THE MANAGEMENT OF RESOURCE USE IN SEMI-ARID LANDS: A CASE STUDY OF AGRICULTURAL DEVELOPMENT IN JEBEL EL AKHDAR REGION, NORTH EAST LIBYA

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DEDICATION

To my parents on their farm

and my wife Fatma and Children,

Mabrouka, Eanas, Abdelaziz and Amanie

ABSTRACT

This thesis is an in-depth case study in agricultural resource management for semi-arid regions based on primary data for 120 farms gathered in the three farming areas of the Jebel El Akhdar region of north-east Libya and on secondary data for the physical environment.

The research analyses the impact of agricultural development on farm structure in the study area. Social and economic change is evaluated with a view to the resolution of long-standing regional problems of the physical and human limitations on the progress of agricultural development.

This study provides an overview of resource management together with a geographical treatment of physical landscape and social resources. Thus it provides an integrated review of the rural resource system. It isolates potential and actual conflicts between resources in farming with the help of detailed case studies by comparing two types of farming systems according to development policy. Modern farms, either rainfed or irrigated, are developed with intermediate technology, and are very different from small traditional irrigated farms.

The study also addresses a number of questions concerning the agricultural policy bias towards new modern farming methods . It is shown that the use of capital intensive technology of government projects severely affects land potential in the long term.

All in all, the state has played a dominant role in developing and changing the farm structure in Libya. Increasing oil revenues have made available massive funds for economic and social development programmes

and facilitated certain changes in agricultural land use. Arable land has experienced and continues to experience rapid expansion and in many cases this growth has outpaced the planning process, reducing its effectiveness to control vertical expansion and creating serious problems of physical resource management and social adaptation.

This study highlights the major problems facing Libyan agriculture in terms of farm and resources management conflict and development policies.

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ABBREVIATIONS

F.A.O.	Food and Agricultural Organisation
G.E.F.L.I.	Groupement D'Etude Francais En Libye
L.D.	Libyan Dinar. The average 1985 exchange rate was US $ 1 = L.D. 0.296. £ = L.D. 0.379
N.A.S.A.	National Agricultural Settlement Authority a department of the ministry of agriculture pre-1969.
S.D.W.R.	Secretariat of Dams and Water Resources
S.P.L.A.J.	The Socialist Peoples Libyan Arab Jamahiriya

CONTENTS

			Page
ABSTRACT			i.
ACKNOWLEDGEMENT			iii.
ABBREVIATIONS			v.
CONTENTS			vi.
LIST OF TABLES			vii.
LIST OF FIGURES			x.
LIST OF PLATES			xii.
CHAPTER ONE	:	INTRODUCTION	
CHAPTER TWO	:	RURAL DEVELOPMENT IN PERSPECTIVE	8
CHAPTER THREE	:	CLIMATE AND CROP ECOLOGY	58
CHAPTER FOUR	:	WATER RESOURCES	112
CHAPTER FIVE	:	SOIL	177
CHAPTER SIX	:	LANDSCAPE ANALYSIS	208
CHAPTER SEVEN	:	HISTORICAL BACKGROUND ON AGRICULTURE IN THE REGION	234
CHAPTER EIGHT	:	DESCRIPTION OF AGRICULTURE IN THE REGION	267
CHAPTER NINE	:	AGRICULTURAL DEVELOPMENT IN THE JEBEL EL AKHDAR REGION	316
CHAPTER TEN	:	SAMPLE DETAILED STUDY AREA	368
CHAPTER ELEVEN	:	ANALYSIS OF FARM SURVEY DATA BY SIMPLE CORRELATION and MULTIVARIATE TECHNIQUES	434
CHAPTER TWELVE	:	CONCLUSION	487
BIBLIOGRAPHY			500
APPENDICES			527

LIST OF TABLES

Table No.			Page
2.1	:	Total Land Reclamation Programme and Achievement up to 31/12/1983	46
2.2	:	Comparison of Agricultural Land Between the Years 1974 and 1984 in Libya	54
3.1	:	Monthly Rainfall Data Relevant to the Total Study Area and the Area of Detailed Study	59
3.2	:	Pluviometric Gradient at Selected Stations	63
3.3	:	Frequency of Rainy Days at Selected Stations	66
3.4	:	Percentage of Monthly Rainfall of Selected Stations	67
3.5a	:	Classification of Daily Rainfall in mm	71
3.5b	:	Average Distribution of 24 hr. Rainfall (pr mm) cummulated frequencies as a percentage	71
3.6	:	The Coefficient of Variability of Monthly and Annual Rainfall for Selected Stations Relevant to the Study Area	74
3.7	:	Correlation Coefficient of Mean Monthly Rainfall (1964-75) for Selected Stations in the Region	81
3.8	:	Probability of Receiving Given Rainfall Amounts or More at Selected Stations	83
3.9	:	Probability of Two Successive Years having Rainfall Greater than Evapotranspiration at El Marj Station	85
3.10	:	Mean Monthly Temperature at Selected Stations	87
3.11	:	Comparison of Temperature and Relative Humidity Data for Coastal and Inland Stations in North East Libya	90
3.12	:	Monthly Aridity Index for Selected Stations	97
3.13	:	Basic Temperature Points for Growth of Seedlings, °C	99
3.14	:	A comparison of minimum and maximum temperatures for selected crops, with mean minimum, mean and mean maximum temperatures in the Jebel El Akhdar region	101
4.1	:	Hydrological Balance for El Marj Units	133
4.2	:	Annual Run-off and Run-off Coefficient Values for El Marj	135
4.3	:	Springs of North Eastern Jebel El Akhdar Flowing more than 10 l/sec	138
4.4	:	Growth of Ground Water Exploitation in El Marj Area	149
4.5	:	Run-off Value Calculated by Section of Watershed (in mm)	157
4.6	:	Classification of Water Quality Based on SAR	171
4.7	:	Ground Water Discharge and Use in El Jebel El Akhdar	176
5.1	:	Asystematic Classification of the OSTROM and Other Systems of Classification	183
5.2	:	Soil Classification and Sample Detailed Study Area	183
5.3	:	Soil Mechanical Analysis	192
5.4	:	Range and Mean of Soil Chemical Analysis	193

6.1 : Land System Description of Northern Flank of the Jebel El Akhdar and Adjacent Area..... 211

7.1 : Land Acquired by Ufficio Fondiario up to 1931 for Colonisation Purpose (in hectares):..... 240
7.2 : Italian Agricultural Settlement in Jebel El Akhdar, 1940..... 244
7.3 : Italian Agricultural Colonisation in Cyrenaica up to 1940..... 247
7.4 : ENTE Farms in Jebel El Akhdar Region 1958..... 248
7.5 : Estimates of Barley and Wheat Production - Eastern Libya..... 254
7.6 : Time Series of the Median of Agricultural Wages Paid; From the Accounts of a Farm Close to Tripoli... 257

8.1 : Type of Farming..... 271
8.2 : Farm Population Density..... 277
8.3 : Farm Population Resident and Non-Resident on Farm..... 279
8.4 : Agricultural Work Forces..... 282
8.5 : Density of Agricultural Workers per Cultivated Hectare..... 285
8.6 : Land Ownership..... 287
8.7 : Type and Intensity of Cultivation..... 292
8.8 : Type of Land Utilisation with Method of Irrigation.... 299
8.9 : Agricultural Water Resources..... 304
8.10 : Off Farm Employment of the Farmer..... 307
8.11 : Agricultural Machinery..... 310
8.12 : Agricultural Productivity in the Region..... 312

9.1 : Summary of Public Finances 1954/55-1958/59..... 319
9.2 : Self Sufficiency Ratios in 1980 and 1985..... 325
9.3 : The Real Growth of the Gross Domestic Product by Economic Activity During 1976-1980 (At 1975 prices in LD million)..... 329
9.4 : Comparison of the Proposed and Actual Allocations, First Five Year Plan Period 1963-1968..... 331
9.5 : Libya: Development Allocation and Expenditure by Sector..... 334
9.6 : Composition of the labour force, Libyan v. Non-Libyan (in thousands)..... 336
9.7 : Development Allocation Budget Plan 1986-1980..... 341
9.8 : Total Land Reclamation Programme with Reference to Achievement up to 30/6/85 on a Regional Level..... 344
9.9 : Land Use : Libya..... 347
9.10 : Land (Ha) and Rainfall Distribution (thousands)..... 349
9.11 : Cost Benefit Analysis for a Five-Hectare Farm (in constant Price 1970 LD)..... 354
9.12 : Pattern of Land Use for Five Hectate Farms in Fatayah..... 355
9.13 : Proposed Land Use Pattern for Fifty Hectare Farms in El Marj Plain..... 355

10.1 : Proportion of Sample Farms..... 372
10.2 : Areal Photography 5 and Images Used in the Study..... 375
10.3 : Government Assistance..... 393
10.4 : Level of Mechanisation in Case Study Areas..... 398
10.5 : Land Use on Irrigated and Rainfed Farms Studied in the El Marj Area..... 402
10.6 : Scale and Intensity of Farming..... 414
10.7 : Type of Lane Ownership..... 418
10.8 : Education Level and Future Plans of Farmers..... 423
10.9 : Structure of Agricultural Workers in Study Area..... 425
10.10 : Land Use Changes in Case Study Areas..... 429
10.11 : Percentage of Farms with New Inputs, Stocks and Livestocks..... 432

11.1 : Selected Variables Affecting Agricultural Development in the Study Area..... 435
11.2 : Simple Correlation Matrix for 39 Variables 1984 Survey Data for 50 Modern Farms in El Marj Plain in Jebel Al Adkdar in North East Libya, Rainfed, Semi-irrigated and Irrigated Development Farms..... 441
11.3 : Simple Correlation Matrix for 30 variables; 1984 Survey Data for 40 Modern Farms in El Fatayah Area, in Jebel El Akhdar, in North East Libya, Semi-irrigated Farms..... 445
11.4 : Simple Correlation Matrix for 33 Variables 1984 Survey Data for 30 Traditional Farms in Ayn Marah In Jebel El Akhdar, in North East Libya, Small Irrigated Farms..... 447
11.5 : Summary of Principal Solution of 39 Variables After Rotation, Modern Farms Only, Sample Size 50 Farms, All Farms Rainfed and Mixed..... 451
11.6 : Summary of Principal Solution of 30 Variables After Rotation Modern 40 Semi-Irrigated Farms only..... 454
11.7 : Summary of Principal Solution of 33 Variables After Rotation, Traditional 30 Farms only..... 457
11.8 : Devised Communalities from 8, 8 and 6 components for Study Area Respectively..... 464
11.9 : Mean and Standard Deviation Values of Significant Variables Used in Discriminant Analysis for 120 Farms..... 468
11.10 : Summary of F Values and Standardised Canonical Discriminant Function Coefficients..... 471
11.11 : Canonical Discriminant Functions..... 473
11.12 : Classification Results..... 477

LIST OF FIGURES

Figure No.		Page
1.1	North Eastern Libya	3
3.1	Fluctuation of Annual Mean Rainfall in Selected Areas	60
3.2	Distribution of Annual Rainfall in Relation to Relief Profile Between Benghazi, El Abyar, Tacnis, Khawlan and Tmini (inland)	62
3.3	Monthly Rainfall Distribution at Selected Stations	65
3.4	Frequency of Rainy Days at Selected Stations	67
3.5a	Classification of Daily Rainfall in Millimetres	72
3.5b	Average Distribution of 24 h Rainfall in Cumulated Frequencies in Percentages	72
3.6	Monthly Distribution of the Coefficient of Variation at Selected Stations in the Region	76
3.7	Distribution of Annual Rainfall in Relation to Annual Coefficient of Variation for Selected Stations in the Region	78
3.8	Monthly Distribution of the Rainfall Correlation Coefficient Between El Marj and Selected Stations at Distance East (1964-75)	81
3.9	Monthly Temperature at Selected Stations	88
3.10	Maize Growth Rates	92
3.11	Relation Between Distribution, Mean Monthly Rainfall and Temperature to Mean Monthly Aridity Index in Selected Stations	95
3.12	Relation Between Crop Growth Temperature and Selected Station	103
4.1	General Water Resources	113
4.2	The Karastic Features and Physiographic Units of El Marj Plain and the Adjacent Areas	115
4.3	North-South Hydrological Cross Sections for Jebel El Akhdar	117
4.4	Surface Water Drainage	119
4.5	Potential Evaporation per Month at Shahat from Weather Data Averaged to Monthly Values 1945-1976	121
4.6	Water Balance at Selected Stations Based on Penman Formula	127
4.7	Surface Water Sheet Balance for El Marj Plain	131
4.8	Evolution of Groundwater Exploitation in El Marj Area	150
4.9	Water Use in El Marj Plain	151
4.10	Wadi Dernah Project	153
4.11	Hydrogeological Units of Ayn Azzayanah Groundwater Basin	156
4.12	Schematic Hydrgeological Cross-section	158
4.13	Evaluation of Reserves Variations in Coastal Plain Unit	160
4.14	Evaluation of Reserves Variations in Coastal Plain Unit	162

4.15 Water Level Measurement for Some Wells at El Marj Plain..... 165
4.16 Restricted Area for Drilling of New Production Wells.. 167
4.17 Classification of Irrigation Waters..... 169
4.18 El Marj Catchment Area Development..... 175

5.1 El Marj Case Study Area Soils..... 185
5.2 El Fatayah Case Study Area Soils..... 187

6.1 Mizda Region Landscape System..... 209
6.2 Land System of Physiographic Units of North Eastern Libya..... 212
6.3 Landscape Diagram Representing Land Region and Land System for Jebel El Akhdar Unit and Adjacent Area.... 214
6.4 General Pattern of Land use in North-Eastern Libya.... 218

7.1 The Roman Cyrenaica..... 236
7.2 Land Scheduled for Agricultural Development by the Italian Administration, State Agencies, Companies and Private in Eastern Libya..... 242
7.3 Distributions of the Ente Farms in El Marj Plain and the Adjacent Areas..... 249

8.1 Proportion of Agricultural Land by Type of Farming.... 269
8.2 Degree of Farm Land Fragmentation..... 275
8.3 Proportion of Total Farm Population Resident on Farm and Off-Farm..... 280
8.4 Pattern of Land Tenure..... 288
8.5 Agricultural Land Use..... 293
8.6 Proportion of Irrigated Farm Land by Method of Irrigation..... 300
8.7 Proportion of Full-Time and Part-Time Farmers..... 308

9.1 Gross Domestic Production and National Income of Libya..... 318
9.2 Annual Average per Capita Estimates of Income, 1970-83 at Current Prices..... 321
9.3 Oil Revenues, Development Allocations and Actual Spending in Agricultural Sector and Food Imports, 1970-1983..... 323
9.4 Growth Rate of Population and Major Domestic Agricultural Product in Libya 1970-1983..... 327
9.5 Agriculture Development Projects in North Eastern Libya..... 345
9.6 El Fatayah Modern Semi-Irrigated Farming Area..... 352

10.1 Case Study Areas..... 371
10.2 Ayn Marrah Traditional Irrigated Farming Area..... 382
10.3 Land Use Change in El Marj Area 1965-1979..... 405
10.4 Land Use Pattern on Private Farms in El Marj Plain.... 408
10.5 Pattern of Land Use on Farms..... 417

11.1 Territorial Map of Three Groups of Farms Identified by Canonical Discriminant Analysis..... 475
11.2 Plot of Discriminant Scores..... 476
11.3 Dendrogram of Wards Classification Using 40 Variables for 120 Cases..... 480

LIST OF PLATES

Plate No.		Page
4.1a	Wadi Dernah Waterfall "Shalla"	142
4.1b	Wadi Dernah Down Stream of Waterfall	142
4.2	Water Storage and Delivery Tanks used on El Fatayah Project	154
6.1	El Marj Plain Land Facets	221
6.2	Ayn Marrah Land Facets	224
6.3	Martubah Land System	227
8.1	Ayn Marrah Traditional Farming Area	296
8.2	Wadi Dernah Terraced Farms	302
8.3	Traditional Irrigation System (a) Irrigated Reservoir (b) Feeder Canal (c) Jadula Irrigation System	305
9.1	El Awssat Project (a) Newly Terraced Farm (b) Farm Terraces After One Year	362
10.1	Dernah City Small Irrigated Farms	379
10.2	Traditional Small Irrigated Farms	384
10.3	Mixed-Crop Farm Pattern in El Marj Plain	387
10.4	Traditional Method of Irrigation on a Semi-irrigated Modern Farm in El Fatayah Area	389
10.5	Land Use Pattern on Rainfed Modern Farm in El Marj Plain	389
10.6	Symbiotic Crop Livestock Enterprise	390
10.7	Small Scale Mechanization	399
10.8	Large Scale Agricultural Mechanization	399
10.9	Land Use Change in El Marj Plain 1965-1979	404
10.10	Private Farming Area on El Marj Plain	407
10.11	Land Reclamation being Carried Out in 1984 on Al Awssat Project and El Marj Plain	410
10.12	El Fatayah New Farm Model	412
10.13a	Modern Farm House	420
10.13b	Traditional Farm House	420
10.14a	View of Modern Farm Structure	422
10.14b	Farm Road Development	422

CHAPTER ONE

INTRODUCTION

Libya is a relatively thinly populated country extending over a large area in North Africa of about 1,745,000 square kilometres with a population estimated at 3.78 million in 1985. Its location between the Mediterranean sea in the north, and Chad and Niger in the south, Egypt and Sudan in the east and Algeria and Tunisia in the west determine the relationships of Libya, as part of the Arab world, to the Islamic world, Africa, the Third World and the world as a whole. These relationships have had a great influence on the political and socio-economic features of the country.

