANU and my interaction with people knowledgeable in the subject. They are also based on methods and recommendations suggested for most developing countries by such reputable organisations as the FAO, IBRD and the USAID.

The second part of the analysis which forms the main contribution to this study has been concerned with an attempt to develop a suitable methodology for the incorporation of a measure of risk in two selected projects financed by the ADB. Recognising the fact that agricultural projects are risky and have uncertain outcomes, the Monte Carlo Simulation technique has been modified for use in the form

of probability analysis to examine these elements of risk and uncertainty and to ensure the consistency of ex-post and ex-ante project performances.

In the Monte Carlo Simulation technique, eleven uncertain variables (which from the author's subjective judgement and objective experience are thought to have largely explained variations of the rate of return and other project indicators of worthiness by their own variations) were identified for each project. Values of the variables were then split into various divisions and each division was weighted by a probability according to its likelihood of occurrence. By a process of random sampling, values of each of the parameters varied in the analysis were combined to give the observed distribution of the result. Plots of the results in a form of cumulative probability distributions were obtained for the decision analysis.

Summary of the results indicated in Chapter 5 for the pineapple and maize projects respectively indicate that the methodology developed enables us to have a complete picture of projects and also enables us to provide management with more appropriate information for making the right decisions by recognising the likelihood or variable outcomes of projects in the face of risk and uncertainty. For example, results from the pineapple project indicate that the mean IRR obtained under the probability analysis was only about one-half that obtained under the conventional approach of using single-valued estimations for costs and prices adopted in the original analysis - 12.35 per cent and 27 per cent respectively. This means that values of costs and prices had been highly over-estimated by the use of the conventional approach and anticipated results would therefore not be realised. A wide range of IRR outcomes can also be

obtained from the IRR cumulative probability distribution as already illustrated.

The discipline of thinking through the uncertainties of the problem will in itself help to ensure improvement in making investment choices. For, to understand uncertainty and risk as seen by Hertz (1964), is to understand the key business problem and the key business opportunity.

Probability appraisal can thus be expected to contribute new insights into the anatomy of the economic benefits of a project. It is difficult to generalise about the extent of this contribution. In any case, consideration of alternative courses of action in a project is almost always useful. The value of knowing the estimated probability distribution depends on the credibility of the judgements made in the analysis and on knowledge of the probability distributions of alternative projects.

6.2 Limitations of the Analysis

One of the main limitations of this approach, as I perceive it, is the inability to identify the most sensitive parameters to be kept under constant surveillance in the monitoring process. This limitation is overcome when sensitivity analysis is used but then the ceteris paribus assumption comes in and renders the attempt to look at the project in its entirety a nullity. Another limitation is the need to use reliable judgements in assigning probability weights to the various divisions of the uncertain variables. Lack of reliable data to support these judgements could render the result unreliable.

6.3 Directions for Future Research

Risk analysis is in no sense a technique which replaces skilled judgement. On the contrary, it often requires the use of far more judgement than the traditional analysis. The technique cannot provide correct answers on the basis of false assumptions and improper data. Therefore, there is the need for specialists in the various disciplines of project planning and management to look further into the assembly of proper statistical data as the basis for better analysis. Future research should also look at long term projects and how to incorporate the element of time into the analysis since this has not been considered in the study. The possibility of identifying the most important variables in probability analysis, without recourse to sensitivity analysis which only adopts the ceteris paribus assumption, should be examined.

The step rectangular distribution in its discrete form used in this analysis and other distributions like the triangular and trapezoidal may be tried for various types of projects to classify them for better adoption. The ideal and most suitable number of simulations for such an exercise and similar ones should be further examined to establish concrete recommendations for adoption.

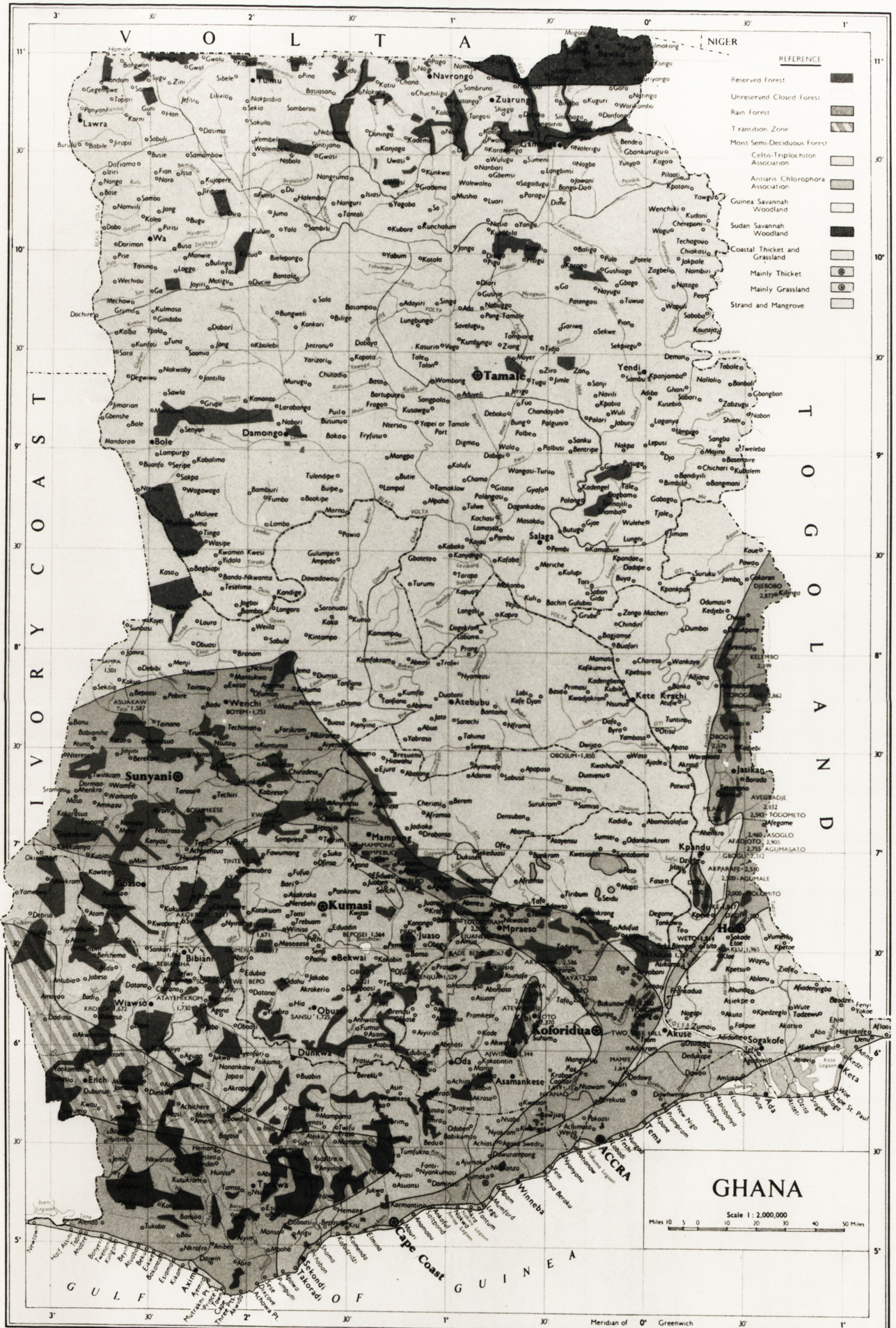
Since the eleven variables, more especially salaries, do not fluctuate year by year, the program should be reviewed to allow for a ratchet effect in its subsequent use (i.e. when salaries go up they are not likely to come down).

In view of time constraints, the writer was unable to

carry out a sensitivity analyses with the six variables which are considered most critical, viz. salaries and wages, farm maintenance costs, running costs of vehicles, running costs of tractor, yield, and price, to see which one is most sensitive to producing the overall results. Given more time, this would have been done. With the availability of computer facilities in Ghana, the writer would follow it up. The writer would follow up this exercise with an ex-post evaluation of the two projects to see how useful the technique has proved to be.

APPENDICES

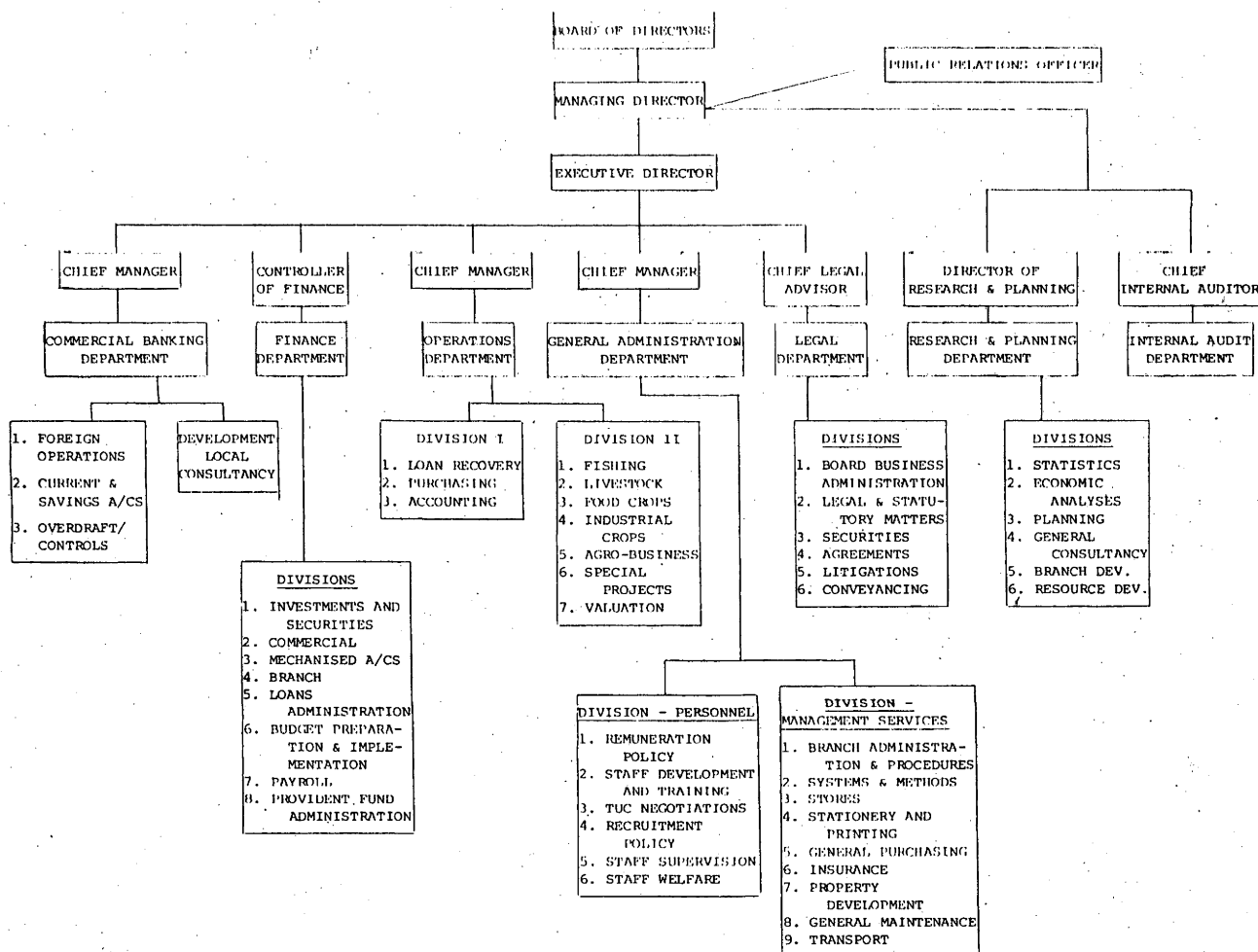
VEGETATION ZONES



Source: Wills 1962.

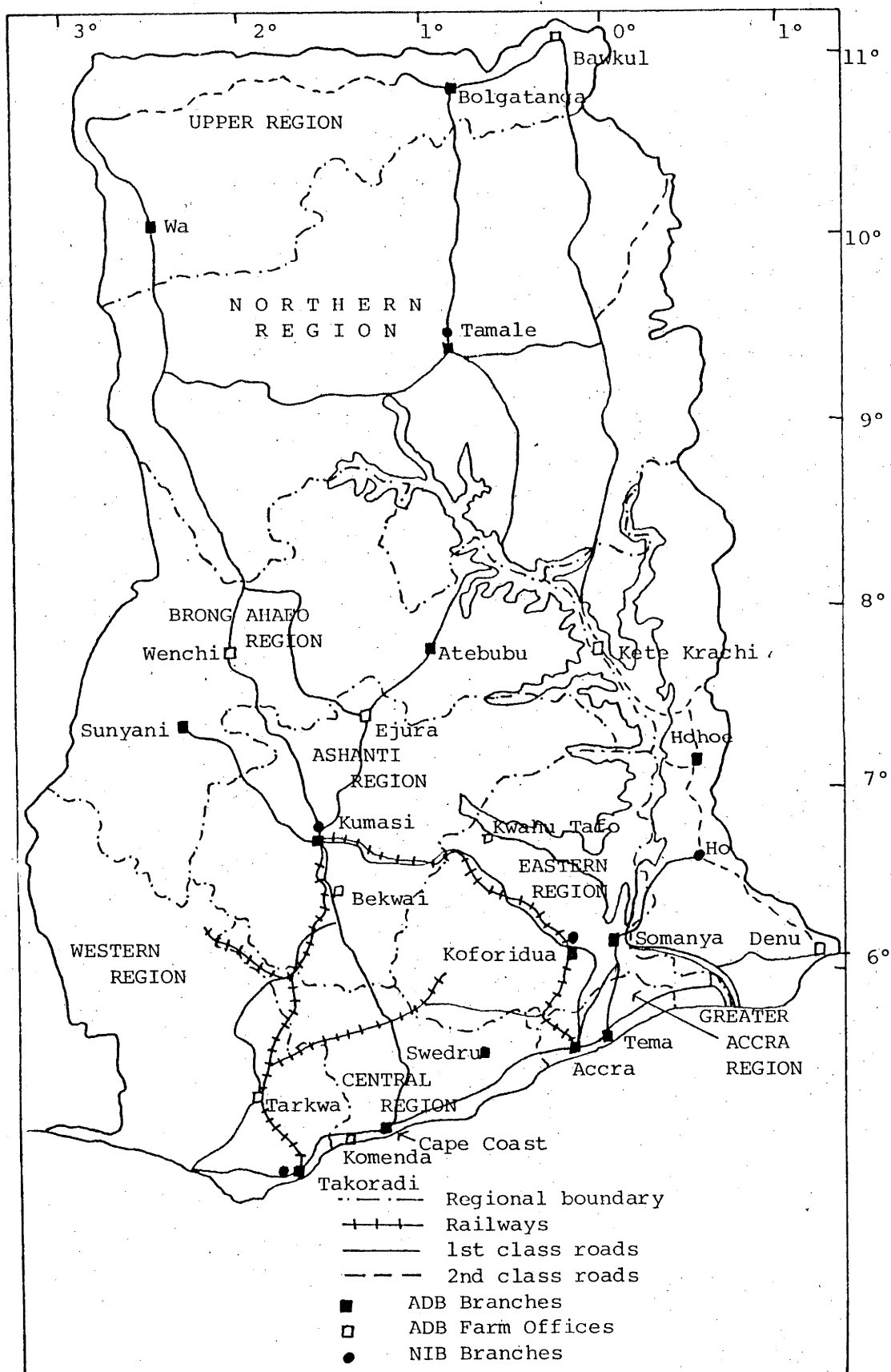
APPENDIX A.2

AGRICULTURAL DEVELOPMENT BANK ORGANISATIONAL CHART - 1977



APPENDIX A.3

MAP OF GHANA SHOWING BRANCHES AND FARM LOAN OFFICES OF THE ADB AND NIB



Source: ADB 1975.

APPENDIX A.4(a)

GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN

(at 1968 market prices)

(per cent)

Industry	1969	1970	1971	1972	1973	1974
1. Agriculture and Livestock	25.5	25.9	25.5	27.4	28.4	29.8
2. Cocoa Production and Marketing	10.8	11.0	10.4	11.4	9.5	8.5
3. Forestry and Logging	3.7	3.5	3.3	3.7	3.7	3.3
4. Fishing	2.1	2.0	2.1	2.7	1.5	1.7
5. Mining and Quarrying	2.2	2.2	2.1	2.3	2.0	1.7
6. Large-Scale Manufacturing	10.6	10.7	11.0	8.7	10.4	9.5
7. Medium and Small-Scale Manufacturing	3.3	3.0	2.9	2.7	2.8	2.7
8. Electricity	1.0	1.0	1.0	1.2	1.7	1.8
9. Water Supply	0.1	0.2	0.2	0.2	0.3	0.4
10. Construction	4.1	4.6	5.3	4.3	4.8	6.0
11. Wholesale and Retail Trade*	13.9	14.4	15.1	13.0	13.5	13.8
12. Restaurants and Hotels	0.5	0.5	0.5	0.6	0.5	0.5
13. Transport and Storage	3.8	3.9	4.1	4.4	4.4	4.0
14. Communications	0.2	0.2	0.2	0.3	0.3	0.3
15. Banking Institutions	0.6	0.6	0.6	0.7	0.8	1.0
16. Insurance	0.2	0.1	0.1	0.1	0.1	0.1
17. Real Estate and Business Services	6.2	5.9	5.6	6.0	5.5	5.0
18. Social Recreational and Community Services	0.5	0.5	0.5	0.6	0.7	0.7
19. Personal and Household Services	0.5	0.5	0.5	0.5	0.5	0.5
20. Producers of Government Services	10.2	9.3	9.0	9.1	8.6	8.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Includes import duty.

Source: Central Bureau of Statistics, 1977, p.145.