An arid and semi-arid country Libya was characterised by a pastoral economy before the discovery and exploitation of petroleum in 1961. The most productive agricultural zone is found in the north of the country along the Mediterranean coast, but this is by no means continuous, being broken by expanses of semi-desert and steppe land which reaches the sea in places. The coastal strip comprises the Jefera plain in the north west of the country and the north-east plateau of Cyrenaica which forms the focus of this study. These two areas contain more than 95% of the population of the country.

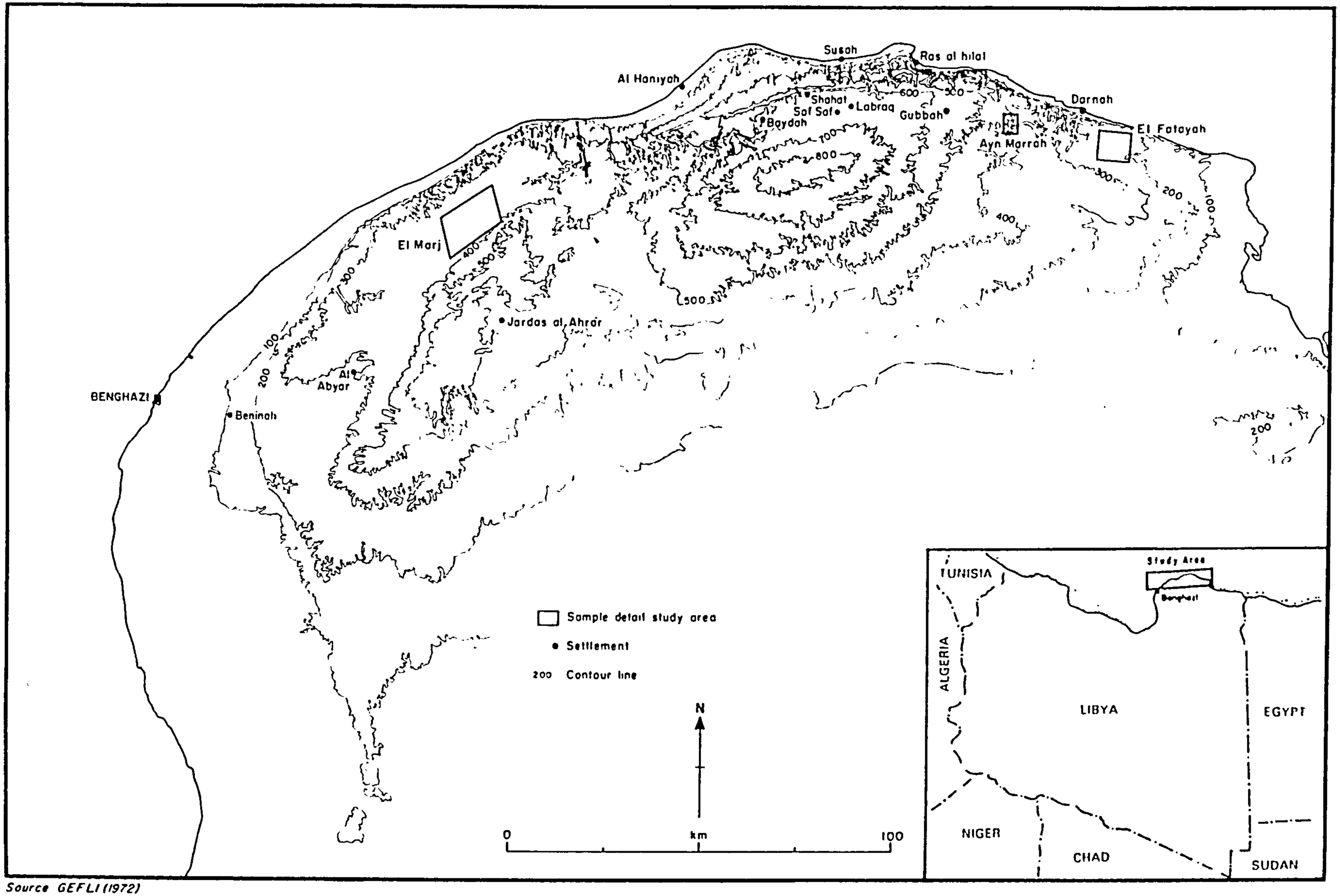
Libya's natural resources in the 1950's showed that Libya, even agriculturally, was one of the marginal or sub-marginal land areas in the world. Nevertheless agriculture was the backbone of the Libyan economy which occupied more than 80% of the population. The

transformation experienced by the economy during the 1960's led to the dominance of the oil sector which by 1969 provided 74% of gross national income.

Libya has had one of the fastest growing economies in the Arab world where, since 1961, the export of petroleum changed its economic features. It is a country that has laid great stress on the necessity of sharing the benefits of that rapid developing economy among the mass as a whole. Therefore, it adopted socialist principles in implementing its economic development plans, but Libyan socialism is of a peculiarly Arab kind being inspired by Islam and the Arab heritage. Through the application of Islamic social justice, which forbids any kind of exploitation, Libya seeks to achieve self-sufficiency in production, in order to liberate the national economy from depending on foreign influence. It also aims to secure equality of distribution among all classes of society.

The wealth generated by oil was used to improve the production of the sectors of the economy, especially agriculture and industry. Thus when Libya's economic fortunes declined rapidly after 1981, it complicated the nation's political and economic problems. The Libyan government was faced with world wide recession and a world oil glut and therefore oil production dropped precipitously. From the fourth quarter of 1981 to the first quarter of 1982, oil production fell 70% while oil revenues from mid-1981 to mid-1982 were less than half of the previous 12 months (Allan, 1984). Continuing expensive development projects further aggravated Libya's constrained economic circumstances. By 1985 annual development budgets had been slashed and sessions of the General People's Congress complained about shortage of foodstuffs and other basic necessities. It became clear that development strategies utilised

Fig. 1·1 NORTH EASTERN LIBYA



Source GEFLI (1972)

during the previous two decades were no longer viable.

The period covered by the present survey forms a watershed during which major changes in rural development strategy have occurred, resulting from changes in the economic and political position of the country since the beginning of the 1970's .

Within this historial context and with an appreciation of the ecological environment and that farming is a way of life in rural Libya, the desire to contribute to the process of policy formulation led to the following research. This focuses on agricultural development in relation to land use potential and on the changes in farm structure brought about by the land reform of the last 15 years.

This study is based on primary data gathered during field work in the three representative areas of the Jebel El Akhdar region of north-east Libya (Fig.1.1), specifically, the El Marj, El Fatayah and Ayn Marrah areas. Questionnaires were completed for 120 randomly selected farms (Appendix 15). The questionnaire was designed to elucidate information on farm management and farm characteristics. The survey was especially designed in such a way as to obtain the data required for an empirical analysis of the dimensions, nature and causes of farm structure in areas undergoing rapid agricultural development. In addition the interview data were submitted to multivariate statistical analysis in order to test the following hypothesis.

(1) That agricultural development has resulted in an improvement in the adjustment of the pattern of crop production to environmental potential in Libya.

(2) That the farmer's traditional attitudes based on semi-nomadic and nomadic practices inhibit the modernisation of agriculture.

(3) That arable agriculture in North East Libya (Jebel El Akhdar) may be classified in two ways : by structure into modern and traditional, and by farming methods into rainfed and irrigated agriculture.

(4) That progress on the Jebel El Akhdar Agrarian Reform Project was being hindered by technical and other problems.

The study, however, goes beyond a more quantitative analysis of the survey results. It draws upon a wide range of other primary and secondary data to analyse the dynamics of agrarian change in Libya over the last fifteen years. The important instrument of this change is the reform of the old land tenure system based on common land tenure and the creation of an alternative form of organisation believed to be more conducive to an egalitarian rural population structure. This change was brought about by successive agrarian reforms and the introduction of a wide range of state-supported strategies affecting such things as marketing and investment.

Previous research by others on agricultural development in Libya has been mainly of two different types. Firstly researchers have looked at the impact of agricultural development programmes and government policies on the growth of agricultural output in terms of either horizontal or vertical expansion. The extensive reports by El Wafatie (1980) Bansil (1978) and Agrawal (1982) are exemplary. In this study attempts were made to discover some of the constraints limiting the progress of agricultural development.

Secondly, the focus has been on the effect of land reform on rural Libya. The emphasis here is on briefly describing the objective of such a reform and the legal and institutional framework, thereby introduced into the agrarian system. The impact of these factors and others on farm structure has been noted by McLachlan (1982) and Alawar (1985). Very few studies, however, have concerned themselves with the assessment of the actual impact of agrarian reform on the farming system in Libya (see Allan, 1971). This researcher's knowledge of local agricultural systems and farm structure give him the ability to approach this study with a more behavioural viewpoint. An attempt is made to analyse the problems of farm management and the farmer's perspective on the future of his family and land. This differs in some respects from other studies such as those of El Wafatie (1977), Najm (1982) and Benkhial (1985).

The purpose of this study was three fold: (a) to provide up-to-date data on various aspects of agricultural development in Libya; (b) to evaluate the impact of different strategies on the agricultural sector in general and on the farming system in particular; (c) to deduce the policy implications of the present situation. The main weakness of the survey was the very limited and superficial coverage of aspects related to farm incomes and farm output generally. This problem arose because the farmer's education level was not sufficient to enable him to keep accurate records of his farm operation.

The orientation of the present study is, therefore, different from that of previous work with the focus being on the issue of physical and human limitations on the progress of agricultural development. In other words this study provides an overview of resource management together

with a geographical treatment of physical landscape and social resources. Thus it offers an integrated review of the rural resources system, isolates potential and actual conflicts between resources in the rural area with the aid of detailed case studies (Fig.1.1); and explores various broad management techniques and their applicability to different types of resources and resource conflicts.

To achieve these objectives, Chapter 2 briefly discusses rural development in Libya in the context of under developed countries. The next three chapters deal with the climate, water resources and soil of the region and evaluate the land resources potential from the point of view of agricultural utilisation. Chapter 6 deals with landscape analysis through a land system approach. The historical background of Libyan agricultural development is described in Chapter 7. Chapter 8 provides a general picture of agricultural development in the Jebel El Akhdar region and includes an analysis of farm structure, relating farm type to holding characteristics. Aspects of farming method, land utilisation, and agriculture production are also discussed. Chapter 9 deals with agricultural development planning. Chapters 10 and 11 focus on the surveys of the three representative areas. Finally, Chapter 12 examines the future of the Libyan farming system in the light of the preceding discussion.

CHAPTER TWO

RURAL DEVELOPMENT IN PERSPECTIVE

INTRODUCTION:

The objective in this section is to build up an international perspective on rural development with some examples from the developing countries of Latin America, Africa and the Middle East. The discussion will emphasise Libya in a Third World context. There is considerable literature on rural development strategies, which are influenced by ideological orientation. Most strategies aim at self-reliance in order to improve the economic and social life of the peasantry (World Bank, 1975; Harriss, 1982). Rural development is concerned with all aspects of rural land, society and economy. To improve the nature of the relationship between sub-sectors of the rural system necessitates the formulation of development policy and planning. This is usually included in national development planning (Lea and Chaudhri, 1983).

Today many people feel that, rural development in the Third World should follow the path as stated by Harriss, 1982, 38:

> "The prevailing ideology amongst development theorists and planners is that 'Rural Development' based generally on fairly small family farms, should be the main objective of development programmes".

Nevertheless there is opposition to this argument and some encouragement of the strategy of developing relatively large scale farms. However, national plans differ in the emphasis which they give to the various lines of development. Certainly one of the most significant features of any rural development plan is that attention

should be given to farm structure, irrigation, land reform, infrastructure, marketing stability agr o-industry and social aspects.

Rural Development Strategies:

Countries differ primarily in degree, not in kind in their rural development strategies; policies, objectives and ideologies are scattered along a spectrum in multi- dimensional space. Nonetheless, there are three distinct strategies or approaches to development in general and rural development in particular, which are discussed by Griffin (1974), Harriss (1982) and Lea and Chaudhri, (1983). These are the technocratic strategy, the reformist strategy and the radical strategy.

A strategy may be defined according to Harriss (1982:51) as:

"a mix of policies and programmes, that influences the pattern as well as the rate of growth"

In addition to this, Harriss has declared that variation in rural development exists between development projects and development programmes, with the latter includes all aspects of rural development (See Harriss, 1982; Lea and Chaudhri, 1983).

At the same time, others have approached rural development in different ways. For example, centralised approaches to rural development, whether along the lines of neo-classical "trickle down" expectations or socialist "redistribution", and state intervention in production are emerging as new ideas and strategies. These strategies have a variety of names such as "development from below", "alternative development", "agropolitan development" and "ecological development". They contain certain common features. Development within these strategies is derived from concepts of self-reliance through maximum use

of natural, human and institutional resources, in order to meet the need and to satisfy the society of that area. But there is criticism of the 'trickle down' or 'redistribution' of development policies, and Friedmann, (1983) suggests a new strategy of 'development from within' In this strategy:

> "The dominant building block is the rural territorial-based community at the smallest efficient and effective scale. Development in this context is essentially a political act empowering local peoples to control their own destiny. A new balance of power between local communities and the central state is to be established". (Taylor, 1985/33).

However, in this context discussion will be limited to the first three strategies, maintained because they are found throughout the world.

Technocratic Strategies:

The strategy of technocracy for some countries has been given the priority for economic growth, in order to achieve increased agricultural output. They have pursued the "green revolution", concentrating their efforts on particular regions, usually the more prosperous ones, and on particular farms, usually the larger ones. In Mexico the rapid expansion of wheat ouput has been restricted to large commercial farms in the northern part of the country.

In Brazil modernisation policies are intended to establish a condition of capitalist production within a wide range of agricultural and agro-industrial sectors. The Brazilian path has retained the unequal structure of land ownership, despite attempts at land reform, instituting discriminatory policies to modernise large properties, and encourage large investment in agricultural production. In addition to its massive scale and rapid growth, rural credit, which is distinguished by a high rate of government subsidy and by its unequal distribution by crop and region, farm size and value of contract. For example, export

crops accounted for 77 percent of total operating credit in 1976 and 83 percent of the increase in this type of credit in 1969-76 whilst food crops, such as beans, manioc and corn which represented 31 percent of the gross value of production in 1976, received only 13 percent of operating credit. The trend toward increasing vertical integration of the food distribution system is strongly supported by state investment incentives in the North-East, where agriculture continues to exhibit great complexity and diversity. Further, there has been concentration of assistance on medium and large scale farmers (Goodman and Redclift, 1981; Barraclough, 1976; Freebain, 1977; Rask, 1977).

In the Phillippines, central Luzon was given priority in the high technology Rice and Corn Self Sufficient Programme, 1966-67 - 1969-70. Therefore, regional inequality was increased since the Luzon region was the most profitable and advanced agricultural area in the country (Griffin, 1974).

Since independence, government policies in Kenya have favoured an open domestic market system, and although Kenya officially has a development strategy based on "African Socialism" the government is following a capitalist development approach and this creates disparities between north and south, rural and urban areas and rich and poor (Taylor, 1981). Thereafter the strategy of development has changed in order to achieve equality between different classes of society.