APPENDIX A.4(b)

GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN

(at current market prices)

(per cent)

Industry	1969	1970	1971	1972	1973	1974
1. Agriculture and Livestock	28.6	28.5	30.5	31.5	34.2	35.7
2. Cocoa Production and Marketing	12.5	14.0	9.8	10.8	9.8	10.8
3. Forestry and Logging	3.5	3.3	2.8	3.0	3.7	3.5
4. Fishing	1.4	1.1	1.0	1.3	1.4	1.1
5. Mining and Quarrying	2.0	1.7	1.6	2.3	2.3	2.2
6. Large-Scale Manufacturing	8.8	8.1	8.0	8.0	8.9	8.1
7. Medium and Small-Scale Manufacturing	3.1	2.9	2.9	2.9	2.8	2.6
8. Electricity	0.9	0.9	0.8	0.8	0.7	0.6
9. Water Supply	0.1	0.1	0.1	0.1	0.1	0.1
10. Construction	3.8	4.1	4.7	3.7	3.7	4.6
11. Wholesale and Retail Trade*	14.0	14.7	16.1	13.7	14.1	14.6
12. Restaurants and Hotels	0.4	0.5	0.5	0.5	0.5	0.5
13. Transport and Storage	3.8	4.0	4.2	4.1	3.4	3.4
14. Communications	0.2	0.3	0.3	0.3	0.2	0.1
15. Banking Institutions	0.3	0.5	0.5	0.5	0.4	0.2
16. Insurance	0.2	0.1	0.1	0.1	0.1	0.1
17. Real Estate and Business Services	5.8	5.3	6.1	6.4	5.3	3.6
18. Social Recreational and Community Services	0.6	0.5	0.7	0.8	0.8	0.7
19. Personal and Household Services	0.5	0.5	0.5	0.5	0.5	0.4
20. Producers of Government Services	9.5	8.9	8.7	8.7	7.1	7.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Includes import duty.

Source: Central Bureau of Statistics, 1977, p.146.

APPENDIX A.5(a)
GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN
(at 1968 market prices)
(Ø million)

Industry	1969	1970	1971	1972	1973	1974
1. Agriculture and Livestock	459.0	499.5	530.8	542.8	592.7	653.7
2. Cocoa Production and Marketing	195.2	212.0	216.4	225.7	198.3	186.9
3. Forestry and Logging	66.9	67.0	69.2	72.2	77.9	72.5
4. Fishing	38.4	38.6	43.1	54.1	31.2	38.2
5. Mining and Quarrying	40.1	42.9	43.9	45.6	40.9	37.7
6. Large-Scale Manufacturing	190.4	206.6	188.2	171.9	216.3	208.3
7. Medium and Small-Scale Manufacturing	59.1	58.2	60.3	53.9	58.1	59.6
8. Electricity	18.3	19.6	20.6	24.5	36.3	40.3
9. Water Supply	1.0	3.3	4.2	4.5	6.5	8.1
10. Construction	72.6	88.6	110.6	85.3	99.9	130.2
11. Wholesale and Retail Trade*	250.5	277.5	313.9	257.6	232.9	303.3
12. Restaurants and Hotels	9.6	10.5	10.7	10.9	10.8	10.8
13. Transport and Storage	68.6	74.7	85.3	87.6	92.4	88.3
14. Communications	4.4	4.6	4.7	5.4	5.4	5.4
15. Banking Institutions**	10.6	11.3	13.0	14.3	16.6	21.9
16. Insurance	3.1	2.5	2.0	2.5	2.9	2.9
17. Real Estate and Business Services	111.7	113.0	115.6	116.4	114.3	111.2
18. Social, Recreational and Community Services	8.9	8.9	10.6	12.3	14.2	14.5
19. Personal and Household Services	9.9	10.0	9.8	10.2	10.4	10.7
20. Producers of Government Services	184.1	179.4	187.3	180.7	180.1	191.1
Total	1,802.4	1,928.7	2,040.2	1,978.4	2,083.1	2,195.6

* Includes import duty. ** Includes imputed bank service charges.

Source: Central Bureau of Statistics, 1977, p.4.

APPENDIX A.5 (b)

GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN

(at current market prices)

(Ø million)

Industry	1969	1970	1971	1972	1973	1974
1. Agriculture and Livestock	571.6	634.4	764.3	886.5	1,195.7	1,662.9
2. Cocoa Production and Marketing	249.2	317.1	245.3	303.9	343.5	503.5
3. Forestry and Logging	70.1	74.1	71.4	85.6	127.8	164.4
4. Fishing	27.6	25.4	23.9	37.2	47.7	52.3
5. Mining and Quarrying	40.1	38.0	40.6	63.4	81.5	100.0
6. Large-Scale Manufacturing	176.0	182.5	203.2	224.3	309.9	379.5
7. Medium and Small-Scale Manufacturing	72.4	75.1	71.9	81.6	99.4	122.3
8. Electricity	18.1	20.3	19.9	22.6	25.0	25.2
9. Water Supply	0.8	2.9	3.6	3.0	4.5	5.2
10. Construction	76.3	93.8	117.9	104.0	130.9	213.2
11. Wholesale and Retail Trade*	281.1	331.7	402.7	385.2	492.2	680.2
12. Restaurants and Hotels	9.0	10.6	11.6	14.4	7.3	21.2
13. Transport and Storage	76.6	90.1	105.6	115.1	120.5	157.2
14. Communications	3.3	6.8	6.5	9.0	6.3	6.2
15. Banking Institutions	5.8	11.1	13.6	15.4	14.8	8.1
16. Insurance	3.3	2.8	2.4	3.8	4.8	5.7
17. Real Estate and Business Services	115.6	119.0	151.9	179.6	184.9	169.0
18. Social, Recreational and Community Services	11.6	12.2	16.4	21.4	28.5	32.9
19. Personal and Household Services	10.7	11.1	11.9	13.3	16.0	19.2
20. Producers of Government Services	191.5	201.3	216.9	246.1	250.0	331.7
Total	2,000.7	2,259.3	2,501.5	2,815.4	3,501.2	4,660.1

* Includes import duty.

Source: Central Bureau of Statistics, 1977, p.5.

APPENDIX A.6

COCOA PURCHASING COMPANY LOANS APPROVED AND
 REPAYMENT CLASSIFIED BY PURPOSE
 (£ '000)

Purpose	Amount	Amount % of Total	Repayment	Recovery Rate %
Redemption	£3,073.20	94	£587.44	19
Expansion	168.55	5	32.15	19
Improvement	30.00	1	32.88	110
Total	£3,271.75	100	£652.47	20

Source: CMB Loans Department Accounts.

APPENDIX A.7

ADB AND NIB LOANS AS AT DECEMBER 1974

(¢'000)

Sector/Project	ADB	NIB	Total	% of Total
Fishing	4,400.9	892.5	5,293.4	4.7
Livestock	4,013.3	2,366.4	6,379.7	5.7
Industrial Crops	12,967.9	7,706.0	20,673.9	18.3
Food Crops	25,164.3	5,655.7	30,820.0	27.4
Agro Business	5,117.3	16,218.8	21,336.1	18.9
'OFY' (State Agricultural Corporations)	18,920.0	-	18,920.0	16.8
Cocoa Project	2,903.1	-	2,903.1	2.6
Special Projects (Joint Venture)	6,366.2	-	6,366.2	5.6
Total	79,853.0	32,839.4	112,692.4	100.0

Note: Oil palm and pineapple are classified under Industrial Crops, while rice and maize fall under Food Crops.

Source: Loans and Advances Outstanding 31 December 1975. Bank of Ghana Annual Reports for various years. Annual Reports for National Investment Bank (NIB) and Agricultural Development Bank (ADB).

APPENDIX B.1

FEASIBILITY STUDY REPORT

PINEAPPLE PRODUCTION COMPANY

A REPORT PREPARED BY:

AGRICULTURAL DEVELOPMENT BANK
LOANS DEPARTMENT
ACCRA

AUGUST, 1975

TABLE OF CONTENTS

Page

Introduction

The Company

The Project

Growth Requirements of Pineapple

Marketing

Management

Financial Appraisal

Profitability

Conclusion and Summary

Recommendations

Appendices

- 1 Financial Analysis
- 2 Pro-forma Operating Statement
- 3 Cash Flow Analysis
- 4a Imports of Fresh Pineapple and Pineapple
Products into Britain and Export of Fresh
Pineapple and Pineapple Products from Ivory Coast
- 4b CIF (London) Price per Fresh Fruit Pineapple

Schedules

- 1 Land Development
- 2 Cost of Establishing One Acre of Pineapple
- 3 Cost of Planting Material
- 4 Machinery
- 5 Buildings
- 6 Office Equipment
- 7 Tools
- 8 Running Costs of Landrover per Year
- 9 Running Costs of Peugeot Pick-up per Year
- 10 Running Cost of Truck per Year
- 11 Running Cost of Tractor per Year
- 12 Estimated Yield
- 13 Depreciation
- 14 Farm Personnel Schedule
- 15 Non-Capital Farm Inputs
- 16 Working Capital

FEASIBILITY STUDY REPORT
PINEAPPLE PRODUCTION COMPANY

Introduction

Following a series of meetings, correspondences and discussions that have taken place between representatives of the Agricultural Development Bank and the Ghana Export Company Ltd, it has been agreed that a limited liability Company be formed as a joint venture by the two organisations for the production of pineapples for both export and local consumption. The Agricultural Development Bank was delegated to prepare a feasibility study report for the project for the consideration of participating organisations and this report is an attempt to analyse the economic and technical viability of the project.

The Company

A company to be known as Pineapple Production Company Ltd will be incorporated with the Agricultural Development Bank and the Ghana Export Company as shareholders. The proposed shareholding will be as follows:

	<u>%</u>	<u>Amount (¢)</u>
Agricultural Development Bank	60	340,260.00
Ghana Export Company Ltd	40	226,840.00
	<u>100</u>	<u>567,100.00</u>

The Project

The project will involve the establishment of 500 acres of pineapple farm at the Nsawam area in the Eastern Region of Ghana, where previous harvests have indicated that the area will support a

good crop. The establishment will be done over a period of three years then after the fifth year, the whole project will be reappraised to consider whether there is the need for expansion.

Growth Requirements of Pineapple

Pineapple can be grown commercially under a wide range of climatic conditions. The optimum rainfall for its cultivation is between 45-55 inches per annum. Fruiting is much delayed if grown at high altitudes and cooler climates. The ideal conditions are fairly even temperatures 55-90°F and a relative humidity of at least 70 per cent or much overcast weather. These conditions prevail in the Nsawam area.

The cayenne variety is by far the most important commercial variety and will therefore be grown in preference to the Queen, the Sugar Loaf and the Red Spanish.

Of the three types of planting materials, i.e. crowns, suckers and slips, the first two are preferred as they give uniform growth and fruiting. The availability of planting material will however have to be looked into carefully when one is contemplating large acreages of pineapple.

Marketing

The local market consists of purchases of fruits from farmers by three canneries: Nsawam, Nkulenu and Economic Industries. These three canneries have a total capacity of 12,600 tons of pineapple per year, Nsawam cannery alone has a production capacity of 12,000 tons per year, while the other two canneries (especially Nkulenu) have plans for expansion.

The Nsawam Cannery's capacity has not been reached yet, getting an annual supply of only about 2,000 tons.

Available figures on exports of fresh pineapple, canned pineapple and pineapple juice from Ivory Coast to European Countries and also figures on imports into Britain fresh and canned pineapples, give the indication that there is a growing demand for pineapple on the world market, especially in the Western World (see Appendix 4a). The Ghana Export Company can possibly explore the export market for pineapples some more before one can say with any confidence the trend at which the pineapple export market is going.

Foreign Exchange Earnings

It is estimated that an acre will yield about 20 tons of fresh fruit per year and therefore when all the 500 acres have been established, 10,000 tons of fresh fruit should be expected. The local market including the canneries can take 50 per cent of the total produce and the remaining 5,000 tons may be exported to the foreign market to earn some foreign exchange for the country.

Current CIF value (London) for a ton of fresh pineapples is put at £448 or ₦1,148.40 (see Appendix 4b). The costs, i.e. freight rate, cartons for packing and packaging and handling charges, is currently put at about ₦754 per ton. Therefore a profit of ₦392.40 may be made on each ton of fresh fruit exports. When the 20 per cent export bonus is added, the profit becomes higher.

From the estimated 5,000 tons of fresh fruit to be exported therefore, a total profit of ₦1.92 million in foreign exchange will roll in.

Management

A Board of Directors representing the shareholders will be responsible for the management of the project. The Board would formulate policies while the day to day administration of the project will be handled by a Farm Manager who will be an experienced

agriculturist with a bias towards industrial crops plantation management. There will also be an Assistant Farm Manager to assist the Farm Manager, who will possess a certificate or diploma from a recognised agricultural institution in the country or elsewhere.

Financial Appraisal

Capital Requirements

The total capital investment requirement for the project involving the development of 500 acres of pineapple is estimated at ₦1,701,290.00 spread over three years as indicated in Appendix 1.

Financing Plan

On the basis of 1:2 equity/loan base, it is proposed that ₦567,100.00 be raised as equity and ₦1,134,200.00 as loan capital to be spread over a period of three years. The loan portion should be provided by the Agricultural Development Bank.

Pricing and Revenue

A producer price of ₦40.00 per ton is offered by the local canneries. However, an average-sized pineapple fruit ($2\frac{1}{2}$ to 4 lbs) may be sold at 20 pesewas and at this rate, revenue will rise from ₦360,000.00 in the second year to ₦1.2 million in the fourth and subsequent years when all the 500 acres would have been established (see Schedule 12).

Profitability

The project starts showing some profits during the third year when a constant profit of about ₦740,000.00 will start coming in.

Conclusion and Summary

Three major problems involved with large scale pineapple cultivation in Ghana are as follows:

- (1) Pineapple production is a labour intensive business. The work involved in its cultivation is arduous and therefore labour is not very easy to come by for pineapple cultivation.
- (2) The question of availability of planting material for large acreages is also a problem. It is not easy to obtain crowns and suckers to plant big acreages.
- (3) Market avenues, especially the overseas market, should be explored a bit more. Even though there is an apparent market overseas for fresh pineapples, serious contacts should be established.

In spite of the above problems, pineapple production can be a very lucrative concern and the proposed Pineapple Production Company may be a start for breaking new ground in large scale pineapple production in Ghana.

Recommendations

- (1) A company to be known as the Pineapple Production Company should be incorporated with the Agricultural Development Bank and the Ghana Export Company as shareholders. The Company is to start and maintain a 500 acre pineapple farm to produce fresh fruits for the local and export market.

- (2) The following share capitals should be provided by the two establishments:

Agricultural Development Bank	¢340,260.00
Ghana Export Company Ltd	226,840.00
	¢567,100.00

- (3) The Agricultural Development Bank may grant a loan of ¢1,134,200.00 to the Company at an interest rate of $8\frac{1}{2}$ per cent per annum.
- (4) The loan should be repaid over 5 years including a 3-year moratorium on both principal and interest.
- (5) All other lending conditions of the Agricultural Development Bank should also apply.

APPENDIX 1
FINANCIAL ANALYSIS
Capital Investment Schedule

	Year 1	Year 2	Year 3	Total
Acreage	150	150	200	500
	₪	₪	₪	₪
Land Development (500 Acres) (Sch. 1)	142,500	-	-	142,500
Cost of Establishment (Sch. 2)	22,200	22,200	29,600	74,000
Planting Material (Sch. 3)	90,000	90,000	120,000	300,000
Machinery (Sch. 4)	136,000	-	-	136,000
Buildings (Sch. 5)	35,000	-	-	35,000
Office Equipment (Sch. 6)	5,600	-	-	5,600
Tools (Sch. 7)	16,000	-	-	16,000
Working Capital (Sch. 16)	214,640	317,540	319,270	851,450
Contingency (10 per cent)	60,430	38,220	42,090	140,740
Total Investment	722,370	467,960	510,960	1,701,290
Cumulative Investment	722,370	1,190,330	1,701,290	3,402,580
Equity	240,790	155,990	170,320	567,100
Loan	481,580	311,980	340,640	1,134,200
Cumulative Equity	240,790	396,780	567,100	567,100
Cumulative Loan	481,580	793,560	1,134,200	1,134,200

APPENDIX 2

PRO-FORMA OPERATING STATEMENT
(Z)

	Year 1	Year 2	Year 3	Year 4	Year 5
<u>Direct Production Costs</u>					
Farm Maintenance Cost at Ø25.00 per Acre	3,750	7,500	12,500	12,500	12,500
Fertilisers	3,750	7,500	12,500	12,500	12,500
Flower Induction	7,500	15,000	25,000	25,000	25,000
Harvesting 14 Mandays/Acre	-	4,200	8,400	14,000	14,000
Contingency (10%)	1,500	3,420	5,840	6,400	6,400
Total Direct Costs	16,500	37,620	64,240	70,400	70,400
<u>Indirect Production Costs</u>					
Salaries and Wages	116,990	208,450	209,990	211,440	212,890
Social Security - 12 1/2	14,620	26,060	26,250	26,430	26,610
Land Rent	2,500	2,500	2,500	2,500	2,500
Running Costs of Vehicles	18,844	18,844	18,844	18,844	18,844
Stationery and Postage	1,500	1,500	1,500	1,500	1,500
Running Costs of Tractor	10,236	10,236	10,236	10,236	10,236
Maintenance of Buildings - 2 1/2 of cost	750	750	750	750	750
Depreciation	50,870	50,870	50,870	50,870	50,870
Interest - 6% on Loan	68,050	68,050	68,050	68,050	68,050
Total Indirect Costs	284,360	387,260	388,990	390,620	392,250
Total Production Costs	300,860	424,880	453,230	461,020	462,650
Yield (Fruits)	-	1,800,000	3,600,000	6,000,000	6,000,000

APPENDIX 3

CASH FLOW ANALYSIS

(₺)

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Production Costs	300,860	424,880	453,230	461,020	462,650
Total Costs (Cap. Inv. + Prod'n. Costs)	748,160	537,080	602,830	461,020	462,650
Total Revenue (cedis)	-	360,000	720,000	1,200,000	1,200,000
Cumulative Revenue	-	360,000	1,080,000	2,280,000	3,480,000
Net Profit (Loss)	(748,160)	(177,080)	117,170	738,980	737,350
Depreciation	50,870	50,870	50,870	50,870	50,870
Total Cash Flow	(697,290)	(126,110)	168,040	789,850	788,220
Return on Investment (%)	-	-	24.21	216.01	214.51
Pay-Back Period (Years)	-	-	4.12	0.46	0.46

APPENDIX 4a

IMPORTS OF FRESH PINEAPPLE AND PINEAPPLE PRODUCTS INTO BRITAIN
(Tons)

Year	Fresh Pineapple	Canned Pineapple
1971	4,576	30,460
1972	4,773	28,398
1973	5,376	30,397

EXPORT OF FRESH PINEAPPLE AND PINEAPPLE PRODUCTS
FROM IVORY COAST
(Tons)

Year	Canned Pineapples	Pineapple Juice	Fresh Pineapples
1970	26,800	12,300	17,200
1971	25,800	13,100	19,400
1972	44,200	12,800	37,400

Source: Fruit Intelligence, Commonwealth Secretariat,
September 1973.