A technocratic approach based on irrigation is exemplified in the scheme for the Senegal river. This international programme (Mauritania, Senegal, Mali and formerly Guinea and its foreign aid) is expressed through the organisation pour la Mise en Valeur de Fleuve Senegal (OMVS), whose role is to investigate the potential of the Senegal valley

and to coordinate planning and implementation. This is organised on a national basis, with a commonality of strategies and techniques among the member nations. For example, the Societe National de Development Rural on the Mauritanian bank of the river has created two types of irrigated holdings: large (500ha or more) with dams and large scale pumping equipment, and smaller (13-35 ha), based on small motor pumps. The former have become state farms with wage labour, the latter, less than 100 farms, are managed by peasant farmers. They have rights of usage and are fully responsible for management. By 1978 about 40 small farms had been constructed and planned development of small holdings extended to the middle and upper valley, with 35 scheduled for installation by 1980. A typical installation consists of a 20 ha plot, divided among 50-100 farmers who formed a cooperative to manage the irrigation system, each receiving a small plot within it. Size of plot varies between 0.2 and 0.3 ha. based on the number of farmers in the cooperative and the size of the irrigated area. This is expected to provide a double harvest: paddy rice in the wet season, and a mixture of wheat and maize in the dry season. This example uses a modern technocratic solution to develop traditional farming and weane the farmers away from flood-retreat cultivation, paving the way for large scale irrigation in the future (Bradley, 1980).

Agricultural development in Iran has looked to a long run strategy. The government moved simultaneously in socialist and capitalist directions to state farms as well as agribusiness. It has accommodated capital intensive methods and national economic aims (Weinbaun, 1982; Richards, 1965). The same situation was repeated in Nigeria where the emerging capitalistic image is clear enough in spatial development

planning (Lele, 1974; Hodder, 1980). The resettlement schemes of Indonesia, Papua New Guinea and early resettlemnt schemes in Malaysia all follow technocratic policy. 'Green Revolution' technocratic strategies started at rural development in the Indian Punjab, where capitalist farming introduced new technology for wheat and rice production between 1968-69 and achieved remarkable increases in output (Griffin, 1974; Eckert, 1977). The technocratic strategy has also appeared in Libyan agricultural development. It is most clearly seen in large scale capital intensive schemes, such as those associated with irrigation and water control projects, for example El Kufra and Sarir project in the desert Wadi Dernah and Wodi El Qattara projects in the north.

The Reformist Strategy:

This means that a stick is handled from the middle to achieve a great compromise between the two extreme positions, in order to provide the social security and improve the standard of living of the poor rural community. Quite often, the reforms create a dualistic or bi-modal agricultural sector (see Johnston and Kilby, 1982). This style of rural development strategy gives priority to redistribution of income to small and medium peasantry. It concentrates more on social and economic justice than on agricultural economic growth. This reformist bi-modal strategy is quite clear in Mexico, where a strategy of redistribution of land in favour of the peasantry was carried out in the central part of the country, while a policy of technocratic "capital intensive" farming on large holdings was allowed in the irrigated area of the north. Egypt also followed this path of agricultural development

strategy. The 1952 reform started to encourage labour intensive farming on cooperative and small holdings. Recently there has been a shift in favour of more capital intensive techniques on larger "new farms" as a technocratic solution to the problems experienced on the small farms created by the land reform.

A 'bi-modal' strategy of agrarian change occurs where there is a dualistic size structure of farm units, but in which resources are concentrated on a small highly commercialised sub-sector of the agrarian economy dominated by large farms, (Johnston, and Kilby, 1982; Harriss, 1982; Griffin, 1974; Johnston, 1981). This model has been applied in Tanzania, Malaysia, Sri Lanka, Venezuela (Lea and Chaudhri, 1983; Harriss, 1982; F.A.O., 1981; Thomas, 1982.

The reformist strategy can be unimodal to attain the economic benefits of agricultural output for marketing and generate capital. The uni-modal strategy seeks to encourage a more progressive and wider diffusion of technical innovation adapted to the local sector or environment as a whole. The distinction between the two approaches is that the uni-modal strategy emphasises an innovation that can be used efficiently by small scale farmers and followed progressively. In other words, the type of innovation is appropriate to a progressive increase of output, such as low lift pumps in order to improve the quantitative and qualitative efficiency of irrigation. However, a bi-modal strategy involves a much more rapid adoption of a wide range of modern technologies. This is limited to a smaller fraction of farm units because of the structure of economies in which commercial demand is small in relation to farm output. Under the bi-modal approach the divergence between the factor of intensity and the technical efficiency

of the best and average firms is likely to become progressively greater as agricultural transformation occurs; for example the capital intensive use of mechanisation with other farm input such as fertilizer is essential for increasing crop yields. For reasons discussed above, it is not possible for developing countries to pursue the uni-modal and bi-modal option simultaneously. Some places have shown success within subsectors of large and capital intensive farms where a bi-modal policy has maximised the rate of increase in the short run. However, in the long view, a uni-modal strategy is more efficient, particularly in minimising demands for the shortage of resources of foreign exchange and loan funds. Because of the scope that exists for obtaining widespread and substantial increases in the productivity of abundant resources of labour and land, and of other farm inputs such as draft animals that are internal to the agricultural sector and often to the farm unit, the potential impact on aggregate farm production is very large (Johnston, 1981).

However, the uni-modal strategy is used to minimise the costs of production and increase of agricultural output. The transformation may come about on the basis of capital intensive small scale farms, such as in Japan and Taiwan, where reference is made to the "efficiency of small farms". The context appears to have significant advantages with respect to 'the total efficiency' as well as in its effects on income distribution and equity such as in South Korea, where redistributive land reforms preceded the main attempts at rural development (Lea and Chaudhri 1983; Harriss, 1982; Johnston, 1966 and 1981; Hayemi and Yamada, 1975).

In summary, a uni-modal reformist strategy has a more than

favourable impact on the growth or upsurge of agricultural output and especially encourages the inter-relationship between productive sectors, i.e. the increase of manpower in local manufacturing and supporting service industries, as in agro-industry. (Johnston, 1981).

The reformist strategy of rural development is generally associated with nationalist ideology and occasionally is populist. The land tenure system tends to be the family farm, or cooperative production. Therefore, in practice, the beneficiaries of the strategy are the middle sized farmer on a family farm, and large farmers on substantial holdings. The benefits are mainly distributed to the elite and to people of urban origins who have inadequate experience of farm management. For example, the techno bureaucratic bourgeoisie in Algeria which benefited from this strategy, has brutally affirmed its hegemony on Algerian society and has begun an intensive accumulation of capital to the detriment of the masses. Therefore, the class nature of the policy of economic development is revealed in the choice of priorities.

A Radical Strategy:

This is based on socialist ideology. It has been used widely in Asian and Eastern European countries. It mobilizes untapped human resources with great efficiency. To achieve this, it should involve social and economic equality by emphasising social control and wide ownership of land. Rough equality is achieved by abolishing private property in land and establishing collectives, communes or state farms. This generally tends to favour small peasants and landless workers (Lea and Chaudhri, 1983; Griffin, 1974).

Good examples are in the communist countries, collectives such as the USSR, Hungary and Communist China (Aziz, 1978; Schran, 1976;

Kozlowski, 1975; Todaro, 1981; Gurley, 1979), and in Cuba (MacEwan, 1979; Barraclough, 1976). In north Africa, the first rural development planning of a socialist village for rural families in Algeria is a clear example (Rufweirner, 1980; Bennoune, 1976; Bennoune, 1981). In this context Paul stated that:

> "In the period immediately following independence, it attracted international attention with a system of the work's self-management. As the colonial settlers fled, the new regime swiftly confiscated their property and declared a variety of radical social measures. It later nationalised foreign capital and pursued a policy of economic independence through industrialisation. In short Algeria emerged as the most appealing and progressive of the region's "radical nationalist regime" (Paul, 1978:3).

In China the transition from semi-socialist cooperatives to fully socialist communes was faster in 1955 and was an important factor of China's departure from the Soviet model of industrialisation and urbanisation. The transition stage from socialism to communism started by working on the principal of "from each according to ability, to each according to need" (rather than 'to each according to work'). The decentralisation planning approach was followed. Production and distribution decisions were achieved by production teams which became the basic collective unit for actual cultivation. The new size of commune was achieved by merging two or three old Hsiangs and administrative units built around the traditional market town. The 26,000 communes were sub-divided into 74,000 communes. The private holdings system had been absorbed in the communes and was reintroduced. The total area to be covered by private plots was not to exceed 5 percent of the total land under collectives as against 10 percent before 1958. The new size of private plot was too small to allow a family to be self sufficient. The Chinese managed to create a more viable institutional framework for rural development in order to serve the economic self- interest of the Chinese farmer.

The agricultural crisis of 1959-61 generated debate of different rural aspects, among this the reevaluation of China's agrarian policy. Therefore, in 1962 at the Tenth Plenary Session of the Eight Central Committee of the Chinese Communist Party was decided to give a high priority to agriculture under the new farmers slogan "take agriculture as the foundation and industry as the leading factor". Thus, China's agriculture policy is remarkable in its simple slogans, which indeed developed an understanding of policies at lower levels and gave a certain ideological strength to their implementation. Workers are more willing to follow a specific policy for ideological reasons even if its economic benefits have not yet been demonstrated (Aziz, 1978).

The Chinese experience was mainly concentrated on a basic objective in rural development, the need to organise, develop and utilise the available resources of land, water and manpower in such a manner that the entire rural population dependent upon these resources has an equal opportunity to meet as a minimum, their basic need of food, clothing and shelter with reasonable facilities for education and health and can live together in a positive and healthy social environment (Aziz, 1978). The Chinese opted for self-reliance and a withdrawal from the world economy. This summarised a strong psychological component in the Chinese experience, which mainly depends on great skill and unselfishness and the zeal of sacrifice for the common good. The agricultural foundation is changing with the re-introduction of private farm as China enters into world commerce and is embarking upon a phase of development including a local sophisticated innovative and more liberal society (Simpson, 1980).

The rural sector has appeared as largely self-reliant and self-sustaining incorporating within itself manufacturing industry and education, social and health services. The Chinese created opportunities for work and for a better life within the rural areas and provided a compromise division between urban and rural workers. However, Simpson (1981:6) stated that:

> "The Chinese solution is neither perfect nor complete and it is a development which has been bought at the price of a considerable loss of personal freedom".

The Chinese experience points a way to overcoming the problems of many developing countries and has rid the world's most populated area of the worst evils of chronic poverty.

The importance of the Chinese experience in agricultural development is that it started from below and rose above, while most developing countries began above and fell below, which is less effective. For example, the modernisation of agriculture is developed by local manufacturing and material by local people in China. An opposite example is the introduction of farm machinery into a herding society that has less management operation.

The examples which have been used to indicate the three distinctive strategies in agricultural or rural development are not meant to be stereotypes. There are few countries which can be discussed firmly under one category or another; most countries occupy neither an extreme position nor the mid-point. Thus, some countries have adopted different strategies of rural development, in order to determine the social and economic consequence of a particular or technical change. For example, apart from a general shift towards greater flexibility, agricultural policies in China started to change in 1977. After the principal reform

of the 1950s, and a few modifications in the early 1960s, Chinese agriculture improved. The system of collective agriculture was released and house-hold and other private agricultural activities were encouraged. This shows a slight shift from a purely radical strategy to a reformist one. By this procedure the agricultural output showed a dramatic upsurge between 1972-79 (World Bank, 1982; Reynolds, 1985).

Rural Development and Agricultural Development:

Rural development and agricultural development are not synonymous, although the agricultural production base is, of course, a vital component of rural development (See Harriss, 1982).

In many developing countries attention has been paid to agricultural development, but recently there has been a shift to develop a comprehensive rural development strategy, in order to escape from the dilemma of design particularly in African countries, for example see, Mabogunje (1981). The first development plans of 1964 and 1966 in Kenya gave insufficient attention to rural development, but the second development plans have paid greater attention to the development of rural areas (Republic of Kenya, 1969); Taylor, 1974).

The 1963-69 development plan in Libya gave special consideration to the agricultural sector, being the source of supply of most of the essential consumer goods, as well as being the source of income and employment for the majority of the people. The plan's target was to improve the productive efficiency of farmer and labourer, and to encourage the private sector to invest in agriculture. This plan concentrated on a feasibility study of farm production and the resettlement of semi-nomads on ENTE farms. More recently in 1973-75, the

first plan initiating integrated rural development was put into operation. This led to the integrated rural development planning, similar to that proposed by Mahatma Gandhi for "India" and Chairman Mao for "China". They thought of villages as "closed economies", although there were differences in attitude between the two. Gandhi gave priority to industries, Mao gave more attention to the complementarity of "agriculture plus industries" (Lea and Chaudhri, 1983).

However, integrated rural development means in many cases "throwing money at the problem" in the optimistic hope that it will drive it away (Mabogunje, 1981), and thus emphasises infrastructural development. It involves various aspects of rural society, and emphasises the shift from a re-structuring of social relations of rural production to purely infrastructural development, such as infrastructure, institutions and geographical aspects of a specific region. For example, the Jebel El Akhdar project began in 1974 as part of an integrated rural development plan for the entire region involving the construction of reservoirs, extensive afforestation, complete electrification, road building, setting up of storage facilities, agricultural finance institutions, marketing organisation, establishing research stations and urban development. In another example in Kenya, a special programme set out to include design plans of integrated rural development. This plan revolves around the concept of growth centres of which there are four main types: urban, rural, market and local, in descending order of importance and size. Rural centres have been designated for development to provide to at least 40,000 people of a rural area, both a quality and quantity of services and amenities within the rural area (Taylor, 1974; and 1981).

Integrated rural development has a different meaning. It mainly relies on planners and its goals are discussed by Aziz (1978); Chambers (1974); Griffin (1976), Mabogunje (1981) and Livingstone (1981). They intend that a development programme should include rural and urban development in a complete or interactive context. The integrated rural development objectives emphasise economic and technical aspects of agricultural development, which involves a series of inter-related activities such as agricultural development, rural extension services, community and cooperative development, human resources and social development; development of rural institutions and rural infrastructure. Hence, rural development is a concept of well defined objectives, activities, strategies and executive programmes aimed at rural transformation.

An integrated rural development is part of a comprehensive economic plan, which is simply a specific set of quantitative economic targets to be attained in a certain period of time. A partial plan of rural development covers only some of the rural aspects of the national economy, in order to achieve social objectives and then sets various targets and finally organises a framework for implementing, coordinating and monitoring development plans (Todaro, 1981; Livingstone, 1981).

These aspects have been reflected in the 1973-1975 and 1976-1980 development plans in Libya. It also seems that through these plans, Libyan policy makers aimed at achieving certain important socio-economic and political goals; namely regional equity and national integration.

Libya's economic growth and development during the 1960s and early 70s has strengthened the existing regional per capita income differential. Therefore the 1976-1980 and 1980-1985 plans were

comprehensive. They were national and regional in scope and were intended to establish a close connection between local development and national investment policies. they reoriented priorities in economic, technical and social disparities (Allan, 1981, 1983C; Sankari, 1981; Italconsult, 1976).

Rural Development in Africa:

Some African countries both oil and non-oil countries have achieved a rapid growth rate. The conditions for the rural population may have in fact worsened. Inflation and unequal distribution of income and resources have exacerbated existing inequality. Economic growth in Africa has been accompanied by an uneven distribution of benefits and intensification of inequalities, while living conditions have stagnated, some times deteriorating, for the majority of rural dwellers (Ghai, and Radwan, 1983).

The urban bias of decision makers and the consistent neglect of rural areas in the development of infrastructure facilities accentuated the problem especially in the ecologically disadvantaged rural areas such as Niger, Chad, Sudan, Zambia, Botswana, Central African Republic and Mali. This has also occurred where the agricultural density is very high as in Kenya, Rwanda, Egypt and Liberia. On the other hand, adequate land to produce sufficient food is not fully utilised because of labour shortages due to migration or part time and seasonal employment, such as in Tunisia, Libya and Algeria.

Thus, the African countries have established a series of agricultural development strategies aimed at enhancing rural standards of living and income, and improving employment opportunities in rural

areas. They have also tried to move to a more equitable distribution of land using the land reform approach, and to abolish and reduce landlordism, as in Egypt, Algeria and Morroco. Some countries in Africa have chosen a strategy to develop agricultural production. This they have done through the improvement of capitalist production the agricultural bureaucracy and the farm input facilities.

However, some countries have applied a range of various strategies which they used to find a way around the problems of existing peasant production, either by developing new land in the form of "settlements", state farms and cooperatives, or by inviting in the multinational plantation companies, (Lonrho and Tate & Lyle in sugar in the Sudan, East Africa, and Zambia; and Brooke Bond in tea in Kenya and Swaziland), and even by introducing a new generation of "settlers" (as in Zambia and Malawi).

In the Algerian experience, initially foreign owned state land was consolidated and organised into self contained units "Unites d'autogestion" with an average size of about 1,000 ha. The programme included basic modification of the cropping pattern in an attempt to limit the effects of the foreign market on production (e.g. wine). Algeria's agrarian revolution of the early seventies aimed to solve problems of inequality of income and consumption of the workers, and to solve the problems of traditional agriculture (Paul, 1978; Bennoune, 1976; Griffin, 1974).

Settlement Policies:

A series of projects have been established in Zambia over the last decade - the Chambwa type mechanisation schemes, intensive development

zones, villages productivity schemes, villages regrouping into cooperatives and the Rural Reconstruction Programme. The intensive development zones aim to minimise the disparity between rural and urban society, and create self sustaining improvement in income and productivity in villages. The government has concentrated on integrated development of rural areas. Furthermore, the Rural Reconstruction Programme of 1975 is aimed at reducing rural urban movement among youth. Initially, only youth were to be recruited and trained in all the skills of rural development, mainly agro-industries, and then settled in rural occupations within a cooperative organisation framework (Adepoju, 1982).

The intensive package of rural development projects in Ethiopia, and the land settlement schemes in Kenya, are programmes designed to resettle and redistribute landless peoples in different regions and are both similar to settlement projects in Libya. The government of Kenya also launched a special development programme in 1971. This programme focuses on intensive commercial farming, diversification of agricultural enterprise and the development of trade and rural industry, (Mohiddin, 1981), and is similar to agricultural production projects in Libya. However, the Ethiopian and Kenyan experiences have indicated that there is inequity in the distribution of land rights. Thus, the potential of rural development programmes designed to improve benefits to the lowest income groups is not realised (Lele, 1975).

The Tanzanian cooperative Ujamma scheme has been experimenting with "rural socialist transformation" through self reliance, with agriculture playing the leading role in economic development. The main feature of the policy is the grouping of scattered households in village settlements and the transformation of the villages into Ujamaa 'Family

hood villages' (Lele, 1975; Thomas, 1982; Mohiddin, 1981; Coulson, 1982).

Somalia is predominantly a nomadic pastoral economy. The 1974-78 five-year development plan formulated policies aimed at resettling nomads and demolishing the growing unemployment among younger school leavers who migrate in large numbers to the capital city. These programmes include agricultural crash programmes, agricultural settlement schemes, state farms and large irrigation projects. The agriculture settlement scheme was designed for nomads in the agricultural and fishing sectors.

The farm settlement scheme saw the establishment of rural development in Nigeria in 1960. Meanwhile, between 1967 and 1975 the number of potential 'growth poles' was increased from six to about twenty. This created return migration to the state capitals. In Nigeria, therefore, there are plans to develop agriculture by encouraging capitalist and state farming and imposing state direction on present farmers. The state then enables private capitalists to acquire the money for their commercial activities and personal consumption (Williams, 1976).

In Swaziland, rural development areas were set up to modernise traditional agriculture and reduce the gap between urban and rural amenities, so to stem rural exodus. Also, in 1977 Zaire established a regional development programme, which aimed to reconstitute the regions into autonomous economic entities in the hope that the project would control rural exodus (Adepoju, 1978; 1982; Wood, 1982; ECA, 1984; Lele, 1974).

The most commonly used development-oriented strategies which have both direct and indirect effects on population distribution include rural development and new urban centres. These take two forms

Firstly resettlement schemes of farm settlements, such as the Awash Valley Scheme in Ethiopia and Ujamaa villages in Tanzania. The Socialist villages in Algeria and the million-acre settlement scheme in Kenya. Egypt, Jordan and South Yemen have developed settlement schemes for resettlement of nomads, as has Libya as in the example of the detailed study area. All of these aim to improve conditions for rural communities, as a part of rural development strategy.

Secondly the creation of new urban centres as growth poles (see Kuklinski, 1972;) Darwent, (1969), e.g. Liberia, Nigeria, Libya, Tanzania and Kenya, in order to strengthen regional level planning, and to improve the situation of rural people. Overall, national development programmes aim to achieve a balance for all the people through integrated rural and urban regional development programmes. In this context Southall,(1979:8), stated that:

> "The positive development role of small urban centres presupposes the possibility of decentralisation and deconcentration, permitting genuine grass roots participational input to the development process. Despite some serious efforts in this direction it is doubtful whether this is a reality anywhere in Africa".

He argues further:

> "Thus, many studies seem to document conclusively the overwhelming trends of centralisation and international capitalist penetration, stifling the possibility of small urban centres themselves stimulating their rural hinterlands in a positive way". (Southall, 1979:9).

He declared policies with tendencies towards centralisation, both political and economic, reinforced by forces both internal and external small urban centres, see, Keizeri (1984). Therefore, some countries

with centrally planned socialist oriented economics, particularly Tanzania, Somalia, Zambia, Algeria, Kenya and Libya, have articulated rural development programmes. They include village regrouping, agriculture projects and public work schemes to retain rural urban movement, and to create self-sustaining improvement in income and productivity in villages. They mobilise rural resources for diversified production and the location of economic activity, providing a base for future development of rural area. Therefore, they have implemented an integrated approach of rural development (F.A.O. 1983; Todaro, 1981; Southall, 1979)

. The contrasting approach is decentralisation which is stated by (Thomas, et al, 1974:460).

> "The desirable extent and route of decentralisation depends on a number of variables. These include the extent and calibre of local bureaucratic and representative institutions, the degree to which the programme aims at mobilisation and increased participation, the nature of the distribution of land, income and social status, the anticipated amount of political opposition at the local level and the potential political strength of target groups. A limited decentralisation including participation beyond the ranks of the civil service seems desirable in those cases where the distribution of scarce resources is sufficiently equitable that local government is not dominated by a single group".

This approach follows one of two routes. Most programmes are bureaucratically decentralised. Some programmes are politically decentralised, involving local and regional councils, including elected officials such as in Bangladesh and Pakistan. Further the executive authority of El Kufra and El Sarir projects and recently the council of the Great Man Made River in Libya. At the beginning of 1986, the Libyan Congress declared that some secretariats should be decentralised, among them the secretariat of agriculture. This approach permits an efficient degree of local participation and implementation of agricultural

development programme. It is possible to take advantage of the enthusiasm of local groups and permits programme planning to gain from local experience and knowledge. It concentrates the full responsibility of management of programmes into one group. This creates competition on a regional scale, in order to attain equality in regional planning.

Some detailed examples of rural development programmes from Algeria, Egypt, Tanzania and Libya will exemplify the range of agricultural development strategies in Africa.

Algeria:

Algeria has now been an independent nation for 25 years. It states that social justice and truth are inseparable from the ideals of social revolution which has prevailed from November 1954 to the present. The welfare state, the "milch cow" was the reality of the 1970s, the period of the oil boom. Algeria is the most important case in Africa of an attempt to exploit mineral resources and industrialise in the framework of decentralisation. The most ambitious socialist development of decentralisation in the country was the "one thousand socialist villages" programme (Southall, 1979; Hadjou, 1982). Up to 1980, about 340 socialist villages had been built. In 1981, the government decided to stop the whole programme, and launch a new scheme for the reorganisation of the rural area, as they discovered that there were discrepancies between the aim and the reality of the viallages. As a result, the peasant's role is changing from that of sharecropping for large landlords into sharecropping for the state, while the farmers have become increasingly impatient and patronising towards the peasantry.

Thus, the new programme seems, in some ways, more realistic under the ideology of the socialist village programme.

The objective of the socialist villages was divided into two categories; the first category aimed at "a radical transformation to the social economic and cultural norms" of the rural family in the socialist village. The second category concerns the spatial reorganisation of the general rural settlement pattern. The agrarian revolution, started in 1971, stated that the private landowner delimited between 20 and 50 ha of land based on land capability. The state land was distributed to self management cooperatives, and nationalised land from large landlords was distributed to landless and small-holding peasants. The latter would be granted permanent use of the land, but they would have to belong to the cooperative set up by the authority. They are assured state assistance and subsidies in both farm input and output. The agrarian revolution goal is on the modernisation of agriculture. Assistance is provided by the Multi-Functional Service Cooperative "Cooperative Agricoles Polyvalente Communale de Services" (Griffin, 1974).

Generally between 1965 and 1970 the agricultural policy of the Algerian government was based on the slogan "land belongs to those who work it and those who liberated it" (Bennoune, 1976). Thus the cooperative farms are controlled by the state. The farmers who have worked together are chosen by the authority. Their numbers vary between 8 and 30 persons, based on land capabilities. They are usually from different extended families. As stated by "dans une meme famille toutes les classes sont representees" "within the same rural extended family, all the income groups are represented". At the same time, the agrarian

revolution exclusively concentrates on the poorest group of the rural population. In other words, four to six different families are usually represented in cooperatives with 12 to 16 members (Hadjou, 1982, Farsoun, 1975; Ruf Weirner, 1980.

However, by early 1979 over 6,000 agricultural cooperatives were set up under the agrarian revolution. Most of the peasants are on small land holdings backed by the state. Nevertheless most of the peasants are wary of the government procedures because of the complexity of the agrarian revolutionaru system of production and problems with state management; the exacerbation of inequalities because of the benefits given to the more influential families and the unwillingness of individuals to work on land belonging to the cooperatives (Hodjou, 1982).

Both the agrarian revolution and the socialist villages have goals in the land reform, which as conceived implies radical transformation in the way of life of the peasantry. The relationship between the agrarian revolution and the socialist villages is that most of the inhabitants of the socialist villages are 'the peasantries' of the agrarian revolution. Consequently, the agrarian revolution neglects the traditional peasant sector in particular and there is a decline of productivity in nationalised agriculture in general.

Following the increasing state interference in the workers self management of the former colonial state, yield declined by 50 percent in the late 1960s and 1970s. Algeria has now started importing foodstuff, icluding 20 percent of its cereal and most of its dairy products and sugar (Bennoune, 1976). Agriculture's share in the GDP fell sharply from 17.5 percent in 1963 to 7.7 percent in 1978. Further, rapid

urbanisation and higher living standards (per capita GNP = 1200 US$ in 1980 compared to $200 in 1962) have widened the gap between urban and rural. Thus, per capita agricultural production has declined from an index of 100 in 1969-71 to 83 in 1977. Seventy percent of national food requirements were covered by domestic production in 1969 but the proportion had declined to 30 percent by 1980. The main agricultural export, wine, which was 98 percent of exports in 1967-68 had fallen to 11 percent by 1978 (Lawless, 1984). Algeria is reliant on the export of a few primary raw materials; oil and natural gas make up 90 percent of these.

Algerian socialist policy was changed by declaration in 1978, when the president declared "Reliance on oneself rather than on the state": During the first ten years of independence the private sector was virtually ignored by the government whose attention was firmly focused on self-management. The government adopted laws concerning private national investment, joint ventures, land purchases and the development of agricultural land by private individuals; liberalisation of the trade in fruit and vegetables. Up to 1975, the government's pricing policy for agricultural commodities actively discouraged the intensification of agricultural production.

Under the new government policy, the GDP continues to grow from ten to eleven percent per year, and new jobs are coming onto the market at a faster rate than the demand (Lawless, 1984; Belkacen, 1985). The government is campaigning for more efficient management and a 'new race of managers' throughout the economy, including agriculture to reverse the decline of 20 years experimentation in worker self management 'autogestion' and the 'agrarian revolution' of the early 1960s.

However, they have failed to halt the rural to urban exodus or slow the decline in production (Mark, 1985).

Tanzania:

Tanzania is a large, poor country. Over 90 percent of the total population lives in rural areas. The majority of peasants are involved in both subsistence production for the domestic market, and cash crops for export. The distribution of population is controlled by the distribution of precipitation. Tanzania does not have the problems of many other developing countries, with respect to land shortage, and only about half of the estimated cultivable land is in use. The high potential land was used by foreign-owned estates and plantations, and produced up to 40 percent of total commercial agricultural production. Tanzania space could be described as small islands of relative wealth in a sea of poverty (Briggs, 1980).

Since Independence in 1961, most of this estate and plantation land has been nationalised and agrarian reform has been set up. It entailed the ideology of rural socialism and self reliance, and involves 'ujamaa' villages. The state has monopoly control of almost all of the primary agricultural activities. There are standard forms of state intervention through investment in infrastructure, provision of agricultural and other credit, agricultural research and extension, and the various controlling activities of a large and growing bureaucracy (Lea and Chaudhri, 1983; Harriss, 1982). The state has laid great stress upon various policies to achieve 'socialism and self-reliance'.

The ujamaa Vijijini 'socialism in the villages', is a part of the nationalisation of 1967: the new ujamaa village should have to rely on

its own resources. Under socialist leadership, socialist policies of self reliance would develop agriculture, without the emergence of a rural capitalist class. In other words, Tanzania in the Arusha Declaration (TANU, 1967) gave the world a new nation based on socialism and self reliance. Development would not be based on money, industry, and foreign aid, none of which were forthcoming. Therefore, Tanzanian socialist strategy differs from other socialist countries, e.g. Algeria, in that it is the rural, not the industrialised urban sector, which is to be the socialist base of the economic strategy.

Since ujamaa was declared to be the cornerstone of government development strategy, its application became the task of the government and party officials. Within two years of the Arusha Declaration, the Rurul Development Association as the communal settlement in 1960 was closed down, and TANU and the government took over direct responsiblity for these villages (Cliff and Cunningham, 1973).

Ujamaa villages were slow to develop and failed to increase production. Nevertheless in 1969 the government switched from the stick to the carrot. Therefore, a regional development fund and expenditure for schools and services was provided to people who agreed to settle themselves in the ujamaa villages. Moreover, the World Bank extended schemes of supervised production of tobacco and tea, which realised greater success than communal production. In 1970, the second National Development Plan promised a 'frontal' approach which would extend ujamaa across the whole country. The rural capitalist farmers and rich peasants resisted the scheme. The conflict within rural communities is the result of peasant hostility to the local allies of an oppressive government. However, the government's own policy followed the dictates

of bureaucratic practice rather than Leninist theory or Moaist exhortation (Williams, 1976). The failure of forming villages (or settlements of communally ujamaa) turned into a programme of compulsory villagisation, without any element of communal production (Raikes, 1975; Coulson, 1975). Furthermore, the leaders argued that if Tanzanians are to succeed in realising the new society, they will have to take into account the objective realities within Tanzania, i.e. poverty and the rural nature of the economy To the extent that the government took certain measures - economic - political - educational and so on, it is certain that the development of the country would progressively depend on the decisions and resources of Tanzania, and it can be claimed that the foundation for self reliance was established. This is indicated by the growth of agricultural investment: in 1967 only Shs. 45 million were spent on agriculture. By the end of 1979 the figure was Shs. 400 million (Mohiddin, 1981; Cooksey, 1986).

Overwhelmingly, Tanzania has failed to produce economic growth. It is surprising that the country could not benefit from changes in economic policy. However, it started with next to nothing and has been assaulted by rocketing energy prices and heavy adverse movement in terms of trade affecting her major commodity exports such as sisal and cotton (Michael, 1986). For example, the Cashewnut Authority of Tanzania bought little more than 32,000 tons of cashews from local producers in 1984, highlighting the recent decline of this once flourishing industry. Such poor production figures were last recorded in 1958 when farmers sold 145,000 tonnes of cashews (Cooksey, 1986). The government has blamed the declining production on the biophysical environment and poor

farming methods. Others though blame the government and some of its outside advisors.

Through the 1970s, the government's critics say official policy discouraged production of export crops by peasants, who were treated as a source of investment for other sectors. The growth of parastatal crop authorities with monopoly purchasing powers, the abolition of cooperatives and the communisation programme were all meant to further state control of farm surpluses. By 1980 producers were receiving only 24 percent of the export price of raw nuts, down from 72 percent in 1970. Communcation was another big disincentive, while both these policies have now been officially reversed, the latest increase in production prices is only half the official inflation rate.