APPENDIX 4b

CIF (LONDON) PRICE PER FRESH FRUIT PINEAPPLE
(Pence - p)

	Range	Average
Ghana	60-110 p	80 p
Kenya	40- 75 p	55 p
Ivory Coast	35- 65 p	50 p
South Africa	31- 41 p	35 p

Source: Broome & Greene (London) Ltd,
February 1975.

SCHEDULE 1LAND DEVELOPMENT

Acreage - 500 Acres

Land clearing - Ø2.00 per acre	Ø100,000.00
12.5 miles of access road	25,000.00
Land acquisition expenses, i.e. drinks, surveying fees, soil tests, etc.	12,500.00
Miscellaneous infrastructure	5,000.00
	<u>Ø142,500.00</u>

SCHEDULE 2COST OF ESTABLISHING ONE ACRE OF PINEAPPLE

Lining and pegging - 8 mandays at Ø2.00 per manday	16.00
Cleaning of planting material - 7 mandays at Ø2.00 per manday	14.00
Carrying of planting material - 9 mandays at Ø2.00 per manday	18.00
Digging of Holes - 14 mandays at Ø2.00 per manday	28.00
Filling holes with plants - 7 mandays at Ø2.00 per manday	14.00
Planting - 14 mandays at Ø2.00 per manday	28.00
Transportation of suckers	30.00
	<u>Ø148.00</u>

SCHEDULE 3COST OF PLANTING MATERIAL

	Year 1	Year 2	Year 3	Total
Acreage	150 ø	150 ø	200 ø	500 ø
15,000 plants needed to plant one acre - 100 plants cost ø4.00, therefore ø600.00 needed for one acre	90,000	90,000	120,000	-
	<u>90,000</u>	<u>90,000</u>	<u>120,000</u>	<u>300,000</u>

SCHEDULE 4MACHINERY

3 tractors with implements at ø15,000.00 each	ø45,000.00
1 land rover at ø16,000.00	16,000.00
2 7-tonner trucks at ø25,000.00 each	50,000.00
3 weighing scales at ø3,000.00 each	9,000.00
2 Peugeot 404 pick-ups at ø8,000.00 each	16,000.00
	<u>ø136,000.00</u>

SCHEDULE 5BUILDINGS

1 10-room office block	25,000.00
2 storage sheds	10,000.00
	<u>ø35,000.00</u>

SCHEDULE 6OFFICE EQUIPMENT

3 typewriters at ¢500.00 each	¢1,500.00
1 steel vault	1,000.00
1 set office furniture	2,500.00
3 steel cabinets	600.00
	¢5,600.00

SCHEDULE 7TOOLS

125 mattocks at ¢8.00 each	¢1,000.00
250 hoes at ¢2.50 each	625.00
50 pick axes at ¢10.00 each	500.00
250 pairs of hand gloves at ¢7.00 each	1,750.00
50 shovels at ¢9.00 each	450.00
250 pairs of farm boots at ¢20.00 each	5,000.00
25 reaction tanks and applicators at ¢200.00 per set	5,000.00
250 pairs of eye protective goggles at ¢4.00 each	1,000.00
65 head pans at ¢10.00 each	650.00
	¢15,975.00
approximately	¢16,000.00

SCHEDULE 8RUNNING COSTS OF LANDROVER PER YEAR

It is assumed that Landrover will do 2,000 miles each month.

Fuel at 10 miles/gallon at Ø1.20 per gallon	Ø2,880.00
12 engine oil changes at Ø4.50 per change	54.00
Greasing at Ø1.50 per month	18.00
Lubrication - 4 gear boxes and axil oil changes at Ø6.00 per change	24.00
Repairs - 5% original value	800.00
Insurance and registration	700.00
Miscellaneous expenses	900.00
	Ø4,676.00
Say	
	Ø4,700.00

SCHEDULE 9RUNNING COSTS OF PEUGEOT PICK-UP PER YEAR

It is assumed that the Pick-up will do 3,000 miles each month.

Fuel at 25 miles/gallon at Ø1.20 per gallon	Ø1,728.00
Greasing at Ø1.50 per month	18.00
12 oil changes at Ø4.50 per change	54.00
Lubrication - 4 gear boxes and axil oil changes at Ø5.00 per change	400.00
Repairs - 5% of initial value insurance	450.00
Miscellaneous expenses	200.00
	Ø2,870.00
Therefore for 2 Pick-ups	
	Ø5,740.00

SCHEDULE 10RUNNING COST OF TRUCK PER YEAR

If the truck does 3,600 miles a month and fuel consumption is 20 miles/gallon, the following running costs are estimated.

Cost of diesel oil at 80 p/gallon	ø1,728.00
Lubrication - twice a month at ø6.00 each	144.00
Maintenance and repairs	1,730.00
Insurance	600.00
	<u>ø4,202.00</u>
Therefore for 2 trucks	<u>ø8,404.00</u>

SCHEDULE 11RUNNING COST OF TRACTOR PER YEAR

Fuel consumption per hour is 2.2 gallons at 80 p/gallon working 5 hours a day and 5 days in the week	ø2,112.00
Lubricants - 6 oil changes at 2 gallons per change	40.00
Greasing - 24 lbs at 47 p/112 lbs	10.00
Insurance	200.00
Maintenance and repairs	1,050.00
	<u>ø3,412.00</u>
Therefore for 3 tractors	<u>ø10,236.00</u>

SCHEDULE 12ESTIMATED YIELD

1 acre is expected to yield about 12,000 fruits, therefore from 500 acres 6,000,000 fruits are expected.

Estimated Revenue

If each fruit will sell at 20 p then 6,000,000 fruits will give ₦1,200,000.00.

SCHEDULE 13DEPRECIATION

Machinery and trucks	20% of ₦136,000	₦27,200.00
Buildings	10% of ₦ 35,000	3,500.00
Office equipment	20% of ₦ 5,600	1,120.00
Capital farm equipment	30% of ₦ 16,000	4,800.00
Land and land development	10% of ₦142,500	14,250.00
		<u>₦50,870.00</u>

SCHEDULE 14

FARM PERSONNEL SCHEDULE

		Year 1	Year 2	Year 3	Year 4	Year 5
		ø	ø	ø	ø	ø
Farm Manager	(1)	4500 x 150	4,500	4,650	4,800	4,950
Assistant Farm Manager	(1)	2400 x 120	2,400	2,530	2,640	2,760
Farm Supervisor	(3)	1500 x 80	4,500	4,740	5,080	5,320
Accounts Clerk	(2)	2000 x 100	4,000	4,200	4,400	4,600
Tractor Operator	(3)	780 x 50	2,340	2,490	2,640	2,790
Land Rover Driver	(3)	720 x 50	2,160	2,310	2,460	2,610
Truck Driver	(2)	770 x 50	1,540	1,640	1,740	1,840
Clerk/Typist	(3)	850 x 50	2,550	2,640	2,730	2,820
Watchmen	(5)	600 x 50	3,000	3,250	3,500	3,750
Permanent Labourers	(250)	720	90,000	180,000	180,000	180,000
			116,990	208,450	209,990	211,440
Social Security	(12½%)		14,620	26,060	26,250	26,430
						26,610

SCHEDULE 15NON CAPITAL FARM INPUTS

3,750 bags of fertiliser at ¢3.00 each	¢11,250.00
1,500 cutlasses at ¢3.00 each	4,500.00
300 tins of calcium carbide at ¢8.00 each	24,000.00
315 drums of pesticides at ¢30.00 each	9,450.00
	<u>¢49,200.00</u>

SCHEDULE 16WORKING CAPITAL

Salaries and Wages	116,990	208,450	209,990	211,440	212,890
Social Security	14,620	26,060	26,250	26,430	26,610
Non-Capital Farm Inputs	49,200	49,200	49,200	-	-
Land Rent	2,500	2,500	2,500	2,500	2,500
Stationery and Postage	1,500	1,500	1,500	1,500	1,500
Running Costs of Vehicles	18,844	18,844	18,844	18,844	18,844
Running Costs of Tractors	10,236	10,236	10,236	10,236	10,236
Maintenance of Buildings	750	750	750	750	750
	<u>214,640</u>	<u>317,540</u>	<u>319,270</u>	<u>271,700</u>	<u>273,330</u>

APPENDIX B.2

MAIZE PROJECT - DETAILED FINANCIAL COST-BENEFIT ANALYSIS

The descriptive part of this report has been left out since it follows more or less the same format as depicted in Appendix B.1(a).

Appendix 1Financial Analysis

<u>Investment</u>	<u>Year 1</u>	<u>Year 2</u>	<u>Year 3</u>	<u>Year 4</u>
Existing Capital Investment (Sch.1)	23,820	-	-	-
Proposed " " (Sch.1)	40,140	-	-	-
Total " "	63,960	-	-	-
Working Capital (Sch.2)	29,860	23,260	23,260	23,260
Total Investment	93,820	23,260	23,260	23,260
Cumulative Investment	93,820	117,080	140,340	163,600
Funds Ploughed Back	-	23,260	23,260	23,260
Cumulative Ploughed Back	-	23,260	46,520	69,780
Borrower's Contribution (Sch.3)	23,820	-	-	-
Required Loan	70,000	-	-	-
Cumulative Required Loan	70,000	70,000	70,000	70,000

Proforma Profit/Loss Statement

Direct Production Cost (Sch.4)				
Maize	10,260	10,260	10,260	10,260
Indirect Production Cost (Sch.5)				
Salaries and Wages	8,580	8,580	8,580	8,580
Maintenance of Machinery & Equipment	1,196	1,495	1,794	2,093
Land Rent	300	300	300	300
Fuel and Lubricant	1,120	1,120	1,120	1,120
Insurance and Licensing	640	640	640	640
Contingency	7,764	865	566	267

Interest	4,200	-	-	-
Commitment Fee	700	-	-	-
Depreciation	7,751	7,751	7,751	7,751
Total	32,251	20,751	20,751	20,751
Total Production Cost	42,511	31,011	31,011	31,011
Cumulative Production Cost	42,511	73,522	104,533	135,544

Production Volume (Sch.6)

Maize	2,400	2,400	2,400	2,400
-------	-------	-------	-------	-------

Revenue (Sch.7)

Maize	62,400	62,400	62,400	62,400
Gross Income	62,400	62,400	62,400	62,400
Cumulative Income	62,400	124,800	188,200	250,600
Net Income After Deduction of Production Cost	19,889	31,389	31,389	31,389
Cumulative Net Income	19,889	51,278	82,667	114,056
Return on Investment (%)	-	44.17	59.32	70.14
Pay-Back Period (Years)	-	1.73	1.31	1.12

Cash Flow

Net Income	19,889	31,389	31,389	31,389
Depreciation	7,751	7,751	7,751	7,751
Net Cash Flow	27,640	39,140	39,140	39,140
Cumulative Cash Flow	27,640	66,780	105,920	145,060

Sources and Uses of Funds

Funds Ploughed Back	-	23,260	23,260	23,260
Borrower's Contribution	23,820	-	-	-
Required Loan	70,000	-	-	-
Total Available Resource	93,820	23,260	23,260	23,260
Required Investment	93,820	23,260	23,260	23,260

Income and Loan Repayment

Income

Gross Sales and Income	62,400	62,400	62,400	62,400
------------------------	--------	--------	--------	--------

Less Commitment Fee	700	-	-	-
Borrower's Contribution of Working Capital	-	-	-	-
Net Sales Income	61,700	62,400	62,400	62,400

Loan Repayment

Interest	4,200	-	-	-
Working Capital Portion of Loan	8,954	8,953	8,953	3,000
Capital Investment Portion of Loan	10,035	10,035	10,035	10,035
Total Repayment	23,189	18,988	18,988	13,035
Ending Cash Balance	38,511	43,412	43,412	-

Schedule 1Capital InvestmentExisting Capital Investment

1 Tractor (Zector)	¢ 2,000
1 Trailer	900
Tractor Implements (plough, harrow, slasher, cultivator, etc)	1,500
2 Maize Shellers	1,600
1 Planter	2,120
1 Tractor Mounted Sprayer	3,100
Farm Shed	2,600
	<u>¢23,820</u>

Proposed Capital Investment

1 David Brown L1210 Tractor	8,888
1 Heavy Duty Disc Plough	1,290
1 Heavy Duty Harrow	1,115
1 Lister Drying Machine	7,670
1 Lister Oil Fired Heater	1,700
1 Auxiliary Alternation	1,950
1 Corn Mill with Motor	1,129
Cost of constructing the building for the drier	15,000
Weighing Scale	1,400
	<u>¢40,140</u>

Schedule 2Working Capital

	<u>Year 1</u>	<u>Year 2</u>	<u>Year 3</u>	<u>Year 4</u>
(i) Total Production Cost	42,511	31,011	31,011	31,011
(ii) Less (a) Interest	4,200	-	-	-
(b) Commitment Fee	700	-	-	-
(c) Depreciation	7,751	7,751	7,751	7,751
(iii) Working Capital = (i-(a+b+c))	29,860	23,260	23,260	23,260
Cumulative Working Capital	29,860	53,120	76,380	99,640

Schedule 5 (contd.)Maintenance of Farm Machinery & Equipment

	<u>Year 1</u>	<u>Year 2</u>	<u>Year 3</u>	<u>Year 4</u>
Maintenance at (4%, 5%, 6%, 7% cost of Machinery and Equipment)	1,196	1,495	1,794	2,093

Land Rent

Ø300.00/Annum	Ø 300.00
---------------	----------

Fuel and Lubricant

1 Gallon of Fuel to Plough and Harrow 2 Acres at 80p/gallon ∴ 300 Acres	120.00
Allow Ø300.00 for Carting and Shelling	300.00
Allow Ø100.00 Fuel for Drying	100.00
Allow Ø2.00/Acre for Lubricant	600.00
	<u>Ø1,120.00</u>

Insurance and Licensing

Comprehensive Insurance for 2 Tractors	600.00
Licensing of 1 Tractor	40.00
	<u>Ø640.00</u>

Depreciation

Farm Machinery & Equipment 20% of Ø29,955.00	Ø5,191.00
Farm Shed and Drying House - 10%	1,760.00
	<u>Ø7,751.00</u>

Schedule 6Production Volume

<u>Maize</u>	<u>1 Acre</u>	<u>300 Acres</u>
Estimated Yield/Acre 8 Bags (220lbs ea.)	8	2,400

Schedule 7Revenue

	<u>300 Acres</u>
1 Bag of Seed Maize Sells at Ø30.00 6 Bags/Acre Ø180/Acre	Ø54,000
2 Bags/Acre Discard at Ø14.00/bag	8,400
	<u>Ø62,400</u>

Appendix 2Disbursement Schedule

¢

January-March - Land Rent	300.00
Salaries	2,145.00
Tractor and Implements	11,303.00
Construction of Building for Drier	15,000.00
Insurance	640.00
	29,388.00
April-June - Salaries	2,145.00
Fuel	510.00
Seed Maize	600.00
Fertiliser (Compound)	1,680.00
Transportation	240.00
Herbicide	2,520.00
	7,695.00
July-September - Salaries	2,145.00
Fertiliser (SA)	600.00
Transportation	120.00
Corn Mill	1,127.00
Weigh Scale	1,400.00
Drier and its Auxiliaries	11,320.00
	16,712.00
Oct.-December - Salaries	2,145.00
Fuel	510.00
Harvesting and Dehusking	3,300.00
Handling Charges	1,200.00
Maintenance	1,196.00
Fuel for Driving	100.00
	8,451.00
Contingency	7,754.00
	70,000.00

Appendix 3Repayment Schedule*

October-December, 1975	-	ø16,500.00
October-December, 1976	-	16,500.00
October-December, 1977	-	16,500.00
October-December, 1978	-	16,500.00
October-December, 1979	-	16,500.00
Total		<u>ø81,000.00</u>

* Excluding interest (includes balance of first loan).

APPENDIX D.1

DIVISIONS OF VALUES OF UNCERTAIN VARIABLES AND
THEIR ASSIGNED PROBABILITY DISTRIBUTIONS
(PINEAPPLE PROJECT)

Variable	Range of Year 1 Values (in Cedis)	Mean of Range (in Cedis)	Group No.	Probability Distribution
1. Cost of Establishment	19980 - 22200 (-10% of base fig.)	21090	1	.10
	*22200 - 24420 (+10%)	23310	2	.40
	24420 - 26640 (+10%)	25530	3	.10
	26640 - 28860 (+10%)	27750	4	.15
	28860 - 31080 (+10%)	29970	5	.05
2. Planting Material	81000 - 90000 (-10%)	85500	1	.05
	*90000 - 99000 (+10%)	94500	2	.50
	99000 - 108000 (+10%)	103500	3	.30
	108000 - 117000 (+10%)	112500	4	.10
	117000 - 126000 (+10%)	121500	5	.05
3. Farm Maintenance	3375 - 3750 (-10%)	3562.5	1	.01
	*3750 - 4125 (+10%)	3937.5	2	.12
	4125 - 4500 (+10%)	4312.5	3	.12
	4500 - 4875 (+10%)	4687.5	4	.25
	4875 - 5250 (+10%)	5077.5	5	.50
4. Fertilisers	3375 - 3750 (-10%)	3562.5	1	.00
	*3750 - 4125 (+10%)	3937.5	2	.60
	4125 - 4500 (+10%)	4312.5	3	.05
	4500 - 4875 (+10%)	4687.5	4	.15
	4875 - 5250 (+10%)	5062.5	5	.20
5. Harvesting Cost**	3780 - 4200 (-10%)	3990	1	.01
	*4200 - 4620 (+10%)	4410	2	.12
	4620 - 5040 (+10%)	4830	3	.12
	5040 - 5460 (+10%)	5250	4	.25
	5460 - 5880 (+10%)	5670	5	.50
6. Salaries and Wages	105291 - 116990 (-10%)	111140.5	1	.00
	*116990 - 128689 (+10%)	122839.5	2	.10
	128689 - 140388 (+10%)	134538.5	3	.20
	140388 - 152087 (+10%)	146237.5	4	.30
	152087 - 163786 (+10%)	157936.5	5	.40
7. Flower Induction	6750 - 7500 (-10%)	7125	1	.05
	*7500 - 8250 (+10%)	7875	2	.40
	8250 - 9000 (+10%)	8625	3	.30
	9000 - 9750 (+10%)	9375	4	.20
	9750 - 10500 (+10%)	10125	5	.05
8. Running Costs of Vehicle	16960 - 18844 (-10%)	17902	1	.10
	*18844 - 20728 (+10%)	19786	2	.15
	20728 - 22612 (+10%)	21670	3	.15
	22612 - 24496 (+10%)	23554	4	.40
	24496 - 26380 (+10%)	25438	5	.20
9. Running Costs of Tractor	9212 - 10236 (-10%)	9724	1	.10
	*10236 - 11260 (+10%)	10748	2	.15
	11260 - 12284 (+10%)	11772	3	.15
	12284 - 13308 (+10%)	12796	4	.40
	13308 - 14332 (+10%)	13820	5	.20
10. Yield/Acre***	8400 - 9600 (-10%)	9000	1	.35
	9600 - 10800 (-10%)	15000	2	.30
	10800 - 12000 (-10%)	11400	3	.15
	*12000 - 13200 (+10%)	12600	4	.15
	13200 - 14400 (+10%)	13800	5	.05
11. Price/Fruit	0.18 - 0.20 (-10%)	0.19	1	.15
	*0.20 - 0.22 (+10%)	0.21	2	.40
	0.22 - 0.24 (+10%)	0.23	3	.30
	0.24 - 0.26 (+10%)	0.25	4	.10
	0.26 - 0.28 (+10%)	0.27	5	.05

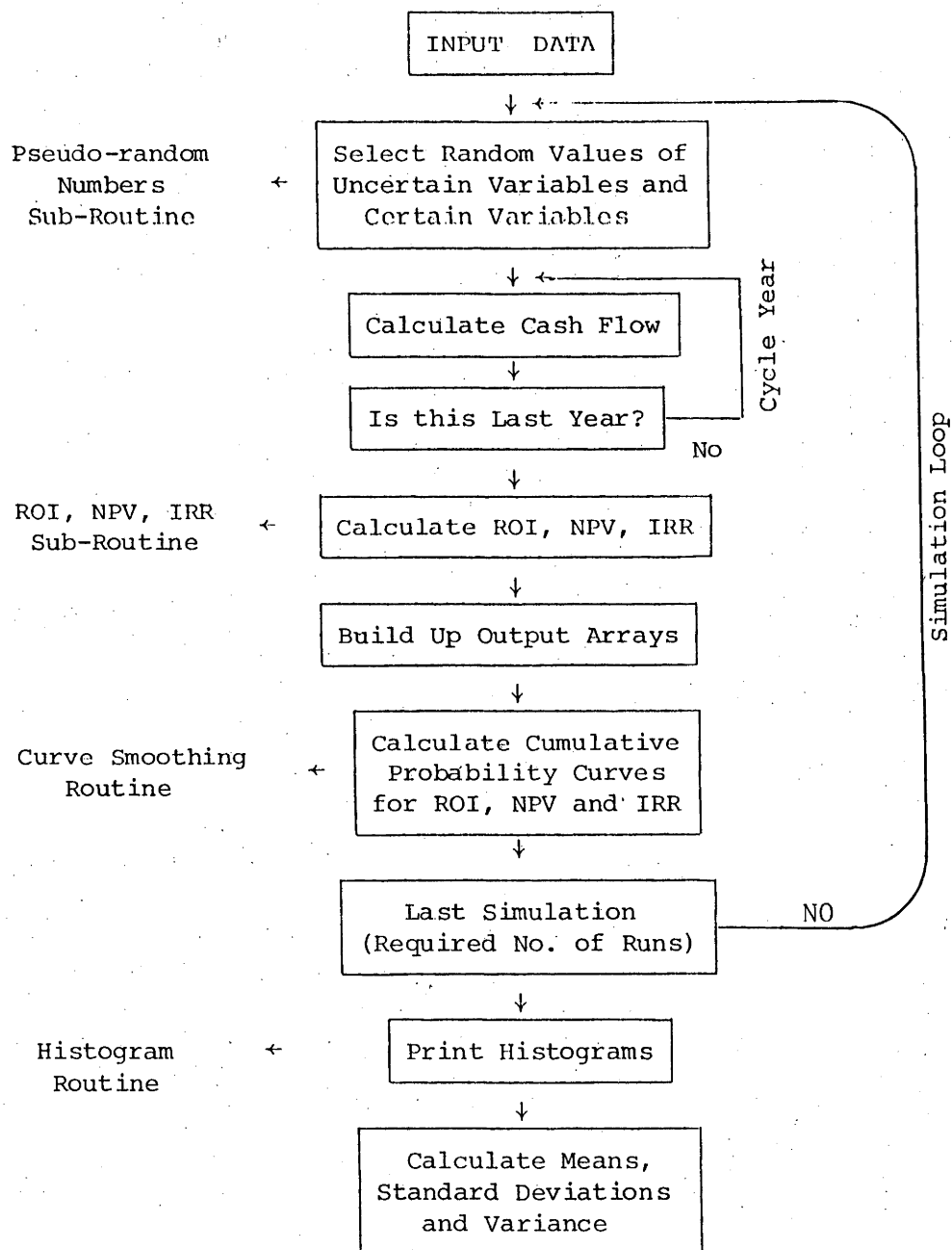
* Base figure of value. Note: Ranges are also assigned to values in subsequent years in the same manner.

** Range of values start from Year 2 since there is no harvesting in Year 1.

*** Range of values start from Year 2 when harvesting is started.

APPENDIX D.2

FLOW CHART FOR PROBABILITY ANALYSIS
(MONTE CARLO SIMULATION)



APPENDIX D.3

(a) THE MONTE CARLO SIMULATION PROGRAM

```

1  IMPLICIT REAL (A-Z)
2  REAL VRCOST(10),TRCOST(10),YIELD(10),CFRT(10),FRMAIN(10),
    FERT(10),HARV(10),WAGES(10),TEMP(11),MEAN(11),SD(11),
    PLANTG(10),ECOST(10),FLIND(10),BMINC(10),TOTINV,NPROF
    INTEGER NUMSIM,YEARS,I,J
    LOGICAL PRI
    PRI = .TRUE.
    CALL GETPAR(NUMSIM,YEARS,PRI)
    DO 200 I = 1,NUMSIM
    NPROF = 0.0
    NPV = 0.0
    TOTINV = 0.0

C
    DO 100 J = 1,YEARS
        CALL GETVAL(J,VRCOST(J),TRCOST(J),YIELD(J),CFRT(J),
1        FRMAIN(J),FERT(J),HARV(J),WAGES(J),FLIND(J),
2        ECOST(J),PLANTG(J))
        TEMP(1) = VRCOST(J)
        TEMP(2) = TRCOST(J)
        TEMP(3) = YIELD(J)
        TEMP(4) = CFRT(J)
        TEMP(5) = FRMAIN(J)
        TEMP(6) = FERT(J)
        TEMP(7) = HARV(J)
        TEMP(8) = WAGES(J)
        TEMP(9) = FLIND(J)
        TEMP(10) = ECOST(J)
        TEMP(11) = PLANTG(J)
        CALL FLOW(TEMP,CFLOW,ROI,NPV,BMINC,J,NPROF,TOTINV)
        IF(.NOT.PRI) GO TO 100
        CALL PRINT(I,J,TEMP)
100    CONTINUE
C
    CALL CALCIRR(IRR,YEARS,BMINC)
    CALL CALCRO(NPROF,TOTINV,ROI)
    CALL EPRINT(YEARS,ROI,IRR,NPV,PRI)
200    CONTINUE
    ENDFILE 33
    STOP
    END

*****
SUBROUTINE GETPAR(NUMSIM,YEARS,PRI)
    INTEGER NUMSIM,YEARS
    LOGICAL PRI
05    TYPE 10
10    FORMAT(' HOW MANY DIFFERENT SIMULATIONS OF THE SAME COND
    ITIONS ? ',S)
    ACCEPT 20 , NUMSIM
20    FORMAT(G)
    IF(NUMSIM.GE.1.AND.NUMSIM.LT.101) GO TO 50
    TYPE 30 , NUMSIM
30    FORMAT(' DO YOU REALLY WANT ',I10,' SIMULATIONS
    6 ? ',S)
    ACCEPT 40 , ANSWER
40    FORMAT(A1)
    IF (ANSWER.NE.'Y') GO TO 05
50    CONTINUE
    TYPE 60

```

```

60  FORMAT(' HOW MANY YEARS DO YOU WANT EACH SIMULATION TO R
1UN FOR ? ',S)
    ACCEPT 20 , YEARS
    IF (YEARS.GE.1.AND.YEARS.LE.1000) GO TO 90
80  TYPE 80 , YEARS
    FORMAT(' DO YOU REALLY WANT THE SIMULATION TO RU
1N FOR ',I10, ' YEARS ? ',S)
    ACCEPT 40 , ANSWER
    IF (ANSWER.NE.'Y') GO TO 50
90  CONTINUE
    TYPE 100
100  FORMAT(' PLEASE TYPE A NUMBER TO START THE RANDOM NUMBER
    GENERATOR ',S)
    ACCEPT 20 , DUMMY
    CALL SETRAN(DUMMY)
    TYPE 110
110  FORMAT(' DO YOU WANT THE DETAILS PRINTED? ',S)
    ACCEPT 40 , ANSWER
    IF (ANSWER.EQ.'N') PRI = .FALSE.
    WRITE(33,20) DUMMY
    IF (.NOT. PRI) RETURN
88  PRINT 88 , DUMMY
    FORMAT('///20X, ' STARTING VALUE = ',G)
    RETURN
    END
*****
SUBROUTINE GETVAL(YEAR,VRCOST,TRCOST,YIELD,CFRT,FRMAIN,
1  FERT,HARV,WAGES,FLIND,ECOST,PLANTG)
2  REAL VFMAF(5), VHARV(5), VWAGE(5), VVRCST(5), VTRCST(5),
1  VYIELD(5), VCFRT(6), MULTG(6), MULTY(6), VFLIND(5),
2  VECOST(5), VPLANT(5)
1  REAL VRCOST,TRCOST,YIELD,CFRT,FRMAIN,FERT,HARV,WAGES,
1  VALUE,DUMMY,BASE,LOWER,UPPER
1  INTEGER GVC,GTRC,GY,GCERT,GFRM,GFERT,GHARV,GWAGE,YEAR
1  INTEGER GFL,GEC,GPL
DATA VFMAF/3750.,7500.,12500.,12500.,12500./ ,
1  VHARV/0.,4200.,8400.,14000.,14000./ ,
2  VWAGE/116990.,208450.,209990.,211440.,212890./ ,
3  VVRCST/18844.,18844.,18844.,18844.,18844./ ,
4  VTRCST/5.,10236.,/ ,
5  VYIELD/0.,4*12000./ ,
6  VCFRT/.18, .2, .22, .24, .26, .26/ ,
1  DATA MULTG/-.10, .20, .10, .20, .30, .40/ ,
1  DATA MULTY/-.3, -.20, .10, .0, .10, .20/ ,
2  DATA VFLIND/7500.,15000.,3*25000./ ,
1  VPLANT/2*90000.,120000.,2*0./ ,
2  VECOST/2*22200.,29600.,2*0./
C
C *** FARM MAINTENANCE
C
C   CALL GENDIS(GFRM,1)
C   CALL DIST(MULTG,VFMAF(YEAR),LOWER,UPPER,GFRM)
C   CALL SELECT(LOWER,UPPER,FRMAIN)
C
C *** FERTILIZERS
C
C   VALUE = RAN(DUMMY)
C   IF (VALUE.EQ.0.) GFERT = 1
C   IF (VALUE.GT.0. AND.VALUE.LE..6) GFERT = 2
C   IF (VALUE.GT..6.AND.VALUE.LE..65) GFERT = 3
C   IF (VALUE.GT..65.AND.VALUE.LE..8) GFERT = 4
C   IF (VALUE.GT..8) GFERT = 5
C   CALL DIST(MULTG,VFMAF(YEAR),LOWER,UPPER,GFERT)
C
C   CALL SELECT(LOWER,UPPER,FERT)
C
C *** HARVESTING
C
C   CALL GENDIS(GHARV,1)
C   CALL DIST(MULTG,VHARV(YEAR),LOWER,UPPER,GHARV)
C   CALL SELECT(LOWER,UPPER,HARV)
C
C *** SALARIES AND WAGES
C
C   VALUE = RAN(DUMMY)
C   IF (VALUE.EQ.0.) GWAGE = 1
C   IF (VALUE.GT.0. AND.VALUE.LE..1) GWAGE = 2
C   IF (VALUE.GT..1.AND.VALUE.LE..3) GWAGE = 3
C   IF (VALUE.GT..3.AND.VALUE.LE..6) GWAGE = 4
C   IF (VALUE.GT..6) GWAGE = 5

```

```

      CALL DIST(MULTG,VWAGE(YEAR),LOWER,UPPER,GWAGE)
      CALL SELECT(LOWER,UPPER,WAGES)
C
C *** RUNNING COSTS OF VEHICLES
      CALL GENDIS(GVC,2)
      CALL DIST(MULTG,VVRCST(YEAR),LOWER,UPPER,GVC)
      CALL SELECT(LOWER,UPPER,VRCST)
C
C *** COST OF RUNNING A TRACTOR
      CALL GENDIS(GTRC,2)
      CALL DIST(MULTG,VTRCST(YEAR),LOWER,UPPER,GTRC)
      CALL SELECT(LOWER,UPPER,TRCST)
C
C *** YIELD
      VALUE = RAN(DUMMY)
      IF(VALUE.LE..35) GY = 1
      IF(VALUE.GT..35.AND.VALUE.LE..65) GY = 2
      IF(VALUE.GT..65.AND.VALUE.LE..8) GY = 3
      IF(VALUE.GT..8.AND.VALUE.LE..95) GY = 4
      IF(VALUE.GT..95) GY = 5
C
      CALL DIST(MULTY,VYIELD(YEAR),LOWER,UPPER,GY)
      CALL SELECT(LOWER,UPPER,YIELD)
C
C *** COST OF FRUIT
      VALUE = RAN(DUMMY)
      IF(VALUE.LE..15) GCFRT = 1
      IF(VALUE.GT..15.AND.VALUE.LE..55) GCFRT = 2
      IF(VALUE.GT..55.AND.VALUE.LE..85) GCFRT = 3
      IF(VALUE.GT..85.AND.VALUE.LE..95) GCFRT = 4
      IF(VALUE.GT..95) GCFRT = 5
C
      CALL SELECT(VCFRT(GCFRT),VCFRT(GCFRT+1),CFRT)
C
C *** FLOWER INDUCTION
      VALUE = RAN(DUMMY)
      IF(VALUE.LE..05) GFL = 1
      IF(VALUE.GT..05.AND.VALUE.LE..45) GFL = 2
      IF(VALUE.GT..45.AND.VALUE.LE..75) GFL = 3
      IF(VALUE.GT..75.AND.VALUE.LE..95) GFL = 4
      IF(VALUE.GT..95) GFL = 5
C
      CALL DIST(MULTG,VFLIND(YEAR),LOWER,UPPER,GFL)
      CALL SELECT(LOWER,UPPER,FLIND)
C
C *** COST OF ESTABLISHMENT
      VALUE = RAN(DUMMY)
      IF(VALUE.LE..1) GEC = 1
      IF(VALUE.GT..1.AND.VALUE.LE..5) GEC = 2
      IF(VALUE.GT..5.AND.VALUE.LE..8) GEC = 3
      IF(VALUE.GT..8.AND.VALUE.LE..95) GEC = 4
      IF(VALUE.GT..95) GEC = 5
C
      CALL DIST(MULTG,VEECOST(YEAR),LOWER,UPPER,GEC)
      CALL SELECT(LOWER,UPPER,ECOST)
C
C *** PLANTING MATERIALS COST
      VALUE = RAN(DUMMY)
      IF(VALUE.LE..05) GPL = 1
      IF(VALUE.GT..05.AND.VALUE.LE..55) GPL = 2
      IF(VALUE.GT..55.AND.VALUE.LE..85) GPL = 3
      IF(VALUE.GT..85.AND.VALUE.LE..95) GPL = 4
      IF(VALUE.GT..95) GPL = 5
C
      CALL DIST(MULTG,VPLANT(YEAR),LOWER,UPPER,GPL)
      CALL SELECT(LOWER,UPPER,PLANTG)
C
      RETURN
      END
*****

```

```

SUBROUTINE GENDIS(GROUP,DIST)
INTEGER GROUP,DIST
REAL GDIST1(6),GDIST2(6),VALUE,DUMMY
DATA GDIST1/0.,.1,.25,.4,.8,1./
DATA GDIST2/0.,.1,.13,.25,.5,1./
1 VALUE = RAN(DUMMY)
IF(DIST.NE.1) GO TO 20
DO 10 I = 1,5
1 IF(VALUE.GE.GDIST1(I).AND.VALUE.LE.
GDIST1(I+1)) GROUP = I
10 CONTINUE
RETURN
20 CONTINUE
DO 30 I = 1,5
1 IF(VALUE.GE.GDIST2(I).AND.VALUE.LE.GDIST2(I+1))
GROUP = I
30 CONTINUE
RETURN
END
*****
SUBROUTINE SELECT(LOWER,UPPER,VALUE)
REAL LOWER,UPPER,VALUE
VALUE = (UPPER + LOWER) / 2.
RETURN
END
*****
SUBROUTINE FLOW(VARS,CFLOW,ROI,NPV,BMINC,YEAR,NPROF,
1 TOTINV)
REAL VARS(11),CFLOW,8VAL,ROI,NPV,IRR,NPROF,BENFIT,
1 COSTS,DCRATE(14),LDFLOW,LDRATE(14),TOTINV,
2 TOOLS(5),SOCSEC(5),RENT(5),POST(5),BMAINT(5),
3 DEPREC(5),INTRST(5),ACRGE(5),BMINC(10)
REAL LCOST(5),MACHY(5),BUILD(5),OFFICE(5),INV,YNPROF
INTEGER YEAR
DATA DCRATE/.909,.826,.751,.683,.621,.564,.513,.467,.424,
1 386,.351,.319,.293,.263/,
2 352,.307,.286,.263,.237,.211,.186,.161,
3 146,.122,.101,.085,.057,.031,.005/
DATA SOCSEC /14620.,26060.,26250.,26430.,26610./,
2 RENT/5*2500./, POST/5*1500./, BMAINT/5*750./,
3 DEPREC/5*50870./, INTRST/5*68050./,ACRGE/0.0,150.,
4 300
DATA LCOST/142500.,4*0.0/, TOOLS /16000.,4*0.0/
1 MACHY /136000.,4*0.0/,
2 BUILD/35000.,4*0.0/, OFFICE/5600.,4*0.0/
C *** CALCULATE COSTS AND BENEFITS
C BENFIT = VARS(3) * ACRGE(YEAR) * VARS(4)
C COSTS = VARS(1) + VARS(2) + VARS(5) + VARS(6) + VARS(8) +
1 VARS(7) + TOOLS(YEAR) + SOCSEC(YEAR) +
2 RENT(YEAR) + POST(YEAR) + BMAINT(YEAR) +
3 DEPREC(YEAR) + INTRST(YEAR)
4 + LCOST(YEAR) + VARS(9) + VARS(10) + VARS(11) + MACHY(YEAR)
5 + BUILD(YEAR) + OFFICE(YEAR)
C *** NETT PROFIT AND CASH FLOW
C YNPROF = BENFIT - COSTS
C CFLOW = DEPREC(YEAR) + YNPROF
C DCFLOW = CFLOW * DCRATE(YEAR)
C LDFLOW = CFLOW * LDRATE(YEAR)
C INV = COSTS - (DEPREC(YEAR) + INTRST(YEAR))
C *** NPV
C NPV = NPV + DCFLOW
C *** RDI
C NPROF = NPROF + YNPROF
C TOTINV = INV + TOTINV
C *** IRR
C BMINC(YEAR) = CFLOW
C RETURN
C END
*****