Eventually, the policies of rural development in Tanzania aim to prevent the development of privilaged capitalist classes in the urban and rural areas and to end dependence on foreign corporations by resting control of industry and marketing on the state and by the development of cooperative production in agriculture. But there was no alternative to open the country to others, such as handing land and profits to US agribusiness, further to the World Bank schemes which support tobacco projects, financing eight plants of cashews producers, plus two more to be financed by the Bank of Sicily to add to two existing factories built during the 1960s. Italian, British and Japanese companies were more than happy to build installations capable of processing more than 100,000 tonnes of raw cashews a year. Therefore, Tanzania is now saddled with millions of dollars worth of idle plants, and they have opted to intensify state and aid supported programmes for the industry. This means more of the bureaucracy and interference that brought the

sector it is knees. In addition to increasing the number of bureaucrats, decentralisation entailed the transfer of skilled personnel from one area to another. This inevitably caused confusion and inefficiency as well (Cooksey, 1986; Williams, 1976; Mohiddin, 1982).

Egypt:

Despite a twenty-five year development strategy that heavily favours industry, agriculture remains the largest sector in the Egyptian economy. It employs 44 percent of the workforce, provides 29 percent of the GDP and about 30 percent of the exports. The close linkage between farm and non-farm sectors, changes in aggregate agricultural output or its composition are generally reflected quickly throughout the entire economy. In 1952, after the agrarian revolution the agricultural share in the GDP was 28 percent. In 1975 it had risen to 30 percent of the GDP. The major structural change was the growth of the non-farm sector's share in the GDP.

However, Egypt's total area is about 100 million hectares. Arable land is limited to about 2,730,000 ha. growing almost all irrigated cash crops such as cotton, rice and maize, along the Nile River and its Delta in the summer, and rainfed crops in the winter. Vegetables are increasing in importance with three crop seasons per year. This means that Egypt is still dependent on the farm sector. Nevertheless, the distribution of land ownership was skewed, with 90 percent of the land titles being for lots of less than 2.1 ha. Leasing was common on about 40 percent of the farms, so that the average farmed unit was 1.5 ha (Ikram, 1980; Cooper, 1982; Kamal and Eshag, 1967, 1968).

Thus the Egyptian government has significantly intervened into the agrarian sector since 1952, and transformed it in a number of crucial

ways, with the agrarian reform laws of 1952, 1961 and 1969 regarding land ownership and tenancy. In Egypt as in Iran, attention has been given to the integration of land redistribution, in order to abolish a feudal system. In Egypt, government controlled production arrangements and provided services through cooperative societies and the associated credit banks thus displacing the private entrepreneur in providing facilities of input and output of farm production.

In the agrarian reform laws a legal maximum limit of land owernship was established. In 1952 4,000 landlords owned the same amount of land as 2.6 million peasants, and 1.2 million labourers were landless. A series of reform laws in 1952 set the maximum limit of land ownership at 84 ha for a single person, with 42 ha extra allowed for their dependent children, provided that the total did not exceed 126 ha (Abdel-fdil, 1975; Kamal and Eshag, 1967, 1968). In 1961 the upper limit was lowered to 42 ha for single owners and in 1969 it was lowered for a third time to 21 ha per person or 42 ha per family unit (Ikram, 1980; Kamal and Eshag, 1967, 1968). Changes in land rents, tenancy conditions and farm wages affected many people. Consequently 12.5 percent of the arable land was distributed amongst about 9 percent of the rural population in 1970, in plots of at least two, but not more than 2.1 ha per family. In other words, the average holding rose from 0.33 to 0.50 ha (Abdel-Fdil, 1975; Ikram, 1980; Byres, 1983).

On the other hand, the relationship between landlord and tenant made it almost impossible to remove a tenant unless he failed to pay his rent for several years. Therefore, about 40 percent of the total area continues to be rented in one of the legally specified ways. Moreover, this law has divided equally the income between tenant and owner (Ikram,

1980; Kamal and Eshag, 1967). Thus, through these changes in land ownershp and tenancy, the Egyptian government insured the sanctity of private property and reinforced small famer production as the predominant form of production with Egyptian agricuture in order to alleviate rural poverty.

The government intervened directly on an increasingly wider scale from the nationalisation of the cotton trade in 1961 to a system of government monopolies, exchange controls, price differentials and compulsory delivery of the export crops to maintain supplies. The government had reorganised the cooperative system through land consolidation, pest control and modernisation of the farming system (Ikram, 1980; Cooper, 1982; Kamal and Eshag, 1967).

The mechanism of agrarian reform in Egypt is indicated in the changing of the "Izba" system, which is a relic from the 19th century. A creation of Egypt agrarian capitalism, Izba is comparable with the 'hacienda' and other systems of large farm units. As a result of agrarian revolution in Egypt Izba has lost its former importance in Egyptian agriculture, and it has been replaced by the large state schemes as a production unit (George, 1981: Samire, 1977). The system of Izba has been destroyed by the Nasserite Revolution, and it was replaced by the class of the village headman. In addition, the gap between the small cultivator and the rich farmer has narrowed as a result of the 1952 and 1961 laws (Weinbaum, 1982). Despite these inovations, the number of landless rose from 40 percent to 50 percent between 1952 and 1972. Regulations relating to tenancy, as elsewhere, were not as effective as had been hoped. In 1975 there was also a trend towards removing the provision of security of tenure F.A.O., 1981;

Cooper, 1982), because population growth had been ignored by policy makers for too long which created a major problem of employment.

On the other hand, the influence of the green revolution was to weaken the small farmer and the availability of resources for agricultural investment was limited for the period up to the early 1970s. This was entirely opposite to the Libyan and Algerian economic circumstances.

Now, resources are relatively available from migrant workers' remittances, tourism, the Suez Canal, and external assistance. The policy package introduced in the 1960s was basically unaltered with marginal changes resulting from the open door policy in 1973. The Sadat regime started to establish state farms, such as El Tahrir project. This aims to double the cultivated area by the year 2000 (Allan, 1982). In other words, the development strategy in Egypt has concentrated recently on increasing the area of irrigated land. By the end of 1976, the government had reclaimed 300,000 ha of which about 100,000 were kept as state farms or large scale agricultural industry. These schemes were implemented under integrated development and settlement of new land irrigated by high dam water. These are to establish and develop the self help schemes.

Finally, Nasser's regime which placed emphasis on bringing new land into cultivation was replaced by Sadat's scheme stressing industry and related economic activities following the policy of the Open Door Economy (Weinbaun, 1982; Allan, 1982; Cooper, 1982). The recent development plans in 1980-84 give food and agriculture top priority encouraging Egyptian private capital and foreigners to invest in land reclamation as well as vegetables and export crops. The same situation

has been repeated in both Algeria and Tanzania in recent times. On the other side, the use of scientific agriculture for land reclamation or 'Green Revolution' was a national endeavour which would make a substantial growth of agriculture production such as in Libya in recent development planning where emphasis is more on vertical expansion, particularly in a region of insufficient natural resources.

Libyan Rural Development Strategy:

The revolutionary regime has guided Libya on the road of state capitalism and Arab nationalism. In this path, Libya is different from the petit-bourgeois, technocratic regimes of Algeria, Egypt, Syria and Iraq. Libya has sought to avoid excessive reliance on either the capitalist or socialist camps through diversifying its relationship with the two camps. Libya is different in another way from the other Arab countries which have undergone 'revolution'. It has a capital surplus, but is poor in natural resources except for minerals. Therefore, the ideology of the revolutionary regime has a strong populist aim which seeks to abolish exploitation and ameliorate the neglect of rural Libyans; who had suffered at the hands of the tribal `aristrocracy, exploiting capitalists and foreign imperialists.

The populism is anti-communist and anti-Marxist. It views "Arab Socialism" or the "Socialist Islam" in terms of "social justice" and mutual egalitarian rights and responsibilities. Therefore, the government involves itself and intervenes in the economy, as a means of realising greater Libyan control over its economic resources. This process was implemented by the progressive nationalisation of various economic sectors and the state stated, participation and control of the

productive sectors, in order to achieve self sufficiency in production and to liberate the national economy from foreign influence (Collins, 1974; Allen, 1981; 1983; Habib; 1975; Ruth, 1974; El-Fathley, 1977, 1980; McLachlan, 1982).

The Development of Agricultural Institutions: By 1970 the state had established a number of state corporations to cope with the many agricultural problems and to channel the increased amount of investment to that sector, particularly into new projects. In the late 1970s, cultivation practices were changing from subsistance farming to highly mechanised production, although animal-drawn equipment could still be found in use, especially on traditional farms. The new regime established a number of executive authorities to carry out the state programmes and policies, namely the Secretariat of Agriculture and Agrarian Reform, the Secretariat of Dams and Water Resources, and the Secretariat of Land Reclamation and Development. All of these implemented the policies established by the Council of Agriculture Development, which was formed in 1974 for long range planning of integrated rural development. These have created a dilemma of organisation see Mabogunje, (1981), which restricted and slowed down the process of rural development in the country. The most important state body was the Secretariat of Land Reclamation and Development, which engaged in agricultural development and was responsible for the establishment of five main agricultural projects; Gefara Plain, Jebel El Akhdar, Fezzan, Kufra and Sarir and Salul El Khaddar. The largest, on the Gefara Plain, involved six sub-projects totalling some 509,700 ha. At Jebel El Akhdar the project to improve dry farming and animal

husbandry took up 508,900 ha. The two additional sites include massive challenges, since both are in the southern Sahara region, Kufra and Sarir where the latest irrigation techniques are being introduced, includes a total of 97,200 ha. The Fezzan scheme is located in the most isolated area south of Libya, where 37,700 ha on six projects is being used for the development of 1,440 farms. The Salul el Khaddar projects of pastures and rainfed production involve 406,600 ha.

The Effect of National Policy and Planning Decision on Agricultural Programmes: The projects were run directly by the state to carry out land reclamation and settlement schemes throughout Libya. At the same time the government continued the policy of assisting the farmer through subsidies of as much as 50 percent, including seeds, fertilizers, pesticides, agricultural machinery and fuel, as well as fodder. Interest-free agricultural credit facilities were officially provided for those in need (S.P.L.A.J.,Agricultural Bank, 1977).

The agricultural policy aims to achieve food self-sufficiency. To attain this, the state has exerted a great effort, and allocated huge financial resources for the promotion of this vital sector of the national economy. For example, during 1970 to 1983 L.D. 3396.9 million was earmarked for agriculture, agrarian reforms, land reclamation, nutrition and dams and water resources (see Appendix 10).

Libya has a dualistic strategy of agricultural development. In a way, Libyan agriculture is not very amenable to transformation. Capital in itself, even capital which provides access to a 'green revolution' and allows the importation of farm labour cannot transform agriculture.

Libya has invested massively in modern agriculture, which makes nonsense of conventionally desirable capital output ratios. The Libyan agricultural policy is flexible. This is explained by the development of remote regions (desert) which may not be economic, but there is a human aspect because it is not fair to concentrate solely on economic aims in a developing country like Libya, since economic development plans differ mainly in their motivation. Generally, the aims of development plans are to raise per capita income in all countries, but the decisive criteria may be more social, political or strategic than economic, Hodder, (1980). In 1970 the state, in its agricultural investment strategy emphasised reclamation and irrigation of as much land as possible. Although less than 5 percent of the land will ever be suitable for agriculture, some 2 percent is arable, and one percent is forest and pasture, but the Libyan state intends to raise the degree of self sufficiency in food production.

To achieve this goal, agriculture received 25 percent of development spending according to the first plan, 1969-1973. The proportion of funds allocated to agricultural development in the 1976-80 plan had fallen to 17 percent. Even at this level the allocation was much higher than was consistent with the natural and sustainable development of agriculture (Allan, 1981). The government initiated a large scale land reclamation programme in 1971. A high percentage of the national budget is now being spent to support 5 regional agricultural development programmes, as mentioned. These can only be expected to bring long term and indirect results. Up to the end of 1983 the number of the agricultural development projects in the country had reached 117, and the area of the projects which have been

finished or are under construction was about 2,398,379 hectares up to the end of 1983. These are divided into firstly, agricultural and productive projects mainly located in the desert area. The total area of these projects is about 79,000 hectares, 34,000 ha of which are irrigated (El Kufra and Sarir), and 45,000 ha are rainfed production, such as El Salul El Khadar projects.

Secondly Libya has agricultural settlement projects. Up to the end of 1983 there were 75 projects, which occupied more than 500,000 hectares, about 75,000 ha of which were irrigated and the remaining were rainfed. There are 21,000 farms within these projects, and the total area of the lands of 14,000 farms which are planted and reclaimed is about 300,000 hectares.

The state oriented capital intensive settlement schemes were designed to meet growing urban demand. For example, the Jebel El Akhdar project is designed to regulate the process of the settlement of semi-nomadic communities in the Jebel area, and to create a community of family farms with limited holdings which conform to a uniform pattern of land use and husbandry practice. It planned to avoid wage labour as befits the socialist regime. This attempt at creating a new community of small holders has parallels all over the Third World, where settlement schemes have been set up involving new crops, particularly cash crops and new land (as in many irrigated schemes) or even new farmers.

Dilemma of Farm Development Strategy: Nevertheless, Libyan agriculture includes a private sector which juxtaposition the state sector. By 1980, the agricultural sector was the only sector where a significant share of production was in private hands. Its share in 1980 of the three most value adding agricultural commodities, fodder, vegetables and

TABLE 2.1: Total Land Reclamation Programme and Achievement up to 31/12/1983

Description of Project	Unit	Total of Programmes	Total Achievement up to 31/12/1982	Total Achievement up to 31/12/1983	%
Reclamation and Land Development	Ha.	2,398,379	1,205,275	1,255,275	52
Drilling productive wells	Well	3,870	2,823	2,942	76
Irrigation networks	Ha.	140,283	88,138	88,719	63
Farmers houses	House	22,518	10,174	12,527	47
Paved roads	Km.	56,398	2,525	2,604	46
Unpaved roads	Km.	18,072	14,355	14,827	82
Fruit and palm trees	Tree	28,959,446	17,794,016	20,229,012	70
Forest trees	Tree	151,063,088	66,355,293	70,492,710	47
Wind breakers	Tree	76,488,752	54,228,289	58,233,331	76
Grain crops for 83/84 season	Ha.	312,865		62,173	
Improving pastures	Ha.	748,767	406,292	432,292	58
Training		18,999	10,659	10,784	57
Distribution to the farmers					
Tractors	No.	12,790	6,316	6,933	54
Seed sowers	No.	3,799	1,772	1,814	48
Ploughs	No.	17,455	10,143	10,609	61
Trailers	No.	11,832	5,303	5,716	48
Sheep	Head	310,230	120,517	129,312	40
Cattle	Head	15,977	3,538	3,542	22
Poultry	Birds	1,489,220	211,830	223,305	15
Honey beehives	Hives	29,845	2,311	2,361	8
Productive farms	Farms	21,976	14,090	13,283	65

Source: SPLAJ, The General Popular Committee for Agricultural Reclamation and Land Development, 1985
The Green March, Tripoli, 22

fruits, was 100%, 98.2% and 90% respectively (Allan, 1986; Agrawal, 1982). The settlement schemes for farmers are also highly conducive to more balanced regional growth and provide encouragement to the private sector, which still enjoys government aid in different ways through subsidised farm input,and credit. Further to that, almost all trade with Libya is state controlled, with national purchasing agencies responsible for pricing and distributing imported and home produced goods. Farmers enjoy the unique dispensation in Libya of being able to market their own products.

Thus the Libyan government in its agricultural investment strategy has been reluctant to opt for large scale direct production as there is little confidence in state managed schemes, at least in areas such as the Jebel El-Akhdar. There are good political reasons for accommodating local demands for privately owned family land. The state has also ruled out an approach based upon a mass of small holdings. This is largely because of its confidence in the transformation of agricultural production which needs fairly substantial holdings. The Jebel El Akhdar approach is hardly a middle course between small holders and direct production strategies, and the sheer cost of transforming agricultural production in this way limits the relevance of Libya's policy for Third World countries elsewhere. Yet the dilemmas for Libya are familiar (Howell, 1978), in the search for a new approach in agricultural strategy.

This has been indicated by the government centralised socialist approach to economic decision making. By the end of the 1970s a totally centralised approach to import activities had emerged, for example, only rural land remained outside the socialist structure by the end of the

1970s. Meanwhile, the reorganisation of the coastal strip has been evaluated and reevaluated many times by popular committees from 1978 onward (Allan, 1986). The purpose of this project is to group small farms into large units to facilitate technological services and to maintain natural resources, such as water resources. On the other side of the country, in 1984 the Jebel El Akhdar Authority established new apple farms in single units of up to 1,000 ha at El Garigh sub-area in El Marj plain area. This is a foci of collective farms in the area. Moreover there are self-management schemes which started in the south west Benghazi plain. It includes small farms of 2 ha for self sufficiency. These are based on the necessity for maximum food production and minimum consumption, and the direction of energies towards agricultural production and [illegible] on national resources for food, together with development of light industries based on local food resources. There is a programme of revolutionary organised team work. This is mainly encouraging people to reclaim and plant their lands by their own effort while providing them with the necessary inputs such as machinery and plants. Subsequently, about 2 million fruit trees have been planted in the Jebel Al Gharbi (Tripoli) and about 2.5 million in the Jebel El Akhdar during the planting season of 1983-84 (SPLAJ, The General Popular Committee for Agricultural Reclamatino and land Developments 1985). Thus the declaration of policy was more radical and technocratic than other systems, in order to achieve social justice.