```



```

C *** BOTH -VE
30 CONTINUE
   RATE1 = RATE2
   RATE2 = RATE2 + 4
   GO TO 17

C *** SIGNS OPPOSITE
60 CONTINUE
   IF (VAL1.NE.0.0) GO TO 65
   IRR = RATE1
   RETURN
65 IF (VAL2.NE.0.0) GO TO 68
   IRR = RATE2
   RETURN
68 CONTINUE

C *** FIND RATE CLOSEST TO ZERO
C
   RATES(1) = RATE1
   RATES(2) = RATE1 + 1.
   RATES(3) = RATE1 + 2.
   RATES(4) = RATE1 + 3.
   RATES(5) = RATE1 + 4.
   IF (RATES(5).NE.RATE2) TYPE 99
   FORMAT(' SOMETHING WRONG WITH RATES')
99 C
   VALS(1) = ABS(VAL1)
   VALS(2) = ABS(IRRSUM(BMINC,RATES(2),YEARS))
   VALS(3) = ABS(IRRSUM(BMINC,RATES(3),YEARS))
   VALS(4) = ABS(IRRSUM(BMINC,RATES(4),YEARS))
   VALS(5) = ABS(VAL2)

C
   SRATE = 0.
   SVAL = 999999999.

C
   DO 80 I = 1,5
C
      IF (VALS(I).GE.SVAL) GO TO 80
C
      SVAL = VALS(I)
      SRATE = RATES(I)
80 CONTINUE
C
   IRR = SRATE
C
   RETURN
   END

*****
REAL FUNCTION IRRSUM(BMINC,RRATE,YEARS)
IMPLICIT REAL (A-Z)
REAL BMINC(10),TABLE(50,12)
INTEGER YEARS , I , J , RATE
LOGICAL FIRST
DATA FIRST /.TRUE./

C
   IF (.NOT.FIRST) GO TO 04
   READ(22,02,END=04) ((TABLE(I,J),J=1,12),I=1,50)
02 FORMAT(G)
C
04 CONTINUE
C
   RATE = IFIX(RRATE)
   IRRSUM = 0.0
   IF (RATE.GT.50) TYPE 08 , RATE
08 FORMAT(' *** RATE > 50 *** ',G)
   IF (RATE.LE.0.OR.RATE.GT.50) RETURN
   DO 10 I = 1,YEARS
      IRRSUM = BMINC(I) * TABLE(RATE,I) + IRRSUM
10 CONTINUE
   RETURN
   END

*****
SUBROUTINE CALCRO(NPROF,TOTINV,ROI)
REAL ROI,TOTINV,NPROF
ROI = (NPROF / TOTINV) * 100.
RETURN
END

*****
*****

```

```

C      INTEGER COUNT(55), NUM, I, CUME, N
C      REAL VALUE, PROB
C      REAL TOTAL, SQTOT, MEAN, VAR, SD, START
C      DATA NAME/ 'IRR' /
C
C      TOTAL = 0.0
C      SQTOT = 0.0
C      READ (33, 03) START
C      FORMAT(G)
C
C      DO 05 I = 1, 55
C      COUNT(I) = 0
C
C      CONTINUE
C      CUME = 0
C      N = 0
C
C      CONTINUE
C      READ (33, 12, END=15) VALUE
C      FORMAT(G)
C      N = N + 1
C      NUM = IFIX(VALUE + .5) + 2
C      COUNT(NUM) = COUNT(NUM) + 1
C
C      *** ACCUMULATE FOR STATISTICS
C
C      TOTAL = TOTAL + VALUE
C      SQTOT = SQTOT + (VALUE * VALUE)
C      GO TO 10
C
C      CONTINUE
C      DO 30 I = 1, 55
C      J = I - 3
C      CUME = COUNT(I) + CUME
C      PROB = FLOAT(CUME) / FLOAT(N)
C      WRITE (44, 20) J, COUNT(I), CUME, PROB
C      FORMAT(10X, I3, 5X, 2G, 5X, G)
C
C      CONTINUE
C
C      *** CALCULATE MEAN
C
C      MEAN = TOTAL / FLOAT(N)
C
C      *** CALCULATE SD + VARIANCE
C
C      VAR = (SQTOT - ((MEAN*MEAN) / FLOAT(N))) / FLOAT(N)
C      SD = SQRT(VAR)
C
C      *** PRINT SUMMARY
C
C      PRINT 40, NAME, N, START, MEAN, SD, VAR
C      FORMAT('1, 50X, A3, 51X, '---'////',
C      20X, 'THERE WERE ', I7, ' SIMULATIONS. THE STARTING',
C      1  'VALUE = ', G, '/',
C      2  'MEAN = ', G, ' STANDARD DEVIATION = ', G,
C      3  ' VARIANCE = ', G)
C      STOP
C      END
C
C      REAL VAL(110), FREQ(110), CUMFREQ(110), CUMPR(110)
C      INTEGER PEN, UP, DOWN, XCHRS, YCHRS
C      DATA UP, DOWN/3, 2/
C
C      N = 1
C      FTLEN = -1.
C      FTSPCX = 1.32
C      FTSPCY = 1.0
C      XPOS = 0.
C      YPOS = 0.0
C      IFNTH = 3
C      FOSIZ = .3
C      FCSIZ = .3
C      IFNSD = .1
C      IFNTF = .1
C      YCHRS = 22
C      XCHRS = 13
C      XAXLEN = 35.
C      YAXLEN = 10.
C      THETAY = 90.
C      THETAX = 0.
C      ORGY = 0.
C      ORGX = -521000.
C      DVY = 10.
C      DVX = 14000.

```

```

10      FMAX=-999.0
40      READ(45,40,END=99) VAL(N),FREQ(N),CUMFRQ(N),CUMPR(N)
      FORMAT(4G)
      IF( FREQ(N).GT.FMAX ) FMAX=FREQ(N)
      N = N + 1
      GO TO 10

C
99      CONTINUE

C *** CUMULATIVE PROBABILITY
C
      PEN = -3
      N = N-1
      CALL PLOTS(I)
      CALL FACTOR( 10.0,10.0 )
      CALL SETAXS(2)
      CALL PLOT(4.0,-17.0,PEN)
      PEN = UP

C
      FVAL = (VAL(1) * FTSPCX / DVX)
      DO 20 I = 1,N
          Y = CUMPR(I) * YAXLEN
          X = VAL(I) * FTSPCX / DVX - FVAL
          CALL PLOT(X,Y,PEN)
          PEN = DOWN

20      CONTINUE

C
      CALL AXSPRM(FTLEN,FTSPCY,1,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
      CALL AXIS(XPOS,YPOS,"CUMULATIVE PROBABILITY",YCHRS,
1      YAXLEN,THETAY,ORGY,DVY)
      CALL AXSPRM(FTLEN,FTSPCX,IFNTH,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
      CALL AXIS(XPOS,YPOS,"NPV VALUE ($)",XCHRS,XAXLEN,
1      THETAX,ORGX,DVX)

C
C *** FREQUENCY
C
      PEN = -3
      CALL PLOT(0.0,-22.5,PEN)
      PEN = UP
      FVAL = (VAL(1) * FTSPCX / DVX)
      DO 30 I = 1,N
          Y = (FREQ(I) / FMAX) * YAXLEN
          X = VAL(I) * FTSPCX / DVX - FVAL
          CALL PLOT(X,Y,PEN)
          PEN = DOWN

30      CONTINUE

C
      CALL AXSPRM(FTLEN,FTSPCY,1,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
      CALL AXIS(XPOS,YPOS,"FREQUENCY",9,YAXLEN,THETAY,
1      ORGY,DVY)
      CALL AXSPRM(FTLEN,FTSPCX,IFNTH,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
      CALL AXIS(XPOS,YPOS,"NPV VALUE ($)",XCHRS,XAXLEN,
1      THETAX,ORGX,DVX)

      END

      INTEGER COUNT(109),NUM,I,CUME,N
      DATA NAME,"NPV",/
      REAL VALUE,PROR,RANGE(2,109)
      REAL TOTAL,SQTOT,MEAN,VAR,SD,START

C
      TOTAL = 0.0
      SQTOT = 0.0
      READ (33,03) START
      FORMAT(G)

      RANGE(1,1) = -528000
      RANGE(2,1) = RANGE(1,1) + 13999.999
      DO 05 I = 1,109
          COUNT(I) = 0
          IF(I.EQ.1) GO TO 05
          RANGE(1,I) = RANGE(1,I-1) + 14000
          RANGE(2,I) = RANGE(1,I) + 13999.999

05      CONTINUE
      CUME = 0
      N = 0

C
10      CONTINUE
      READ(33,12,END=15) DUMMY,VALUE
      FORMAT(2G)
      N = N + 1

```



```

C *** CALCULATE MEAN
C     MEAN = TOTAL / FLOAT(N)
C *** CALCULATE SD + VARIANCE
C     VAR = (SQTOT - ((MEAN*MEAN) / FLOAT(N))) / FLOAT(N)
C     SD = SQRT(VAR)
C *** PRINT SUMMARY
C     PRINT 40, NAME, N, START, MEAN, SD, VAR
C     FORMAT(1,50X,A3,51X,'- - - - -')
C     1 20X, 'THERE WERE ',I7,' SIMULATIONS. THE STARTING',
C     2  ' VALUE = ',G///
C     3 20X, 'MEAN = ',G,' STANDARD DEVIATION = ',G,
C     4  ' VARIANCE = ',G)
C     STOP
C     END
C     REAL VAL(110), FREQ(110), CUMFRQ(110), CUMPR(110)
C     INTEGER PEN, UP, DOWN, XCHRS, YCHRS
C     DATA UP, DOWN/3,2/

C     N = 1
C     FTLEN = -1.
C     FTSPCX = 6.
C     FTSPCY = 1.0
C     XPOS = -2.0 * FTSPCX
C     YPOS = 0.0
C     IFNTH = 3
C     FDSIZ = 3
C     FCSIZ = 1.
C     IFNSD = 1
C     IFNTF = 1
C     YCHRS = 23
C     XCHRS = 19
C     XAXLEN = 35.
C     YAXLEN = 10.
C     THETAY = 90.
C     THETAX = 0.
C     ORGY = 0.
C     ORGX = -2.
C     OVY = 10.
C     DVX = 1.

C     FMAX = -999.0
C     10 READ(44,40,END=99) VAL(N), FREQ(N), CUMFRQ(N), CUMPR(N)
C     40 FORMAT(4G)
C     IF( FREQ(N).GT.FMAX ) FMAX=FREQ(N)
C     N = N + 1
C     GO TO 10

C     99 CONTINUE

C *** CUMULATIVE PROBABILITY
C     PEN = -3
C     N = N-1
C     CALL PLOTS(I)
C     CALL FACTOR( 10.0,10.0 )
C     CALL SETAXS(2)
C     CALL PLOT(4,0,-17.0,PEN)
C     PEN = UP

C     DO 20 I = 1,N
C         Y = CUMPR(I) * YAXLEN
C         X = VAL(I) * FTSPCX
C         CALL PLOT(X,Y,PEN)
C         PEN = DOWN
C     20 CONTINUE

C     CALL AXSPRM(FTLEN, FTSPCY, 1, FDSIZ, FCSIZ, IFNSD, IFNTF, 0)
C     CALL AXIS(XPOS, YPOS, 'CUMULATIVE PROBABILITY', YCHRS,
C     1  YAXLEN, THETAY, ORGY, DVY)
C     CALL AXSPRM(FTLEN, FTSPCX, IFNTH, FDSIZ, FCSIZ, IFNSD, IFNTF, 0)
C     1 CALL AXIS(XPOS, YPOS, 'IRR VALUE', XCHRS, XAXLEN,
C     THETAX, ORGX, DVX)

C *** FREQUENCY

```

```

PEN = -3
CALL PLOT(0,0,-22,5,PEN)
PEN = UP
DO 30 I = 1,N
    Y = (FREQ(I) / FMAX) * YAXLEN
    X = VAL(I) * FTSPCX
    CALL PLOT(X,Y,PEN)
    PEN = DOWN

```

```

CONTINUE

```

```

CALL AXSPRM(FTLEN,FTSPCY,1,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
CALL AXIS(XPOS,YPOS,"FREQUENCY",9,YAXLEN,THETAY,

```

```

1    ORGY,DVY)
CALL AXSPRM(FTLEN,FTSPCX,IFNTH,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
1    CALL AXIS(XPOS,YPOS,"IRR VALUE",XCHRS,YAXLEN,
    THETAX,ORGX,DVX)

```

```

END
SUBROUTINE AXSPRM( FTLEN,FTSPC,IFNTH,FDSIZ,FCSIZ,IFNSD,
1    IFNTF,TLFACT )

```

INITIAL VALUES OF PARAMETERS ARE:

```

TICK LENGTH      0.2 CM
TICK SPACING     1.0 CM
DIGIT SIZE       0.2 CM
CHAR SIZE        0.2 CM
LABEL EVERY      2ND TICK
AFTER DECIMAL    2 DIGITS
# DIFFERENT LENGTHS = 0

```

```

FTLEN..... THE NEW TICK LENGTH IF > OR = 0.0 ELSE IGNORED.
FTSPC..... THE NEW TICK SPACING IF > 0 ELSE IGNORED.
IFNTH..... NEW VALUE FOR NTH. SEE COMMENTS AT START OF SUB.
            ONLY USED IF > OR = 0 ELSE IGNORED.
            USE 0 IF NO TICK LABELS ARE REQUIRED.
FDSIZ..... NEW SIZE FOR DIGITS USED IN TICK LABELS IF > 0.0
            ELSE IGNORED.
FCSIZ..... NEW SIZE FOR CHARACTERS USED IN AXIS LABEL IF > 0.0
IFNSD..... NEW VALUE FOR NSD IF ITS ABSOLUTE VALUE IS < 10
IFNTF..... THE NUMBER OF VALUES IN THE ARRAY TLFACT IF IT
            IS > 0. IF LESS THAN OR = 0 THEN TLFACT IS NOT
            USED TO DERIVE THE LENGTHS OF SUCCESSIVE TICKS.
TLFACT(I).... REAL ARRAY CONTAINING FACTORS BY WHICH TIKLEN
            MUST BE MULTIPLIED TO OBTAIN THE REQUIRED LENGTH.

```

NOTE:

----- TO ENSURE THAT THOSE PARAMETERS WHICH ARE TO REMAIN UNCHANGED
 USE , SAY , -1.0 FOR ALL EXCEPT IFNSD FOR WHICH YOU SHOULD
 USE A NUMBER WITH MAGNITUDE > 9

```

INTEGER MOV,DRW
DIMENSION TLFACT(1),CHRS(1)

```

```

DATA MOV,DRW / 3,2 /

```

EPS IS THE MAXIMUM DIFFERENCE ALLOWED BETWEEN THE LAST TICK DRAWN
 AND THE END OF THE AXIS SPECIFIED IN THE CALL.
 CURRENTLY 1 MM. (IT'S NOT REALLY WORTH IT BEING ANY LESS THAN THIS)

```

DATA EPS / 0.1 /

```

DEFAULT SIZES

```

DATA TIKLEN,TIKSPC,DIGSIZ,CHRSIZ/0.2,1.0,0.2,0.2/
DATA NTH,NSD,NTLF/ 2,2,0 /

```

```

-----
IF( FTLEN.GE.0.0 ) TIKLEN=FTLEN
IF( FTSPC.GT.0.0 ) TIKSPC=FTSPC
IF( IFNTH.GE.0.0 ) NTH=IFNTH
IF( FDSIZ.GT.0.0 ) DIGSIZ=FDSIZ
IF( FCSIZ.GT.0.0 ) CHRSIZ=FCSIZ
IF( IABS(IFNSD),LT,10 ) NSD=IFNSD
IF( IFNTF.GE.0 ) NTLF=IFNTF
RETURN

```

```
ENTRY AXIS( XPOS,YPOS,CHARS,NCHARS,AXSLEN,THETA,ORGVAL,DV )
```

```
ROUTINE TO DRAW AXIS FOR USER OF PLOTTER
```

```
XPOS,YPOS..... POSITION OF START OF AXIS.
CHARS..... ARRAY OF CHARS FOR AXIS LABEL IN A5 FORMAT
               THIS COULD ALSO BE A HOLLERITH STRING
NCHARS..... NUMBER OF CHARS IN LABEL
               IF +VE THEN TICKS AND LABELS ARE PLACED ON THE
               ANTI-CLOCKWISE SIDE OF THE AXIS LINE.
               IF -VE THEN ON THE CLOCKWISE SIDE.
AXSLEN..... LENGTH OF AXIS IN CENTIMETRES.
THETA..... ANGLE OF AXIS IN DEGREES ANTICLOCKWISE FROM EAST
ORGVAL..... VALUE OF DATA AT XPOS,YPOS
DV..... INCREMENT IN DATA VALUE BETWEEN TICK MARKS.
```

```
THIS ROUTINE HAS BEEN WRITTEN TO REPLACE THAT IN FORLIB
IN ORDER TO GIVE THE USER CONTROL OF VARIOUS PARAMETERS.
THE FOLLOWING PARAMETERS ARE AVAILABLE:
```

```
TIKLEN..... LENGTH OF EACH TICK MARK
TIKSPC..... SPACING BETWEEN CONSECUTIVE TICKS (IN CMS.)
NTLF..... THE MAXIMUM LENGTH OF THE FOLLOWING ARRAY.
               IF =0 THEN THERE IS NO ARRAY TO BE CONSIDERED.
TLFACT(I).... AN ARRAY WHICH (IF SUPPLIED) INSTRUCTS THE ROUTINE
               AS TO WHAT LENGTH SUCCESSIVE TICKS ARE TO BE.
               THUS THE ITH TICK WILL HAVE LENGTH
               TIKLEN * TLFACT( MOD(I,NTLF)+1 )
               E.G.
                   IF NTLF = 4 AND TLFACT(I)=(1.0,0.5,0.75,0.5)
                   AND WE ALSO HAVE TIKLEN > 0 THEN
                   THE TICKS MIGHT LOOK LIKE:
```

```

      |      |      |      |      |
      +-----+-----+-----+-----+ ETC.