Libya Compared with other African Countries: The Libyan economy, unlike that of many other developing countries is not constrained by problems of unemployment and lack of adequate funds. Natural resources, land,

water, climate, skilled human labour and infrastructure are the same in most North African countries. Moreover, inherent biological characteristics of plants and animals, the traditional socio-economic attributes of societies particularly in Egypt are equally, and sometimes even more important. Land, water, manpower, organisation and management are crucial to the development of agriculture in Libya, and due regard has to be given to their potential in defining the role of the agricultural sector in the future economic development of the country. Overwhelmingly, Algeria, Egypt and Libya with closely related historical and cultural features on the one hand, and geographical and ecological harmony on the other, are similar. These resources are sufficient to serve development planning in each country generally.

Most independent African countries give the first priority to industrial development through the context of the growth centre. But some countries with good incomes from oil, such as Algeria and Libya, give agriculture a top priority in development, in order to provide markets for industry (in Algeria) and to attain self sufficiency in food (in Libya). The economy of Libya and Algeria has been dominated by the energy exporting sectors, and Libya has had much larger oil reserves available than Algeria to use for a social rural development policy. On the other hand Algeria and Egypt are more highly populated countries than Libya and both Egypt and Algeria's old Colonial overload are dependent on outside consideration. However, in many developing countries the development approach is inherited from the national social philosophy, as developed by a leader and propagated by a political party. For example, Tanzania, Algeria, Egypt and Libya in Africa. Rural development has also derived from the state's response to urgent

action for helping the rural population. For example, in Kenya and Ethiopia, the resettlement schemes were clearly an attempt to meet the urgent need for employment and to give security to the landless (Taylor, 1974:1981). The same procedures have been noted in Egypt, Algeria and Tanzania, while in Libya they are pursued not only for the sake of providing employment for landless people, but also to increase the food supply and to raise the level of living in rural regions which are practising traditional agriculture. Due to human environment conditions, agricultural development in Libya is not only a costly, but also a slow process.

Therefore, the development plans have been launched in the terminology of Afican socialism, but the practice of socialism has been observed more in the breach than in fact. In comparison to Tanzania, Libyan socialism has received little attention, while the same observation was made in Algeria and Egypt in the early time of independence. More recently, in the mid 1970s, Algeria and Egypt have shifted slightly from strict socialism, due to the failure to apply socialism in agricultural production.

Potential of the Agricultural Sectors of Libyan Economy: Since local production depends almost entirely on imported inputs, it will be clear that unless the farming sector is highly efficient, farming in Libya is not a viable economic proposition (McLachlan, 1982). Thus the present policy of agricultural development and must be based on energy and foreign exchange saving innovations. It must also involve more intensive use of land and a continued shift in the cropping system towards high-value crops in response to changing demand (Allan,

1980;1983b). This is done by applying several of the appropriate technologies and investments, including the green revolution. It involves such practices as the development of new varieties of wheat in El Marj and using chemical fertilizers and mechanisation, in addition to establishing greenhouses.

The principal focus of this brief discussion is upon the alternative strategies that are open to the decision makers in the Libyan economy which might be expected to improve nutritional levels in the country, raise the income of rural people, and limit rural urban movement. The framework within which alternative strategies are examined is characterised by an emphasis upon econmic regions. As indicated previously, Libya as a whole, and Jebel El Akhdar particularly, do not constitute a perfectly homogeneous geographical environment. Physiographic differences within the region are dramatic.

Although these variations are clearly visible, the importance of a regional approach to agricultural development lies more in the differences that now exist, and can be expected to persist in the availability of the inputs needed for agricultural development.

State Intervention in Agricultural Strategy: The major cause of the quantitative and qualitative change of farming activities in the country generally and in the region of Jebel El Akhdar particularly, must be in the rapid industrial expansion in the 1970s and in development directly or indirectly related to this process, of which three factors deserve special attention:

(1) The process of urbanisation took place within a very limited time and with a very little land see Keizeri, (1984). The reason for that is

constrained land resources to allow most farmers affected by urban and industrial projects to be allocated to an alternative smaller piece of land in the farming resettlement area. Besides, due to the limited agricultural resources of the vast land available, farmers are forced to intensify production methods if they want to make a living from agriculture. This is due to the fact that the farming system in the country is a way of life and not merely an occupation or a source of income.

2 The revolutionary government plays a very active role in the development and progress of the nation, with respect to the agricultural situation. Government policy seems to be inspired by the following considerations:

(a) It has decided to maintain or raise the degree of self-sufficiency in food items which are produced locally, in particular as far as the supply of cereal and fresh vegetables, milk and eggs are concerned. As these essential food items formed almost 50% of imported items, complete dependence on foreign sources of supply is therefore undesirable. Thus the government has set up particular areas of land for farming purposes, as just mentioned in the previous discussion.

(b) Government policies and programmes at all levels are influenced by the way land owners use their land and are in fact specifically designed to affect land use. Programmes and regulation such as reclamation of land and infrastructure facilities directly influenced land use by design. Other factors indirectly affecting land use include subsidies on marketing, incentive regulation and research which in their administration necessarily produce land use effects.

A brief discussion of certain factors is necessary to show how they

have influenced land use in the region. The government has established general procedures for agricultural development in the country to overcome the socio — economic obstacles, like fragmentation and alinenation of land to private owners, particularly in traditional irrigated farming, and the predominance of common land. These have been effected by various laws which have been enacted in attempts to control agrarian reform in Libya. Law 142 of 1972 placed all tribal lands and other unregistered lands under the control of government. Law No.123 of 1970 regained land from non- Libyans and provided for the distribution of agricultural lands, future reclaimed lands and virgin land to appropriate farmers to solve the problem of the landless [Jabal al Akhdar Authority (J.A.A), 1978]. To limit the scope of ownership, Law No.4 of 1977 restricted housing and real estate ownership to one per family, if it could be attained.

As a result of that, land is considered a public domain and cannot be privately owned. Each individual is entitled, however, to use land for production purposes in order to satisfy his material needs. This was intended to break up large tribal land holdings, and prevent exploitation and income disparity, which might follow from land ownership (Al Qathafi, 1979).

Therefore, land distribution was changed after these laws had been enacted. Consequently, the number of land holders counted in 1984 was 23.5 percent more than in the agricultural census of 1974. During the last ten years arable land expanded from 1.89 million ha in 1974 to 2.64 million ha in 1984. The percentage of growth was 39.6 percent between the two agricultural censuses. The percentage of irrigated land and rainfed land has grown by 65.9 percent and 35 percent respectively in the same period.

TABLE 2.2: Comparison of Agricultural Land Between the Years 1974 and 1984 in Libya:

Agricultural Census	Arable Land Ha.	Arable Land Ha.		Number of Land Holders	Number of Holdings	Number of Population	Average size of Holding
		Irrigated	Rainfed				
1974	1,891,838	282,250	1,609,588	160,999	2,090,000	2,249,237	14.5
1984	2,640,614	468,127	2,172,487	186,815	3,310,000	3,637,488	18.1
% of growth between 1974/84	39.6	65.9	35.0	23.5	58.4	55.8	

Source: Computed from: (a) Secretariate of Planning (1985),
Primary Results of Agricultural Census 1984, Tripoli
(b) Secretariate of Planning (1985)
Primary Results of Population Census 1984, Tripoli

The total area of holdings in 1984 was 3.31 million ha, while it was 2.09 million ha in 1974. The percentage of growth was 58.4 percent. This is comparable to the population growth of about 55.8 percent during the same period. As a result the average area of holding was 14.5 ha in 1974 and increased to 18.1 ha in 1984. Thus, the spatial implication of agricultural development policy is to expand the physical linkages into the rural areas, in order to minimise the friction of space and to provide food self sufficiency.

Furthermore, Law No.46 of 1971 on agricultural cooperation encouraged the establishment of cooperative societies, and subsidised them at a rate of 50 percent of the purchase cost of basic production requirements. It also subsidised the purchase of irrigation equipment by 75 percent. In addition, legislative measures were enacted during 1974 and 1975 to develop the scope of cooperative linkages with the agrarian conferences, which increased from 74 to 350 between 1974 and 1983 (S.P.L.A.J., the General Committee for Agricultural Reclamation and Land Development, (1985). They reorganised existing units which forced all farmers in the country to be members of an agricultural cooperative society. It has provided its members with the different means of promoting their production, and through the cooperative society the farmers sell their agricultural products. The agrarian cooperative structure also meets the expansion of the functions of the agrarian conferences, whose aim, in principle, is to assist the farmers to cope with the new technology in agriculture.

Conclusion:

Certain conclusions might be drawn from this layout of alternative

choices. It may be that the case for strategic planning is very strong. A policy of encouraging the private sector and using state resources to facilitate its operation. This might lead to imbalance and a dual economy. In other cases the development of agriculture is based on more advanced technology to introduce a balance between productive sectors (industry and agriculture). This is summarised in intensive capital investment, which varies from one country to another depending on the economic situation of the particular country or the access to foreign aid.

These are represented by integrated rural development, which relies on the institutional and administration components to have substantial effects on rural production and incomes comparable with a partial rural development. Nevertheless, a strategic choice of integrated rural development would involve the diversion of considerable resources in human potential and money, which might only give a slow and low rate of return over a long period of time, from other needs which might give a quicker return and higher growth rate. Overwhelmingly, these depend on the ideological aspect of the nations policy and the need to keep a balance between social and economic needs and between urban and rural sectors.

Clearly the tasks and methods of implementation vary enormously with the chosen rural development strategy. If priority is given to industry and attention to agriculture minimised, the task might be left to private enterprise and state resources might be oriented to infrastructure without any great concern with land reform, services to farmers and organisation of farms or agricultural istitutions. The idealistic approach gives emphasis to simultaneous development of

agriculture for both the social and economic aims. A greater emphasis must be put by the government on scarce national resources both human and financial, on improvement in organisational methods of state agencies and on detailed practical ways of ensuring that the benefits of improved agricultural production are widely distributed to farmers with less efficiency.

CHAPTER THREE

CLIMATE AND CROP ECOLOGY

INTRODUCTION

The climate of the Jebel El Akhdar is Mediterranean with winter and spring cyclonic depressions and west north westerly winds causing precipitation. Rainfall averages 250 mm on the north coast (latitude 32° 50N) increasing to 300m on the inland plateau, reaching 600mm on the high mountains above 650 metres. South of latitude 32°N beyond the mountains: it is generally rainless.

GENERAL PATTERN OF THE CLIMATE:

Spatial Rainfall Distribution: Outstanding features of Table 3.1 and Figure 3.1 is the uneven distribution of precipitation through the year. The rainfall decreases slightly westward as a result of the configuration of the coastline, with western northern slopes directly facing the prevailing airstreams; e.g. the rain reaches Shahat which is without modification bringing an average 561 mm higher (620 m.a.s.l) and closer (9km) to the coast.

The rain falls characteristically in the form of showers, which vary considerably from one year to the next in the same place, and may differ in two neighbouring localities in the same year.

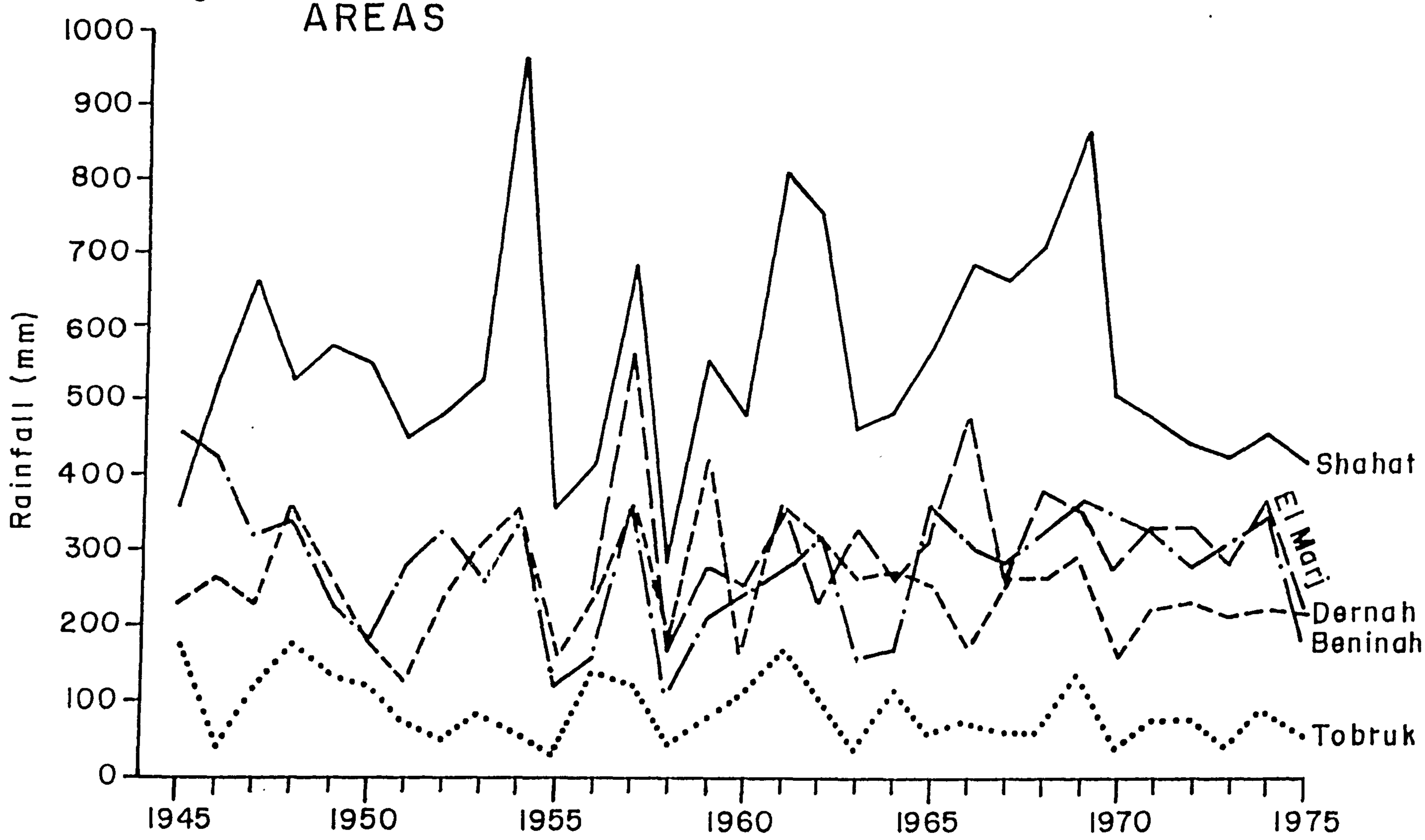
Table 3.1 and Figure 3.1 illustrate the important differences that exist between annual rainfall in the coastal area and the high inland plateau. Figure 3.2 indicates the significance of the relationship between rainfall and topographic profile between Benghazi in the west

TABLE 3.1: Monthly Rainfall Data Relevant to the Total Study Area and the Area of Detailed Study.