```

```
DIGSIZ..... SIZE OF DIGITS USED FOR DATA VALUES
CHRSIZ..... SIZE OF CHARACTERS USED FOR AXIS LABEL
NTH..... EVERY NTH TICK WILL HAVE A DATA VALUE MARKED AT IT
NSD..... THE NUMBER OF DIGITS AFTER THE DECIMAL POINT
               WHEN DRAWING THE TICK LABELS. SEE DOCUMENTATION OF
               THE NUMFR SUBROUTINE FOR AN EXPLANATION.
```

```
INITIALISE PARAMETERS FOR THIS CALL
```

```
EXPSIZ=0.5*CHRSIZ
```

```
THE FOLLOWING ARE USED IN THE PROGRAM
```

```
SIGN=1.0
IF( NCHARS.LT.0 ) SIGN=-1.0
```

```
STH=SIND(THETA)
CTH=COSD(THETA)
```

```
XSIZE=AXSLEN*CTH
YSIZE=AXSLEN*STH
ENDX=XPOS+XSIZE
ENDY=YPOS+YSIZE
TKSPCX=TIKSPC*CTH
TKSPCY=TIKSPC*STH
```

```
DRAW THE AXIS WITH TICKS
```

```
NTICKS=AINT(AXSLEN/TIKSPC+0.001)
```

```
TKSTX=XPOS
TKSTY=YPOS
```

```
TLF=1.0
IF( NTLF.GT.0 ) TLF=TLFACT(1)
ITLF=1
```

```
TKLENX= -TIKLEN*SIGN*STH
TKLENY= -TIKLEN*SIGN*CTH
TKENDX=XPOS + TKLENX*TLF
TKENDY=YPOS + TKLENY*TLF
```

C MOVE TO TOP OF FIRST TICK

```

C      CALL PLOT( TKENDX,TKENDY,MOV )
      IF( TIKLEN.EQ.0.0 ) GOTO 120
      DO 110 I=1,NTICKS
        CALL PLOT( TKSTX,TKSTY,DRW )
        TKSTX=TKSTX+TKSPCX
        TKSTY=TKSTY+TKSPCY
        CALL PLOT( TKSTX,TKSTY,DRW )
        IF( NTLF.LE.0 ) GOTO 100
        ITLF=MOD( ITLF,NTLF)+1
        TLF=TLFACT(ITLF)
100      CONTINUE
        TKENDX=TKSTX+TKLENX*TLF
        TKENDY=TKSTY+TKLENY*TLF
        CALL PLOT( TKENDX,TKENDY,DRW )
110      CONTINUE

```

C NOW IF LAST TICK WAS NOT AT END THEN DRAW TO END

```

C      IF( ABS(ENDX-TKSTX).LE.EPS ) GOTO 130
      CALL PLOT( TKSTX,TKSTY,DRW )
120      CALL PLOT( ENDX,ENDY,DRW )
130      CONTINUE

```

C NOW DO THE TICK LABELS

```

C      IF( NTH.LE.0 ) GOTO 300
      EXP=AIN( ALOG10(ABS(DV))+0.001 )
      IF( (EXP.GE.-1.0) .AND. (EXP.LE.1.0) ) EXP=0.0
      SCALE=10.0**(-EXP)
      DVSCAL=DV*SCALE

```

C THE FOLLOWING IS THE CLEARANCE VECTOR OF TICK LABEL FROM
C TICK MARK AND AXIS.

```

C      CLRNCX= -(ABS(NSD)/2.0+1.0)*DIGSIZ
      CLRNCY= ( (TIKLEN+DIGSIZ)*SIGN - DIGSIZ*0.5 )

```

C HOW MANY TICKS HAVE LABELS ?
C WHICH IS THE LAST - FIRST IS #0

```

C      NVALUD= NTICKS/NTH
      LVALUD= NVALUD*NTH

```

C LAST TICK LABEL HAS FOLLOWING VALUE

```

C      TIKVAL=ORGVAL*SCALE + (FLOAT(LVALUD)*DVSCAL)

```

C FOLLOWING IS POSITION OF LAST LABEL (WE WORK BACKWARDS)

```

C      X=XPOS+(FLOAT(LVALUD)*TKSPCX)+( CLRNCX*CTH-CLRNCY*STH )
      Y=YPOS+(FLOAT(LVALUD)*TKSPCY)+( CLRNCX*STH+CLRNCY*CTH )

```

C NOW PUT IN THE LABELS

```

C      CALL NUMBER( X,Y,DIGSIZ,TIKVAL,THETA,NSD )
      ANTH=FLOAT(NTH)
      DO 200 I=1,NVALUD
        TIKVAL=TIKVAL-ANTH*DVSCAL
        X=X-ANTH*TKSPCX
        Y=Y-ANTH*TKSPCY
        CALL NUMBER( X,Y,DIGSIZ,TIKVAL,THETA,NSD )
200      CONTINUE

```

C LAST OF ALL WE DO THE AXIS LABEL

```

300      NACHRS=IABS( NCHARS )
      ANCHRS=NACHRS
      IF( (EXP.NE.0.0) .AND. (NTH.GT.0) ) ANCHRS=ANCHRS+7.0

```

C FOLLOWING IS CLEARANCE VECTOR OF THE LABEL

```

C      CLRNCX= (AXSLEN - CHRISZ*ANCHRS)*0.5
      CLRNCY= (SIGN*(CHRISZ+TIKLEN+DIGSIZ*1.5) - CHRISZ*0.5)

```

```

C      X= XPOS + CLRNCX*CTH - CLRNCY*STH
      Y= YPOS + CLRNCX*STH + CLRNCY*CTH

```

```

C      CALL SYMBOL( X,Y,CHRISZ,CHARS,THETA,NACHRS )
      IF( (EXP.EQ.0.0) .OR. (NTH.LE.0) ) RETURN

```

C NON-UNITARY SCALING FACTOR SO TELL THE USER

```

C      X= X + (ANCHRS-6.0)*CHRISZ*CTH
      Y= Y + (ANCHRS-6.0)*CHRISZ*STH
      CALL SYMBOL( X,Y,CHRISZ,7H(*10 ),THETA,7 )

```


C NOW MOVE TO THE SPOT FOR THE EXPONENT
C

```
CLRNXC= 4.0*CHRSIZ
CLRNCY= 0.5*CHRSIZ
X= X + CLRNXC*CTH - CLRNCY*STH
Y= Y + CLRNXC*STH + CLRNCY*CTH
CALL NUMBER( X,Y,EXPSIZ,EXP,THETA,-1 )
RETURN
END
```

```
REAL VAL(110),FREQ(110),CUMFRQ(110),CUMPR(110)
INTEGER PEN,UP,DOWN,XCHRS,YCHRS
DATA UP,DOWN/3,2/
```

C

```
N = 1
FTLEN = -1.38
FTSPCX = 1.0
FTSPCY = 0.0
XPOS = 0.0
YPOS = 0.0
IFNTH = 3
FDSIZ = 3
FCSIZ = 3
IFNSD = -1
IFNTF = -1
YCHRS = 22
XCHRS = -13
XAXLEN = 35.
YAXLEN = 10.
THETAY = 90.
THETAX = 0.
ORGY = 0.
ORGX = -30.
DXY = 10.
DVX = 1.
```

C

10
40

```
FMAX=-999.0
READ(44,40,END=99) VAL(N),FREQ(N),CUMFRQ(N),CUMPR(N)
FORMAT(4G)
IF( FREQ(N),GT.FMAX ) FMAX=FREQ(N)
N = N + 1
GO TO 10
```

C
99

CONTINUE

C
C
C

*** CUMULATIVE PROBABILITY

```
PEN = -3
N = N-1
CALL PLOTS(1)
CALL FACTOR( 10.0,10.0 )
CALL SETAXS(2)
CALL PLOT(4.0,-17.0,PEN)
PEN = UP
```

C

```
DO 20 I = 1,N
Y = CUMPR(I) * YAXLEN
X = VAL(I) * FTSPCX - (VAL(1) * FTSPCX)
CALL PLOT(X,Y,PEN)
PEN = DOWN
```

20

C

```
CONTINUE
CALL AXSPRM(FTLEN,FTSPCY,1,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
CALL AXIS(XPOS,YPOS,"CUMULATIVE PROBABILITY",YCHRS,
1 YAXLEN,THETAY,ORGY,DVY)
CALL AXSPRM(FTLEN,FTSPCX,IFNTH,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
1 CALL AXIS(XPOS,YPOS,"ROI VALUE (%)",XCHRS,XAXLEN,
1 THETAX,ORGX,DVX)
```

C
C
C

*** FREQUENCY

```
PEN = -3
CALL PLOT(0.0,-22.5,PEN)
PEN = UP
DO 30 I = 1,N
Y = (FREQ(I) / FMAX) * YAXLEN
X = VAL(I) * FTSPCX - (VAL(1) * FTSPCX)
CALL PLOT(X,Y,PEN)
PEN = DOWN
```

30

C

```
CONTINUE
CALL AXSPRM(FTLEN,FTSPCY,1,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
1 CALL AXIS(XPOS,YPOS,"FREQUENCY",9,YAXLEN,THETAY,
1 ORGY,DVY)
CALL AXSPRM(FTLEN,FTSPCX,IFNTH,FDSIZ,FCSIZ,IFNSD,IFNTF,0)
1 CALL AXIS(XPOS,YPOS,"ROI VALUE (%)",XCHRS,XAXLEN,
1 THETAX,ORGX,DVX)
END
```

APPENDIX D.3 (cont.)

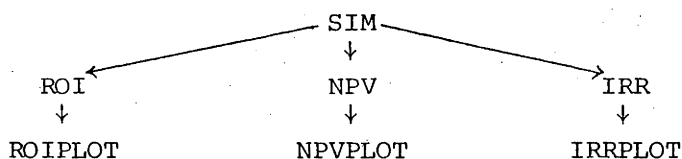
(b) USER DOCUMENTATION

FOR SIMULATION ON DEC 10

(Monte Carlo Simulation for Probability Analysis)

There are seven programs involved in each simulation and these must be run in sequence as shown in Figure 1.

FIGURE 1



The programs are described separately:

(1) SIM

This program carries out the simulation: it asks a series of questions which allow the person running it to vary the number of years, number of simulations, printing of details and the starting value for the random number generator, e.g. (computer output underlined).

NOW MANY DIFFERENT SIMULATIONS OF THE SAME CONDITIONS? 50

HOW MANY YEARS DO YOU WANT EACH SIMULATION TO RUN FOR? 5

PLEASE TYPE A NUMBER TO START THE RANDOM NUMBER GENERATOR 77.77

DO YOU WANT THE DETAILS PRINTED? NO

To run this program on the DEC10 type .EXECUTE SIM

(2) ROI, NPV, IRR

These programs prepare the results from the simulation (SIM) for plotting and compile statistics [mean, standard deviation and variance]. The statistics are printed on the line printer; example of running ROI.

```
EXECUTE ROI
```

```
PLEASE TYPE A FIVE CHARACTER ID FOR THE PLOT
```

```
SIM 1
```

This ID (identification) is written on both the plot and the statistic sheet to identify them.

(3) NPVLOT, ROILOT, IRRLOT

These programs produce the plots (i.e. IRRLOT produces a cumulative probability curve and a frequency plot of IRR found in the simulation).

To execute one of these programs, e.g. IRRLOT, type:

```
EXECUTE /F10 IRRLOT, AXIS, SYS:DAPLOT/SEA
```

The plot will be placed in a file IRR.PLT and can be plotted by typing:

```
PLOT IRR.PLT
```

or if you log off the plot(s) will all be sent to the plotter automatically.

EXAMPLE If you wanted a simulation of 50 and only the IRR and NPV plots (computer output underlined):

.EXECUTE SIM

HOW MANY DIFFERENT SIMULATIONS OF THE SAME CONDITIONS? 50

HOW MANY YEARS DO YOU WANT EACH SIMULATION TO RUN FOR? 5

PLEASE TYPE A NUMBER TO START THE RANDOM NUMBER GENERATOR 65

DO YOU WANT THE DETAILS PRINTED? YES

.EXECUTE IRR

PLEASE TYPE A FIVE CHARACTER ID FOR THE PLOT

SMALL

.EXECUTE /F10 IRRPLOT, AXIS, SYS:DPLOT/SEA

.EXECUTE NPV

PLEASE TYPE A FIVE CHARACTER ID FOR THE PLOT

S SIM

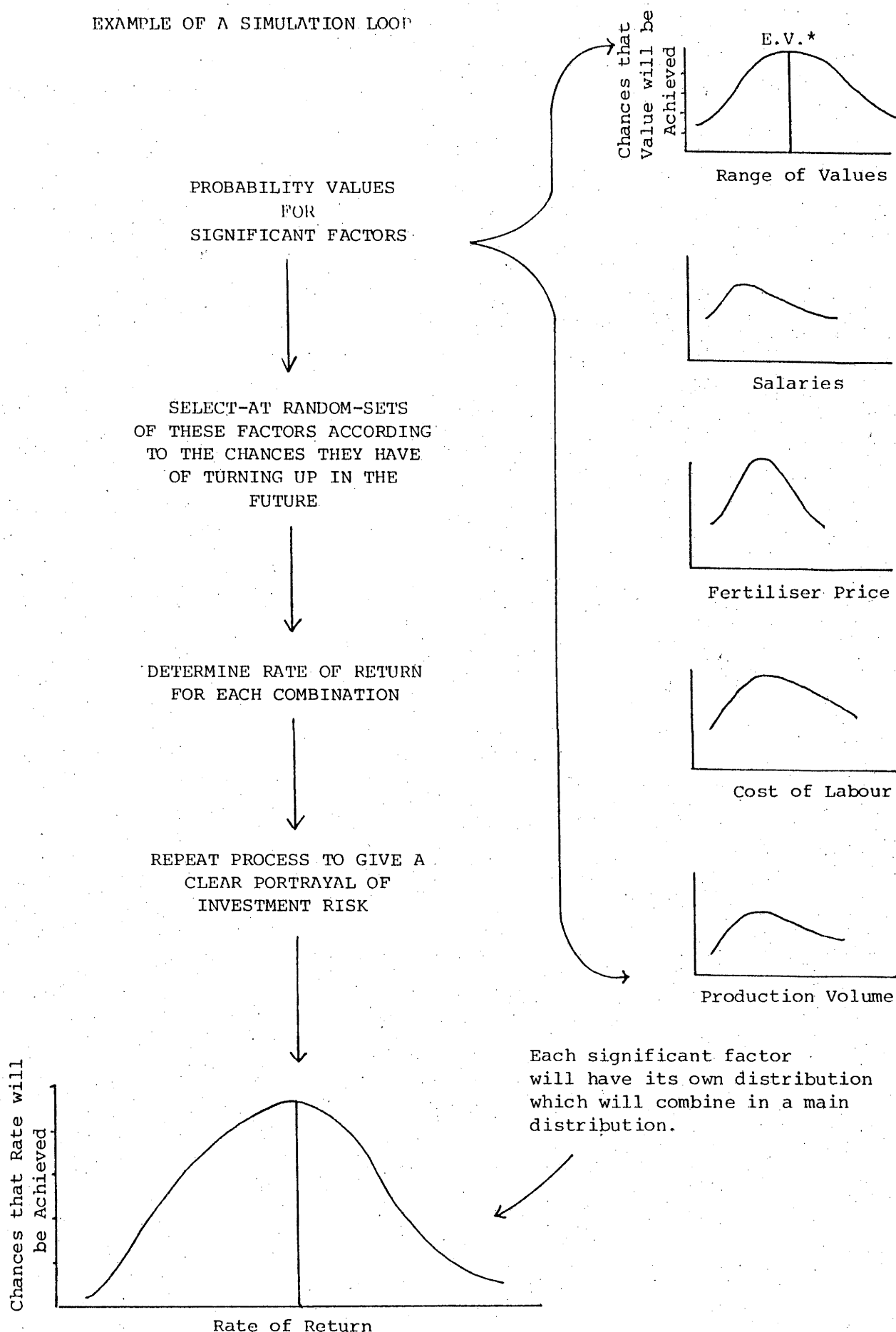
.EXECUTE /F10 NPVPLOT, AXIS, SYS:DPLOT/SEA

Note:

- . If the same value is used to start the random number generator in SIM, then the simulations will be the same, i.e. the random number generator will always produce an identical set of random numbers if the same starting value is used.
- . To run the maize simulation, do everything the same except that all program names begin with an 'M', e.g. MSIM, MIRR, MIRRPLOT.
- . If you reply 'YES' to the printing details question in program SIM, then the values of all the uncertain variables and the IRR, NPV and ROI values for each year of the simulation are printed. You should only do this for small numbers of simulations.

APPENDIX D.4

EXAMPLE OF A SIMULATION LOOP



* Expected value = highest point of curve.