Station	Altitude	Km From Coast	Years Observed	Period of Observation		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
			20	1921 - 1940	Max mm	185.7	102.3	89.5	28.9	9.0	3.8	1.0	0.2	24.6	90.8	146.6	170.6	489.7
Benghazi		0	20	1958 - 1972	Mean mm	84.6	14.3	39.4	1.6	3.1	0.0	0.0	0.0	0.0	0.0	67.7	57.5	228.2
			20	.	Min mm	22.8	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.5	167.4
					Max mm	212.6	134.8	59.1	39.7	45.5	0.0	0.0	1.0	44.7	56.8	126.2	167.3	457.4
Beninah	122	20	33	1945 - 1977	Mean mm	69.8	36.9	42.4	7.4	0.2	0.0	0.0	0.0	5.7	20.5	30.0	68.3	267.3
				.	Min mm	7.4	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.3	127.8
			14		Max mm	188.5	134.5	59.8	28.6	29.3	2.1	0.5	2.5	12.6	118.3	104.8	245.6	482.8
Tolmeitha	0	0	7	1969 - 1975	Mean mm	90.8	49.0	15.1	19.0	4.2	0.0	0.0	0.0	9.7	11.7	48.4	38.5	200.5
			14	.	Min mm	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	6.4	87.1
					Max mm	142.7	142.8	107.2	55.5	40.4	2.7	0.0	0.0	60.6	189.1	172.4	163.6	436.8
Dernah	8	0	33	1945 - 1977	Mean mm	54.7	35.0	24.0	9.2	5.3	0.0	0.0	0.0	7.4	41.2	30.6	48.2	256.0
				.	Min mm	5.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	124.4
					Max mm	55.5	56.5	49.7	30.1	9.6	0.0	0.0	0.0	9.9	48.7	95.2	86.2	308.0
Tobruk	155	10	33	1945 - 1977	Mean mm	26.3	13.8	11.4	4.3	3.9	0.0	0.0	0.0	1.7	10.6	10.7	16.7	105.5
				.	Min mm	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	30.3
			12		Max mm	109.0	109.5	81.6	27.4	19.4	1.9	1.2	0.9	10.0	60.3	73.6	176.9	389.9
Al Abayer	291		17	1924 - 1941	Mean mm	61.2	55.1	22.4	31.6	4.3	0.2	0.1	0.1	1.1	15.6	30.9	84.5	307.1
			12	.	Min mm	18.1	21.0	1.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	19.4	127.9
			21	1921 - 1940	Max mm	240.9	255.4	214.0	159.5	9.5	6.7	4.7	4.5	20.0	131.0	190.4	242.1	773.3
El Marj	282	20	42	1956 - 1977	Mean mm	112.4	69.0	38.2	16.9	4.8	1.1	0.0	0.0	1.5	35.6	40.4	94.2	399.8
			21	.	Min mm	37.7	19.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8	280.3
			11	1928 - 1940	Max mm	163.5	151.9	51.7	30.7	30.5	9.5	1.0	1.5	6.1	52.1	85.0	112.7	339.0
Marawa	505	33	30	1959 - 1975	Mean mm	73.2	52.7	20.7	13.1	3.8	0.0	0.0	0.0	5.2	14.7	20.7	41.0	241.7
			11	.	Min mm	14.5	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	12.3	105.0
			23		Max mm	287.7	284.5	145.6	165.7	72.2	31.3	3.3	42.1	66.4	371.4	169.9	357.2	963.4
Shahat	621	9	33	1945 - 1977	Mean mm	127.4	79.5	64.5	24.1	9.0	2.2	0.9	2.3	10.8	59.9	67.5	112.5	562.8
			23	.	Min mm	26.2	16.2	6.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	9.8	8.0	283.7

Source: (1) Fantoli (1968) Contribute Allu Climatologia Della Cirenaica, Rome. pp. LIV, Table 4.
(2) Ministry of Communication. Meteorological Dept. - Monthly and Annual Climatological Data for Libya. Tripoli (Undated).

Fig. 3.1 FLUCTUATION OF ANNUAL MEAN RAINFALL IN SELECTED AREAS



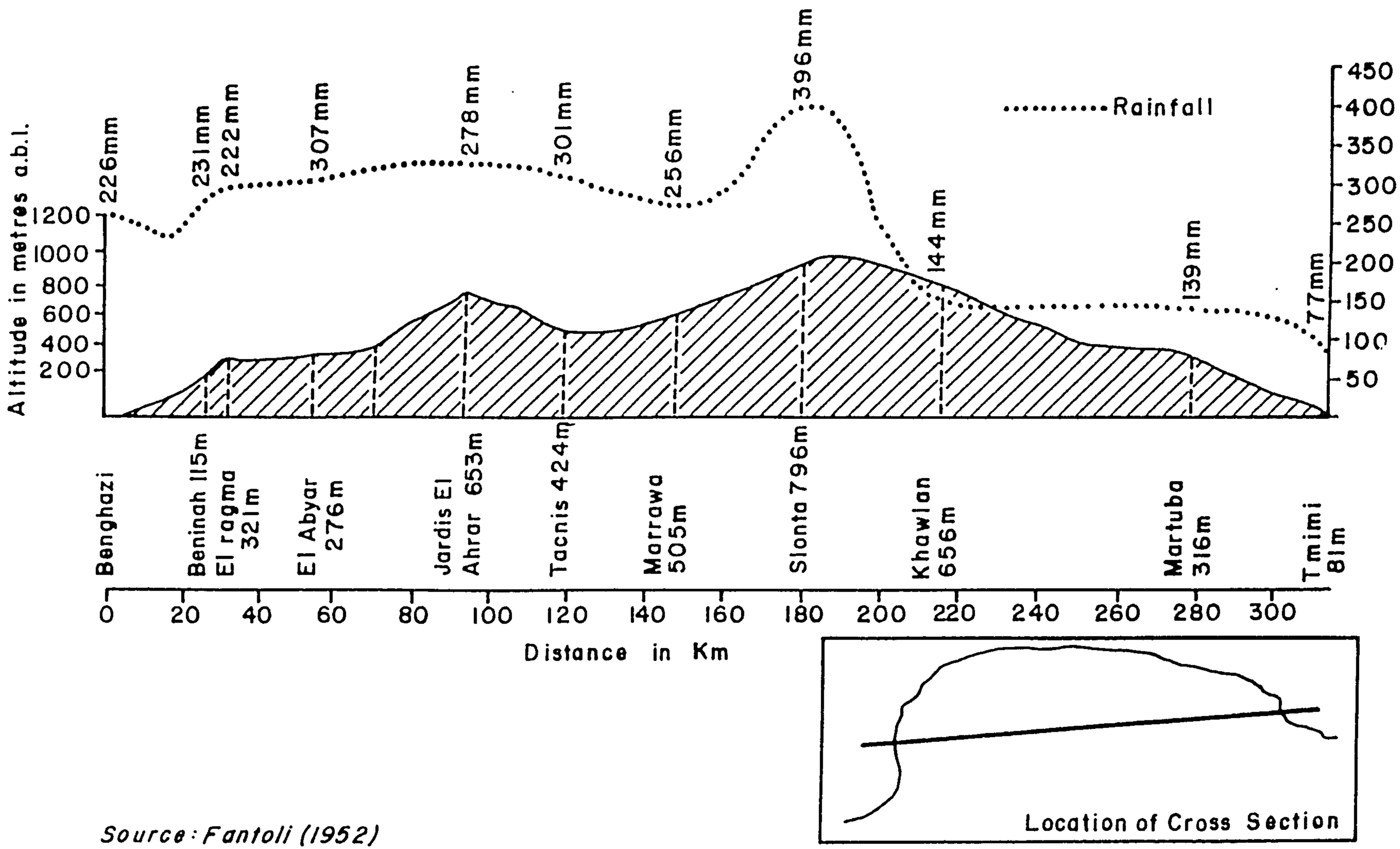
and Tamimi in the east, through the second terrace inland from the north coast. Precipitation is 228 mm at Benghazi at sea level whereas precipitation is 307 mm at El Abayr at 276 m.a.s.l. There is significant control by altitude shown in the rainfall decrease between Jardis El Ahrar and Marawa. This is attributable to the rain shadow because of the topographic saddle between Tacnis and Marawa.

El Gubbah station with 353.5 mm less than 600 m.a.s.l is very similar to Ayn Marrah which receives 346 mm very nearly at the 470 masl, but 12 km east. Both are in a slight rain shadow of Lamludah which receives 400 mm at 658 masl 10 km to the west.

There is a correlation coefficient of 0.520 between mean annual rainfall in mm and altitude in metres for 10 stations (Fig.3.2). These data range from 33 years for some stations to less than 10 years for others, so a time series of variability has not been attempted.

Table 3.2 shows with the pluviometric gradient of rainfall between El Fatayah and Dernah based on 19 years of observation as 8 mm for every 100 metres of altitude. The gradient between Shahat and Sussa is about 25 mm for every 100m height. The figure for El Marj and Tolmeitha is higher, about 48 mm for every 100 m. The explanation for this is attributed to the distance from the sea in a straight line, and also due to the site of Shahat and El Marj on the second escarpment, exposed to the rain bearing winds. Further, El Marj is located in a closed basin surrounded to the north by the first escarpment which rises to 40-50 m above the plain. Five Km to the south the plain is dominated by Jebel El Abid which rises to 168 m above the plain. Correlation of mean annual rainfall with distance east from Benghazi and separately with distance from the nearest coast showed very low coefficients, none of which were significant.

Fig. 3.2 DISTRIBUTION OF ANNUAL RAINFALL IN RELATION TO RELIEF PROFILE BETWEEN BENGHAZI, EL ABAYR, TACNIS, KHAWLAN AND TMIMI (INLAND)



Source: Fantoli (1952)

TABLE 3.2: Pluviometric Gradient at Selected Stations:

Zone	Station	Altitude above sea level mm	Rainfall annual average	Pluviometric gradient each each 100m alt.
Steppe Continental	El Fatayeh	253	336	8
Maritime	Dernah	10	315	
Altipiano	Shahat	621	528	25
Maritime	Sussa	6	340	
Western Altipiano	El Marj	285	492	48
Maritime	Tolmeitha	5	351	
Altipiano	El Regima	321	288	7
Maritime	Benghazi	25	263	

Source: Fantoli, A., 1952, Le Piogia della Libia, Rome, p.281

Rainfall Distribution in The Year:

Figure 3.3 shows the monthly rainfall pattern. The precipitation is greatest between October and March. There is some rain in the last fifteen days of September, and the beginning of April, and into May. Through June, July and August there is generally total drought.

Table 3.3 indicates frequency of rain days at selected stations. Two stations show the pattern. At Tolmeitha, the total number of rainy days is 54, of which 38 days are in the wet season; as a percentage it is 87% for the period of October to March and 13% for April to September. However, Shahat's rain occurs on 82 rainy days, concentrated on 70 days in the wet season and 12 days in the dry season (Fig. 3.4). Consequently, it is distributed through the rain months as follows: 42.7% December and January; 25.5% February and March: 22.6% October and November. This means that 90.8% of the total annual rainfall is in the wet season or the half year October to March, and 9.2% in the dry half of a year April to September.

Seasonality:

Instead of the traditional dry and wet season in absolute terms, an alternative system used by Jackson (1977), defines the "annual total 250-650 mm as a short rainy season (3-4 months each 50 mm) and one long dry season".

Table 3.4 shows that the commencement of the wet season coincides with the first month during which the ratio of the monthly to the annual rainfall exceeds the 10% level. Similarly the termination of the wet season is marked by the month after which rainfall is always less than ten percent of the annual mean. This relates also to the growing

Fig. 3·3 MONTHLY RAINFALL DISTRIBUTION AT SELECTED STATIONS

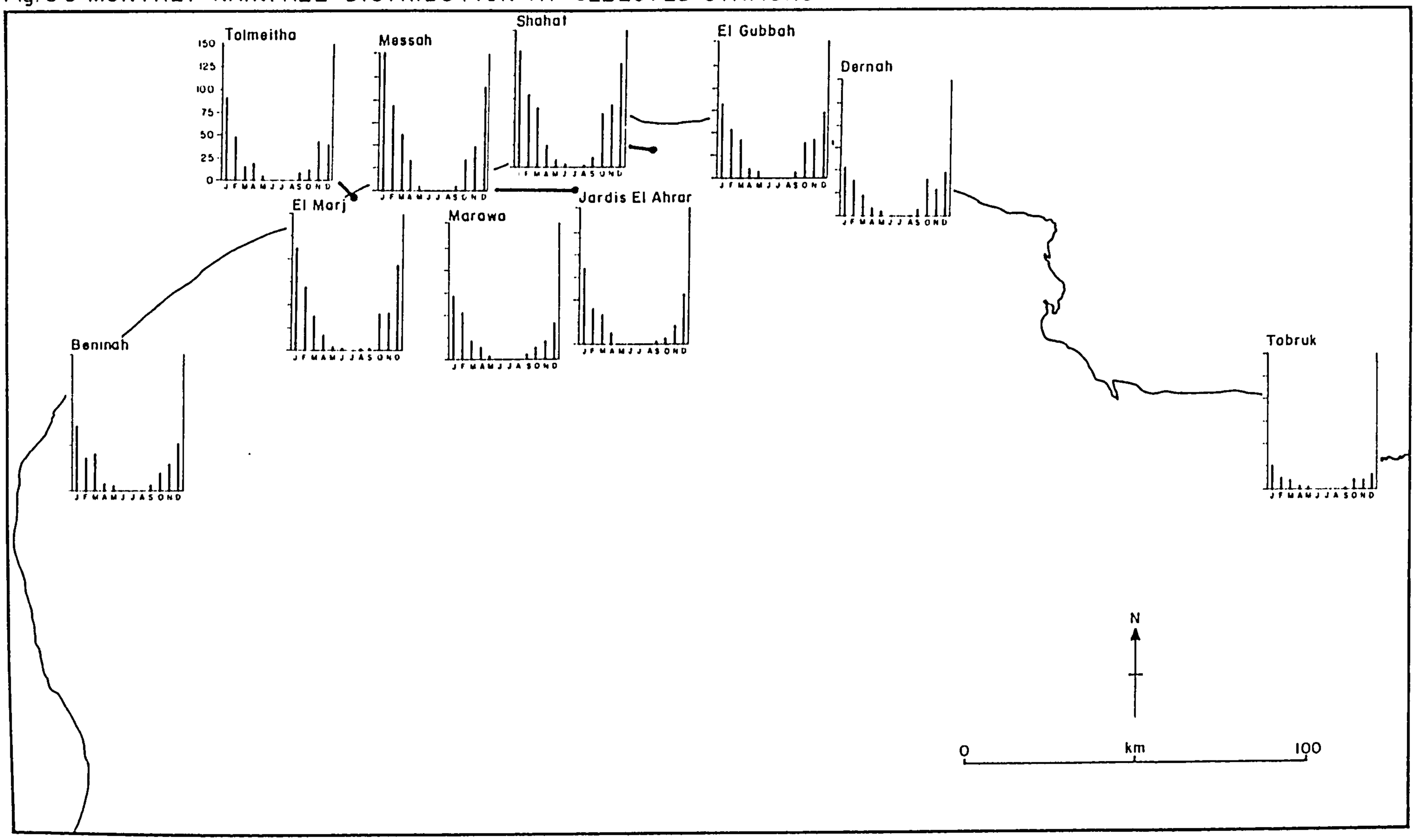


TABLE 3.3 Frequencey of rainy days at selected stations:

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total days
Beninah	13	9	5	3	1	0	0	0	2	4	7	12	56
Tolmeitha	12	10	5	3	1	0	0	0	2	4	6	11	54
Dernah	10	7	7	3	2	0	0	0	1	6	6	9	51
Tobruk	7	4	4	2	1	0	0	0	1	3	3	7	32
El Marj	16	3	8	4	3	1	0	0	2	5	8	15	74
El Gubbah	14	10	9	4	2	1	0	0	2	7	9	12	70
Jardis El Abrav	15	12	7	3	3	0	0	0	1	5	7	13	66
Marawa	13	11	6	2	2	1	0	0	0	4	5	9	53
Messah	16	12	10	7	2	0	1	1	5	3	10	10	76
Shahat	16	12	10	4	3	1	1	0	3	8	10	14	82

Source: Ministry of Communication, Meteorological Department Monthly and Annual data for Libya; Tripoli, (undated).