APPENDIX E.1

DIFFERENT SIMULATION LEVELS AND THE CORRESPONDING MEAN AND STANDARD DEVIATION VALUES OF
THEIR CUMULATIVE PROBABILITY DISTRIBUTIONS (PINEAPPLE PROJECT)

No. of Simulations	IRR (%)		NPV (₺)		ROI (%)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
10,000	12.35	14.70	70,996	217,184	7.70	14.23
5,000	12.13	14.52	66,244	214,923	7.51	14.05
3,000	12.49	14.84	74,383	220,708	7.99	14.48
1,000	11.99	14.52	61,565	219,891	7.24	14.21
500	12.37	14.72	70,812	220,396	7.74	14.39
200	12.28	14.66	70,397	215,199	7.69	14.06
100	12.17	14.72	67,638	222,064	7.65	14.37
50	14.54	16.57	126,136	250,115	10.82	16.66

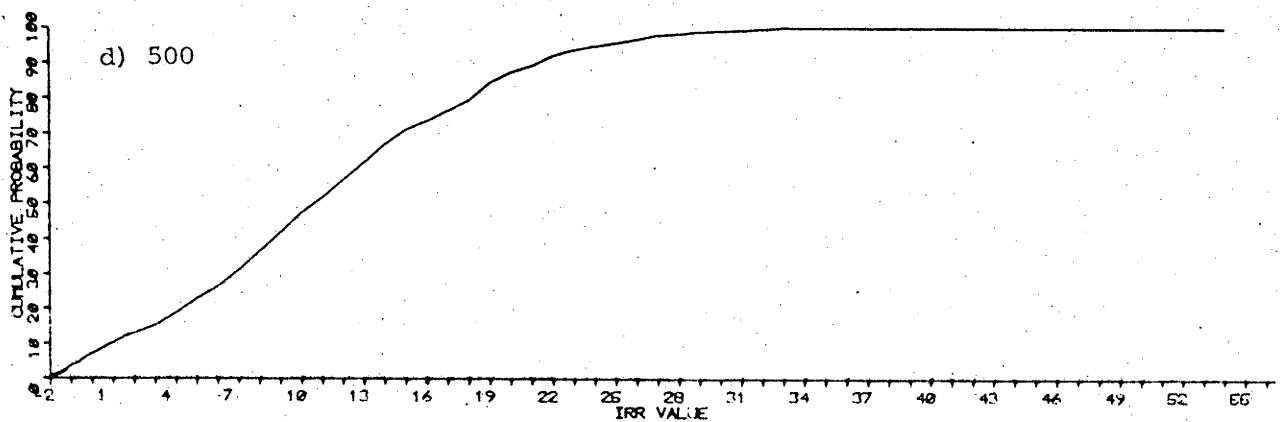
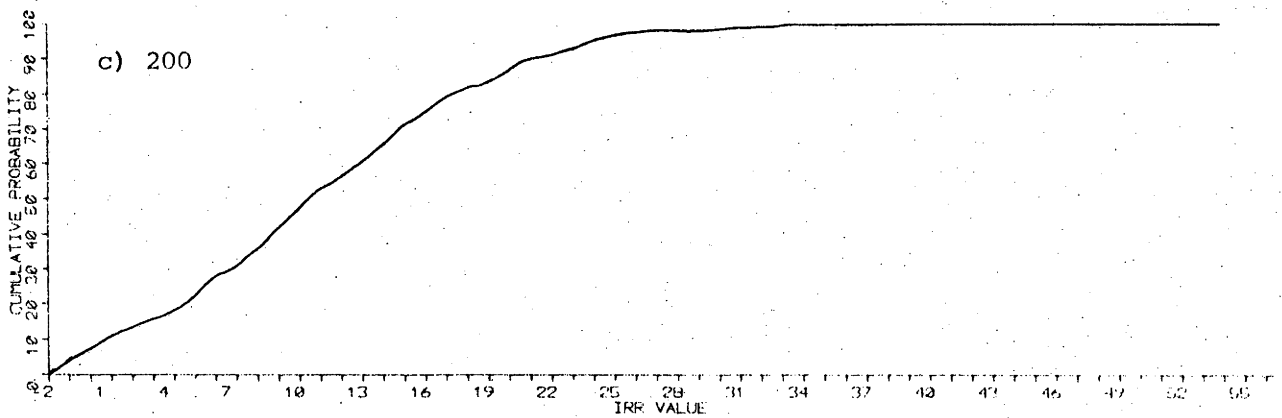
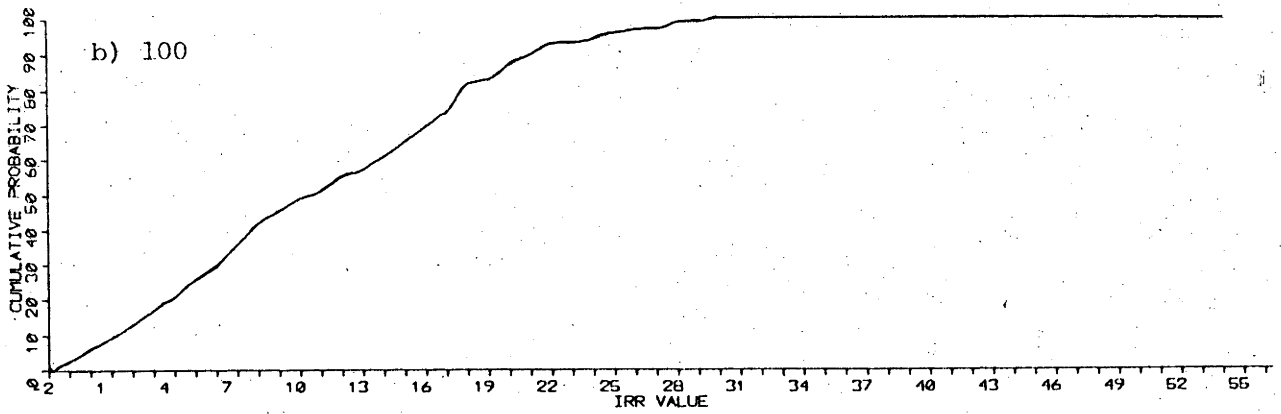
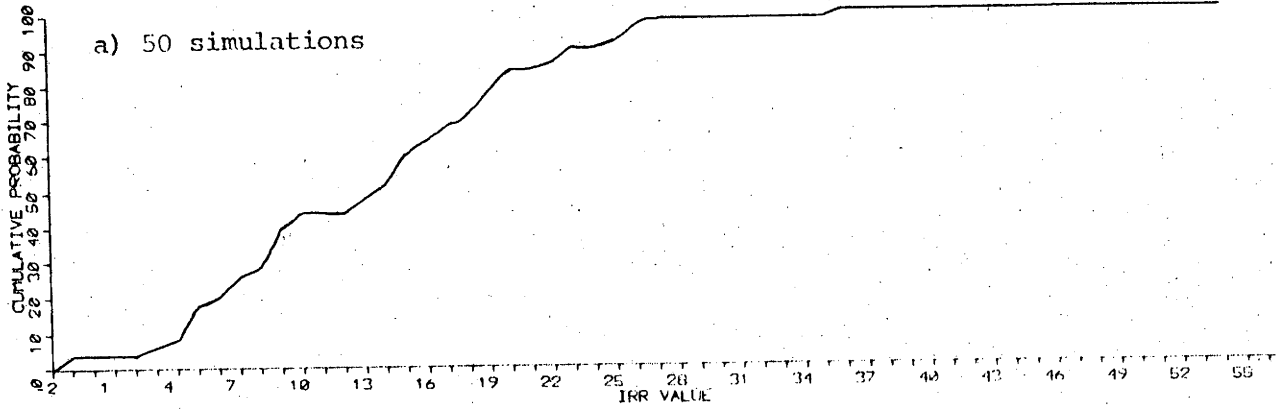
APPENDIX E.2

DIFFERENT SIMULATION LEVELS AND THE CORRESPONDING MEAN AND STANDARD DEVIATION VALUES OF
THEIR CUMULATIVE PROBABILITY DISTRIBUTIONS (MAIZE PROJECT)

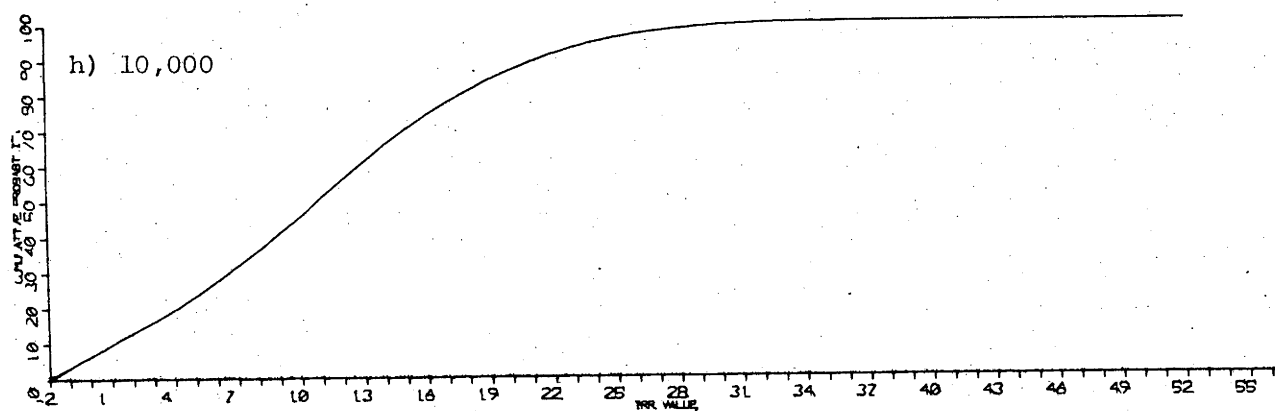
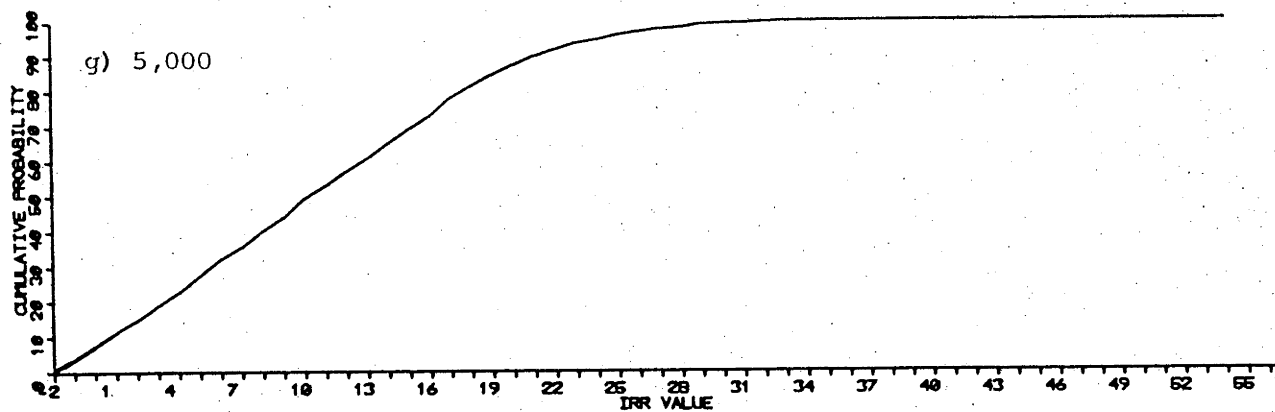
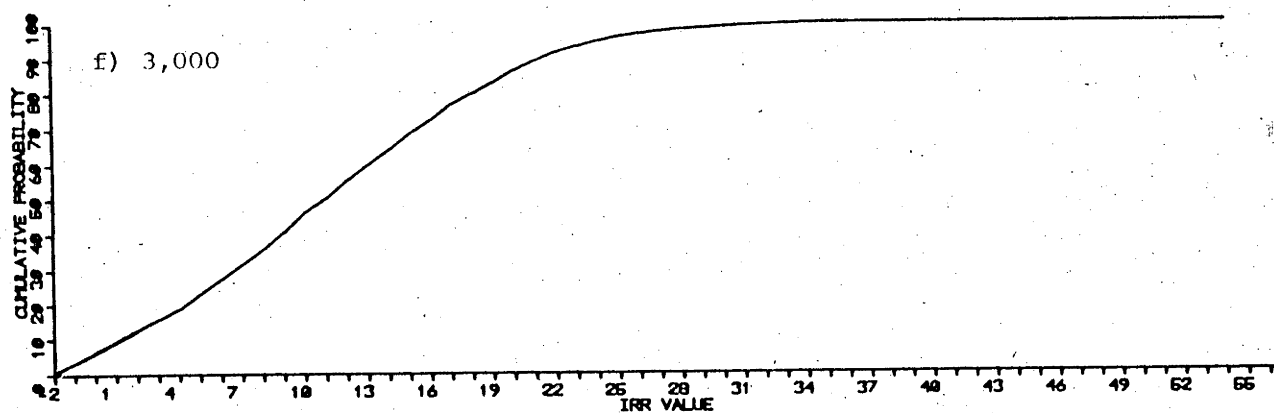
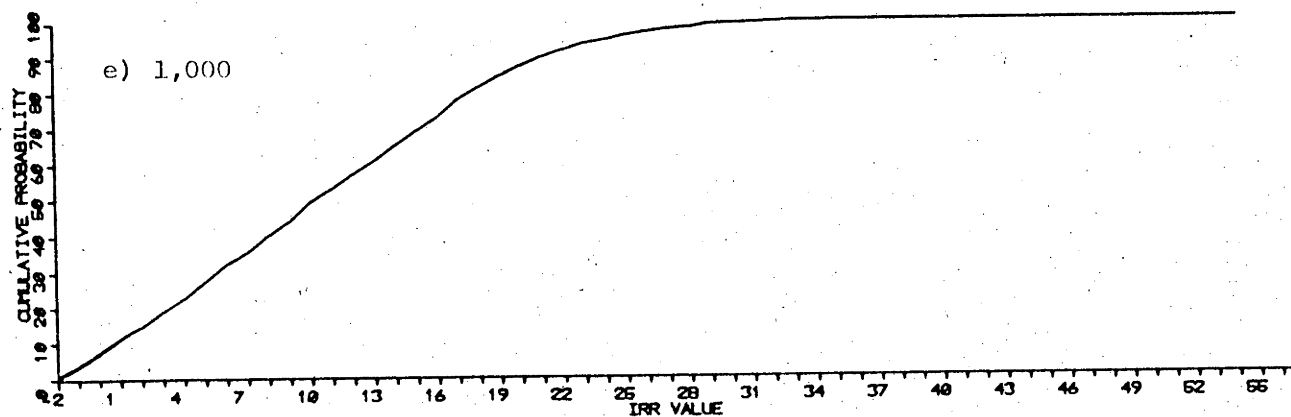
No. of Simulations	IRR (%)		NPV (₹)		ROI (%)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
10,000	> 50	> 50	90,410	92,028	53.81	55.26
5,000	> 50	> 50	90,445	92,066	53.85	55.30
3,000	> 50	> 50	90,667	92,306	54.03	55.50
1,000	> 50	> 50	90,144	91,725	53.64	55.06
500	> 50	> 50	89,045	90,825	52.90	54.51
200	> 50	> 50	90,778	92,250	54.34	55.67
100	> 50	> 50	91,459	92,951	54.37	55.69
50	> 50	> 50	88,919	90,290	52.48	53.71

CUMULATIVE PROBABILITY DISTRIBUTIONS OF IRR (PINEAPPLE PROJECT)

AT DIFFERENT LEVELS OF SIMULATION

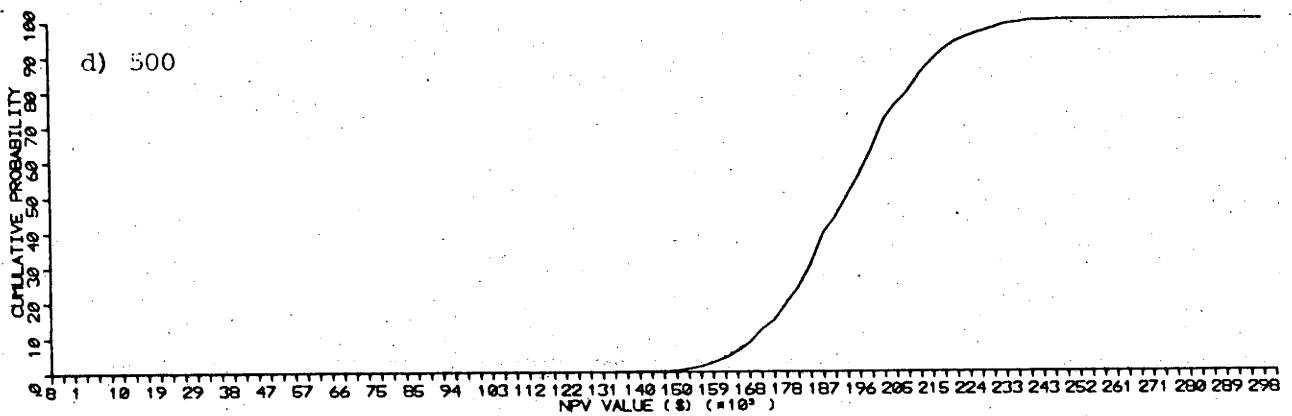
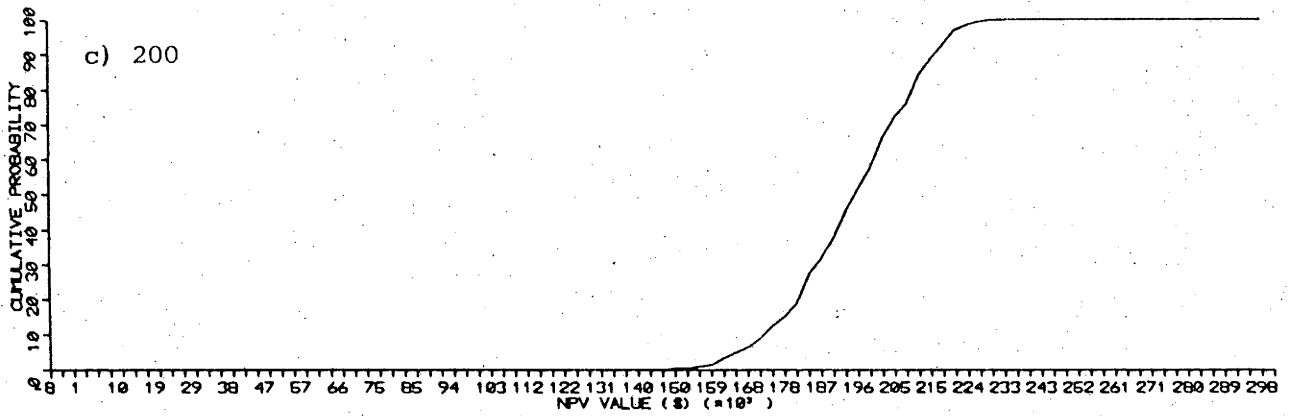
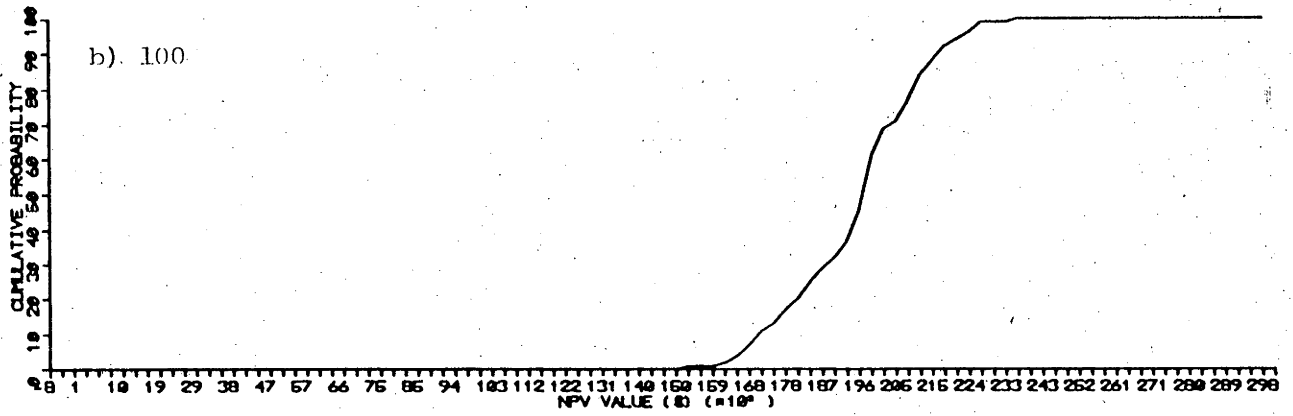
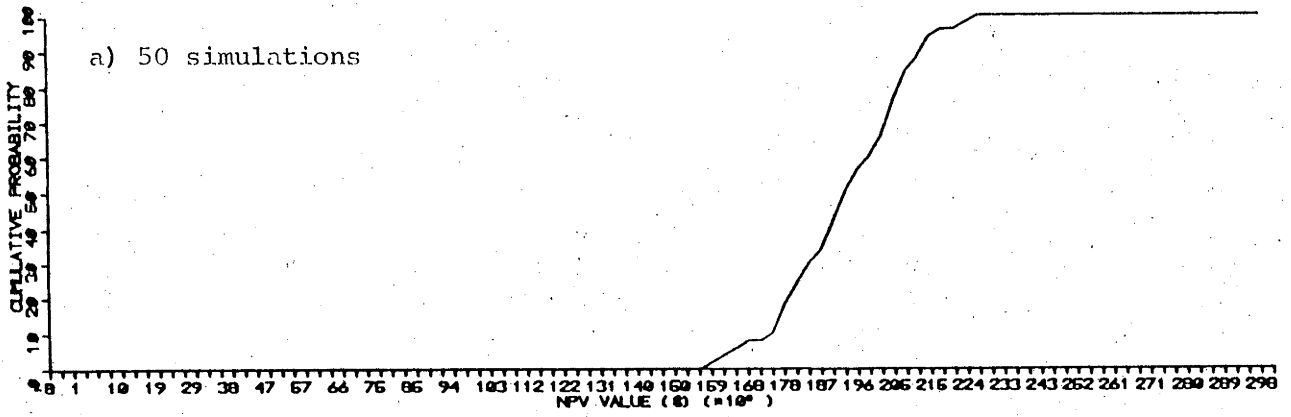


APPENDIX E.3 (cont.)

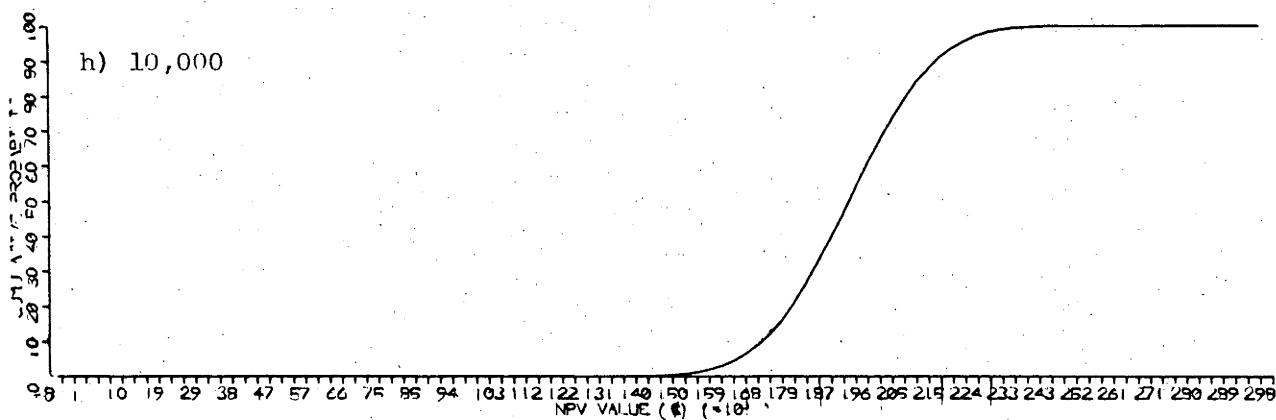
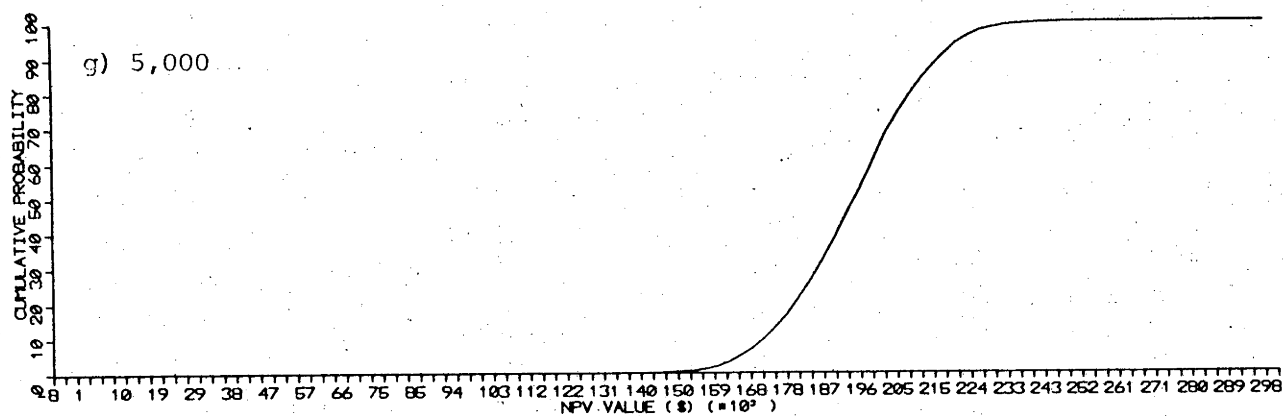
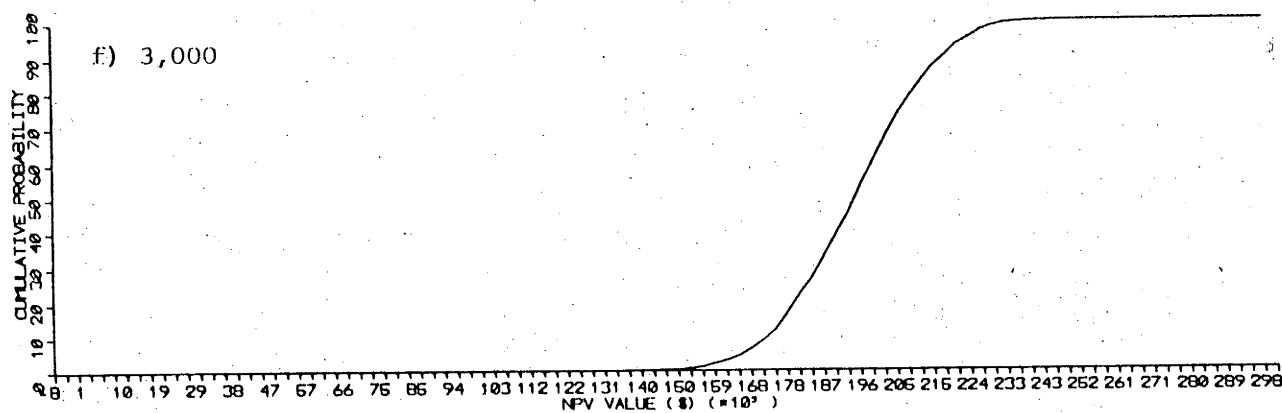
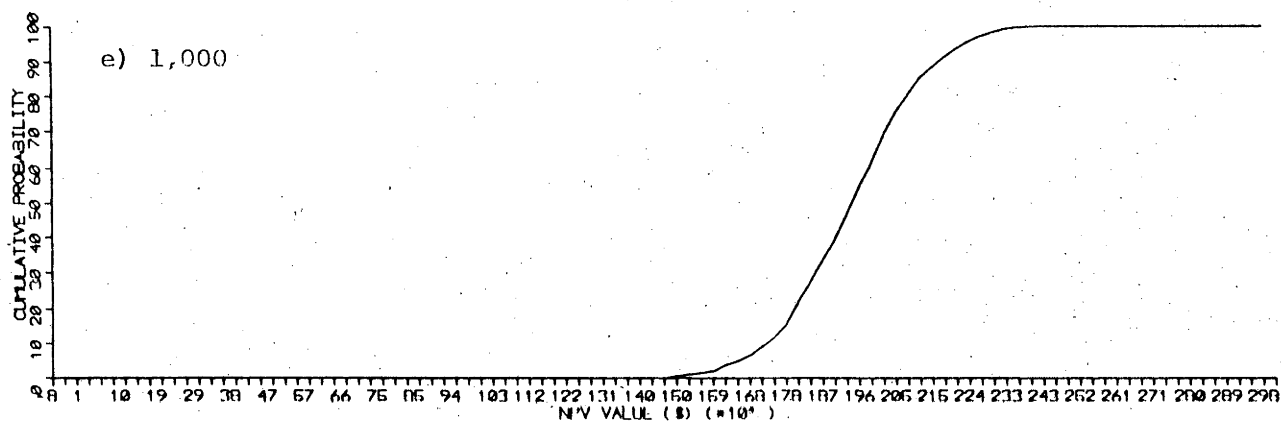


CUMULATIVE PROBABILITY DISTRIBUTIONS OF NPV (MAIZE PROJECT)

AT DIFFERENT LEVELS OF SIMULATION



APPENDIX E.4 (cont.)



BIBLIOGRAPHY

ADDO, S.K.L. and DAVIS, A., 1978. The Monte Carlo Simulation Program, Development Studies Centre, Australian National University.

AGRICULTURAL DEVELOPMENT BANK (ADB), 1965-1976. Annual Reports 1965-1976, Accra.

_____, 1973. Agricultural Credit Programmes in Ghana, A country paper first presented at FAO/Finland Regional Credit Seminar for Africa, Accra.

ALFRED, A.M. and EVANS, J.B., 1965. Appraisal of Investment Projects by Discounted Cash Flow - Principles and Some Short Cut Techniques, Chapman & Hall.

ALLEN, P.W., 1969. 'Analysing Price Patterns', Rubber Developments, 22, pp.122-125.

AMERASINGHE, N., 1978. 'A Course on Elements of Project Planning and Appraisal for Developing Countries', Development Studies Centre, Australian National University (mimeo).

ANDERSON, J.R., 1974. 'Simulation: Methodology and Application in Agricultural Economics', Review of Marketing and Agricultural Economics, vol. 42, no. 1, pp.3-55, NSW, Australia.

ANDERSON, J.R., DILLON, J.L. and HARDAKER, J.B., 1977. Agricultural Decision Analysis, Iowa State.

ANYANE, L.A., 1962. 'Agriculture in the General Economy', Chapter 14 in J.B. Wills (ed.) 1962.

_____, n.d. Agricultural Credit in Accra Agricultural District of Ghana - A Case Study, FAO-UN Working Paper No. 4.

BANK OF GHANA, 1973. Annual Reports, cited in ADB 1973.

BAKER, H.G., 1962. 'The Ecological Study of Vegetation in Ghana', Chapter 9 in J.B. Wills (ed.) 1962.

BROWN, C.K., 1972. Some Problems of Investment and Innovation Confronting the Ghanaian Food Crop Farmer, Technical Publication Series, no.24, ISSER, Legon, Accra.

CARRUTHERS, I.D. and DONALDSON, G.F., 1971. 'Estimation of Effective Risk Reduction Through Irrigation of a Perennial Crop', Journal of Agricultural Economics, vol.XXII, no.1, pp.39-48, Wye College, University of London.

- CENTRAL BUREAU OF STATISTICS, 1970. Economic Survey 1969, Government of Ghana, Accra.
- _____, 1977. Economic Survey, 1972-74, Government of Ghana, Accra.
- CHISHOLM, A.H. and DILLON, J.L., 1966. Discounting and Other Interest Rate Procedures in Farm Management, Third Edition, University of New England, Armidale.
- CONGDOM, T. and McWILLIAMS, D., 1976. Basic Economics - A Dictionary of Terms, Concepts and Ideas, Arrow Reference Series.
- DASGUPTA, P., 1972. 'A Comparative Analysis of the UNIDO Guideline and the OECD Manual', Oxford University Institute of Economics and Statistics Bulletin, no.34, pp.33-51.
- DASGUPTA, P.S., MARGLIN, S.A. and SEN, A.K., 1972. Guidelines for Project Evaluation, Project Formulation and Evaluation Series, no.2, UNIDO-UN, New York.
- LAL, D.K., 1974. Methods of Project Analysis: A Review, World Bank Staff Occasional Paper No.16, Washington.
- DENNIS, A.R. and ASPEY, P.P., (eds) 1976. Project Planning and Implementation in Developing Countries - A Bibliography on Development Project Management, Technology-Development Institute, The East-West Center, Honolulu, Hawaii.
- DOREMAN, R., 1962. 'Decision Rules Under Uncertainty', Ch.15 in R. Layard (ed.) 1972.
- ETHERINGTON, D.M., 1977. 'A Stochastic Model for the Optimal Replacement of Rubber Trees', Australian Journal of Agricultural Economics, vol.21, no.1, pp.40-58.
- FAO, 1971. General Guidelines to the Analysis of Agricultural Production Projects, Agricultural Planning Series No.14, Rome.
- GITTINGER, J.P., 1972. Economic Analysis of Agricultural Projects, The John Hopkins University Press, Baltimore and London.
- GITTINGER, J.P. (ed.), 1973. Compounding and Discounting Tables for Project Evaluation, World Bank.
- GOODWIN, J.B. and SELLEY, R., 1972. 'A Review of Small Farmer Credit in Ghana: The Rice and Maize Scheme of The Agricultural Development Bank' in vol.6, Country Paper no.106SR, Small Farmer Credit in Africa, Agency for International Development, Department of State, Washington, D.C.
- HARBERGER, A.C., 1972. Project Evaluation. Collected Papers, University of Chicago, Markham Publishing Co., Chicago.

- HAWKINS, C.J. and PEARCE, D.W., 1971. Capital Investment Appraisal, Macmillan Studies in Economics, London.
- HERTZ, O.B., 1964. 'Risk Analysis in Capital Investment', Harvard Business Review, vol.42, Jan-Feb 1964, pp.95-106.
- IMBODEN, N., 1978. A Management Approach to Project Appraisal and Evaluation, Development Centre of OECD, Paris.
- JONES, G.T., 1972. Simulation and Business Decisions in Penguin Modern Management texts, D.S. Pugh (ed.).
- KULP, E.M., 1970. Rural Development Planning: Systems Analysis and Working Method, Praeger, New York.
- LANE, D.A., 1962. 'The Forest Vegetation', Ch.10 in J.B. Wills (ed.) 1962.
- LAYARD, R. (ed.), 1972. Cost Benefit Analysis, The Chaucer Press, Bungay, Suffolk.
- LITTLE, I.M.D. and MIRRELES, J.A., 1974. Project Appraisal and Planning for Developing Countries, Heinemann Educational Books, London.
- MALCOM, D.G., ROSEBOOM, J.H., CLARK, C.E. and FAZAR, W.F., 1959. 'Applications of a Technique for Research and Development Program Evaluation', Operations Research, vol.7, pp.646-669.
- MINISTRY OF AGRICULTURE, ECONOMICS AND MARKETING DIVISION, 1970. Sample Census of Agriculture, vols.I & II, Accra.
- MORGAN, J.B., 1975. 'Project Appraisal', in-service training for Project Officers, Agricultural Development Bank, Accra.
- NATIONAL ECONOMIC PLANNING COUNCIL, 1974. 'Guidelines to the Five-Year Plan 1975-1980', Accra.
- NATIONAL INVESTMENT BANK (NIB), 1973. Annual Reports, cited in ADB 1973.
- POULIQUEN, L.Y., 1970. Risk Analysis in Project Appraisal, World Bank Staff Occasional Paper No.11, John Hopkins Press, Baltimore.
- PROU, C., 1973. 'Back to the Shadow Prices', paper submitted to the Colloque Sur l'analyse des Projets de Développement, Clermont & Ferrand, 12-13 Nov. 1973.
- REUTLINGER, S., 1970. Techniques for Project Appraisal Under Uncertainty, World Bank Staff Occasional Paper No.10, John Hopkins Press, Baltimore.
- SCOTT, M.F.G., MACARTHUR, J.D. and NEWBERRY, D.M.G., 1976. Project Appraisal in Practice, The Little and Mirrlees Method Applied in Kenya, Heinemann Educational Books, London.

- SCHLAIFER, R., 1969. Analysis of Decisions Under Uncertainties, McGraw Hill.
- SHERMAN, R.W., 1969. 'Agriculture Credit and the Agricultural Development Bank', Research Memorandum No.10, US Aid Mission to Ghana, Dec. 1969, Accra.
- SQUIRE, L. and VAN DER TAK, H.G., 1975. Economic Analysis of Projects, John Hopkins University Press, Baltimore and London.
- UNIVERSITY OF GHANA, 1969. Background to Agricultural Policy in Ghana, Proceedings of a Seminar Organised by The Faculty of Agriculture, University of Ghana, Legon.
- WALPOLE, R.E., 1974. Introduction to Statistics, Second Edition, Macmillan Publishing Co. Inc., New York
- WEISS, H.C., 1972. Evaluation Research Methods of Assessing Programme Effectiveness, Prentice Hall Inc., New Jersey.
- WILLS, J.B., 1962. 'The General Pattern of Land Use', Ch.15 in J.B. Wills (ed.) 1962.
- WILLS, J.B. (ed.), 1962. Agriculture and Land Use in Ghana, Oxford University Press.
- WOOD, W.D. and CAMPBELL, H.F., 1970. Cost-Benefit Analysis and the Economics of Investment in Human Resources, An Annotated Bibliography, Queen's University, Kingston, Ontario.