Fig. 3·4 FREQUENCY OF RAINY DAYS AT SELECTED STATIONS

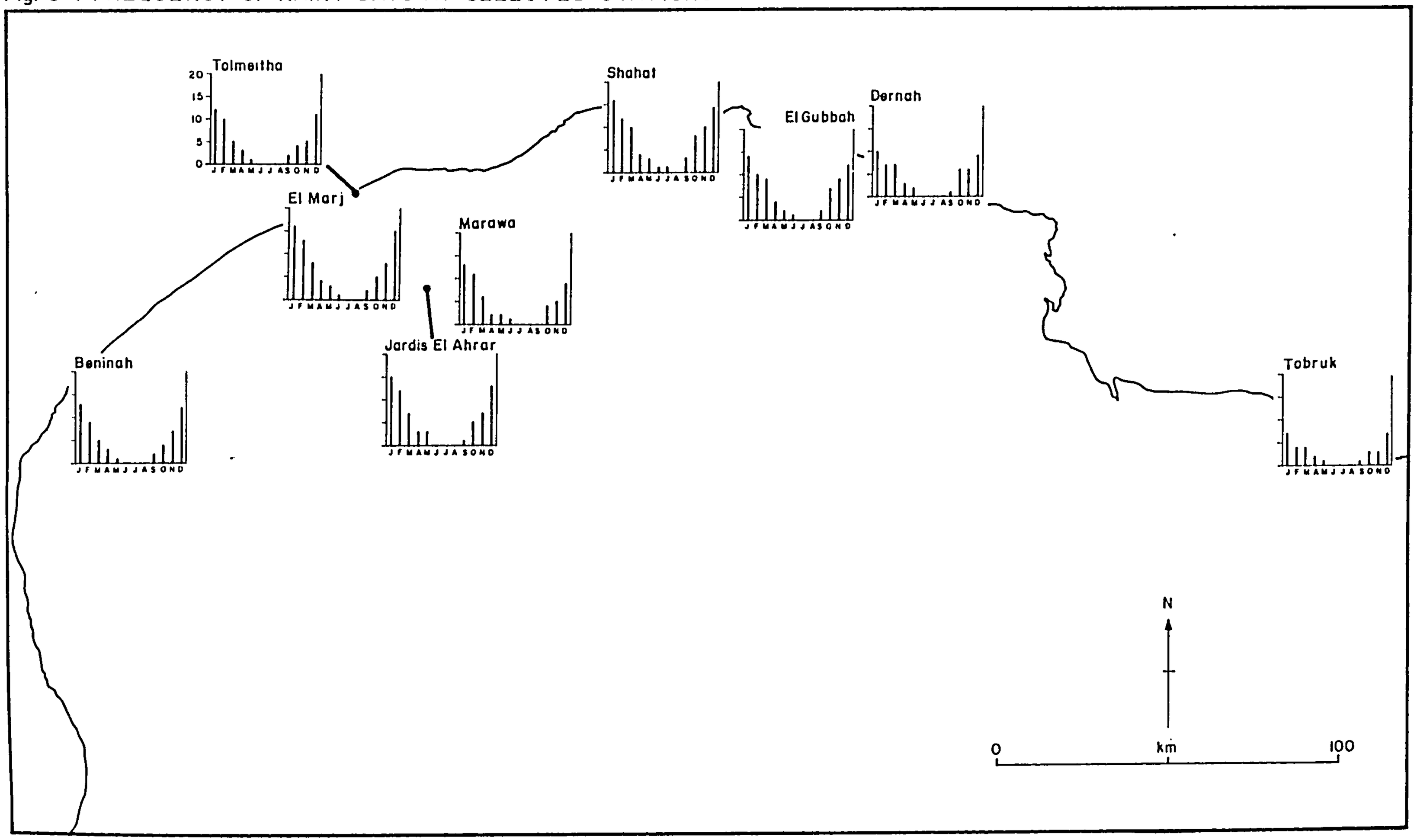


TABLE 3.4 Percentage of monthly rainfall of selected stations

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Beninah	25.6	13.5	15.5	2.8	2.5	0.2	0.0	0.0	2.1	7.5	11.0	19.3	100
Tolmeitha	32.6	17.5	6.0	6.7	1.5	0.0	0.0	0.0	3.4	4.0	17.0	13.7	
Dernah	21.2	13.6	9.3	3.5	2.3	0.2	0.0	0.10	2.9	16.0	12.0	18.8	
Tobruk	26.0	13.9	11.5	4.3	3.9	0.0	0.0	0.0	1.7	10.6	10.7	16.8	
El Marj	27.1	16.7	9.2	4.1	1.2	0.3	0.0	0.1	0.4	8.5	9.7	22.7	
El Gubbah	22.9	14.7	11.7	2.9	2.0	0.16	0.0	0.0	2.0	11.0	11.9	20.0	
Jardis El Abrav	33.0	14.4	13.1	5.2	0.4	0.2	0.0	0.0	0.9	2.8	8.1	21.9	
Marawa	29.1	21.7	8.5	5.4	1.6	0.6	0.0	0.0	2.1	6.1	8.5	17.0	
Messah	27.2	17.0	11.2	6.0	1.0	0.2	0.0	0.1	1.0	6.3	9.0	21.0	
Shahat	22.7	14.0	11.5	5.2	2.0	0.4	0.1	0.4	2.0	10.6	12.0	20.0	

period, (see El Tom, 1973; Gregory, 1965). Although this definition is not applicable in Libya generally, because the ten percent of mean rainfall is not sufficient for plant growth in the country, because of high evapotranspiration, this technique could at least lead to the rainfall seasonality from general point of view.

The application of this technique reveals that the beginning and the end of the wet season differs considerable between the different parts of the region because of rainfall variability. Table 3.4 shows that the duration of the rainy season ranges between 4 and 5 months between November to February in the coastal corridor, and more than five months in the upland or in the second terrace of the region, which has the longest rainy season. It extends between October and March. The duration of the rainy season decreases steadily eastwards; it covers less than four months in the east of Dernah and three months in the south of the Jebel in the lee of the highland, where semi-desert starts to appear.

Generally, about 75% of rainfall distribution is concentrated during the period of November to February. Its peak is in December and January, each month having a mean rainfall above 40% in the coastal stations while it increases to 45% in the upland at El Marj, Marawa, Messah and Jardis El Ahrar. The months of November to February of the wet season for the coastal belt coincide with low temperature, which limit crop growth during this period. This limitation applies exclusively to the northern inland hilly area where the monthly rainfall during this period ranges between 50-150 mm.

The climatic year consists of a wet season, and a slightly longer

dry season where frequently no rainfall occurs for 4 or 5 months. The rainfall is almost always violent and begins in October, sometimes at some localities in September. The main characteristic of early precipitation is to compensate soil moisture deficiency, as plants are under stress in the dry season, and an important need is to store surplus runoff and conserve water for use of the herding community.

Rainfall Intensity:

The last rains in February, March and sometimes April are often intense due to cyclonic depressions. They are all-important for dry farming production, particularly wheat, providing it with sufficient water in the critical stage of growth. Consequently, these rains have a great effect on the quality and quantity of yields.

Although total rainfall statistics are fairly well established the same is not true for rainfall intensity. Data for some stations are shown in Table 3.5a and 3.5b, and Fig. 3.5a and 3.5b . At El Marj only 21.6% of the total annual rainfall is higher than 10 mm in 24 hours. Moreover, there is no precipitation greater than 40 mm in 24 hours. Nevertheless, at Beninah only 12.6% of the rainfall in any 24 hours exceeds 10 mm; this value is only 13.1% at Dernah, but 22.6% at Shahat. Generally, there are a few days on which more than rainfalls 40 mm in 24 hours. This means the greater part of the rainfall is regular. In the vicinity of Shahat where storms are much more frequent than in Dernah, El Marj or Beninah, the mean annual totals are much larger and consequently, 24 hour totals are larger. In the Jebel Al Akhdar region over 24 years, Shahat suffered the heaviest storm with about 136 mm of rain in 36 hours in the year 1959.

TABLE 3.5 (a):
Classification of daily rainfall in mm:

	Dernah	Beninah	El Marj	Shahat
P < 1	17.1	16.2	20.5	19.9
1 to 3	13.8	14.7	15.7	18.1
5 to 8	5.4	7.2	9.2	10.9
8 to 10	2.8	3.0	4.6	4.0
10 to 13	9.3	2.4	4.1	4.9
13 to 15	1.1	1.2	2.1	1.8
15 to 18	0.7	1.2	3.4	3.5
18 to 20	0.5	0.4	1.0	1.8
20 to 25	0.8	1.1	2.2	2.7
25 to 30	0.4	0.4	1.1	1.2
30 to 40	0.4	0.4	1.6	1.8
P > 40	0.7	0.0	0.7	1.1
Total Rain Days	52.9	56.3	75.2	83.1

3.5 (b)
Average distribrution of 24 hr. rainfall (Pr mm) cummulated frequencies as a percentage

	Dernah	Beninah	El Marj	Shahat
P > 0	100.0	100.0	100.0	100.0
> 1	67.7	71.2	72.8	76.0
> 3	41.6	45.0	52.0	54.3
> 5	28.6	30.7	40.0	40.5
> 8	18.3	17.9	27.7	27.4
> 10	13.1	12.6	21.6	22.6
> 13	8.7	8.3	16.1	16.7
> 15	6.6	6.2	13.3	14.6
> 18	5.3	4.1	8.8	10.3
> 20	4.3	3.4	7.5	8.2
> 25	2.8	1.4	4.5	4.9
> 30	2.1	0.7	3.1	3.5
> 40	1.3	0.0	0.9	1.3

Source: G.E.F.L.I., 1978: Water Resources Survey, 22 Climatology, Tripoli: 51.

Fig 3·5a CLASSIFICATION OF DAILY RAINFALL IN MILLIMETRES

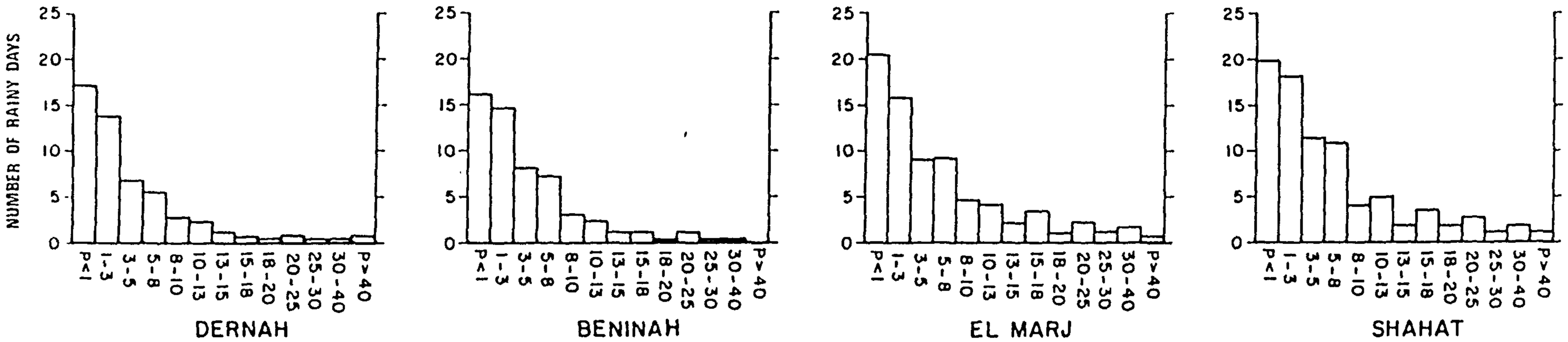
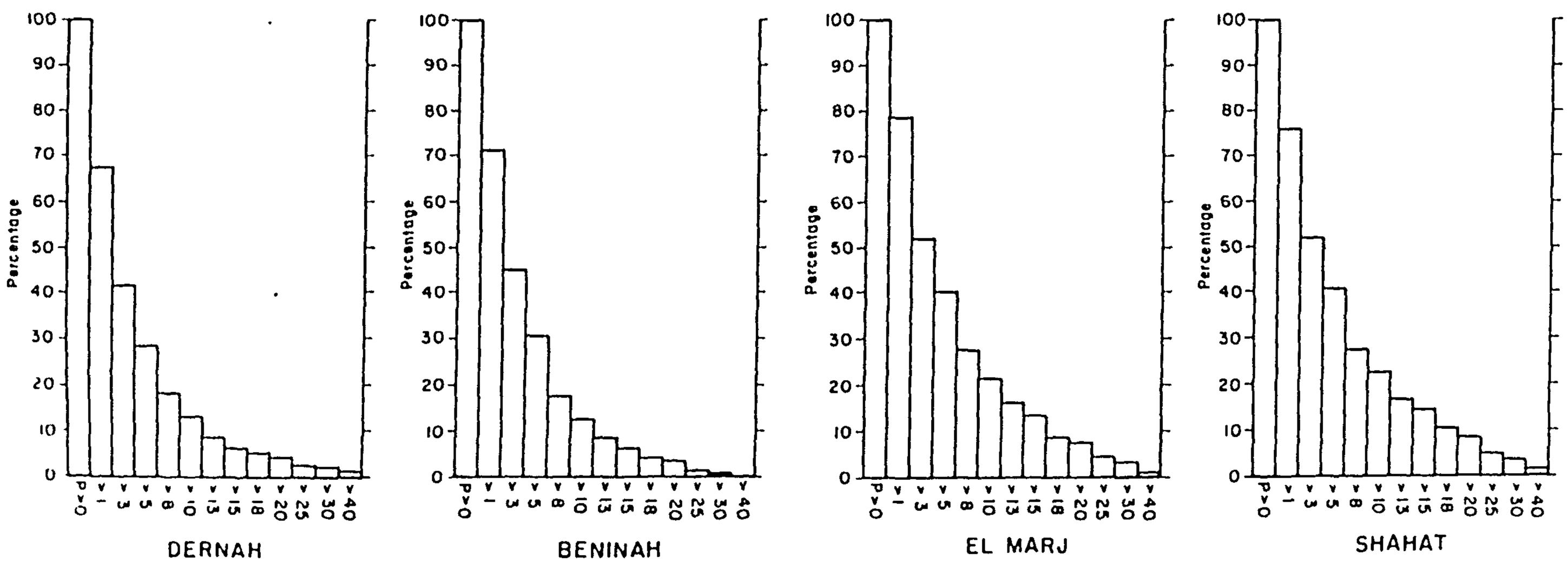


Fig. 3.5 b AVERAGE DISTIBUTION OF 24h RAINFALL IN CUMULATED FREQUENCIES IN PERCENTAGES



The significance of the aforementioned discussion is that rainfall in October and November compensates soil moisture deficiency. because the soil is very dry with much shrinkage and cracks, and no destruction is caused to the soil. Rainfall in December and January is the most effective, although it may cause some erosion when it lasts a long time and falls on water-logged soil. Equally important are other factors such as slope, vegetation cover and soil type. Effective rainfall in agricultural terms is rain entering the soil and remaining within root range (Jackson, 1977). In the case of El Marj basin, the ferrosiallatic soil is well moistened and infiltration is lower which can cause some damage to plant growth due to water logged conditions. Rainfall lost as surface runoff or drainage beyond root range in the sandy soils of the coastal areas of some localities, is ineffective. The El Marj basin could be improved by a more efficient drainage system for more effective use of the rainfall than is possible with the large storms of high intensity at Shahat which result in considerable loss from surface runoff. Dams to retain much of this water are recommended.

Rainfall Variability:

The annual rainfall varies from one year to another, from place to place and even from one month to the next, with variability being highest in the coastal corridor and least on the high plateau of the region. The series through time and the variability is calculated in Appendix 1. Some examples are given from the (Appendix 1) to indicate this variability. Dernah received a total of 436.6 mm in 1956 and only 124.4 in 1951, yet the annual mean is 255 mm.

TABLE 3.6 The coefficient of variability of monthly and annual rainfall for selected stations relevant to the study area:

Station	Altitude m	Km.from Coast	Distance East Km.	Years of Observation		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Beninah	122	20.0	0	33	x	69.8	36.9	42.4	7.4	0.2				5.7	20.5	30.0	68.3	267.5
					cv	52.2	85.9	92.2	143.4	151.0				170.0	93.3	99.8	70.3	32.8
Dernah	8	0.0	236.5	33	x	54.7	35.0	24.0	9.2	5.9				7.4	41.2	30.6	48.2	254.7
					cv	61.2	86.5	97.7	141.0	145.4				209.0	125.2	123.0	77.0	27.3
Tobruk	155	10.0	350.0	33	x	26.3	13.8	11.4	4.3	3.9				1.7	10.6	10.7	16.7	105.5
					cv	82.9	117.6	109.0	182.4	228.0				192.0	117.8	181.7	112.0	55.6
El Marj	282	20.0	77.5	42	x	112.2	69.0	38.2	16.9	4.8				1.5	35.6	40.4	94.2	399.0
					cv	37.8	85.0	100.9	158.5	164.7				228.9	106.4	105.4	72.8	33.5
Jardis El Abrav	653	47.5	73.5	17	x	84.2	39.6	33.5	13.2	0.9				2.5	6.9	20.9	56.1	255.9
					cv	51.6	75.0	116.0	171.0	240.0				297.0	134.0	87.0	95.4	35.8
Marawa	505	33.0	117.5	30	x	70.5	52.7	20.7	13.1	3.8				5.2	14.7	20.7	41.0	241.7
					cv	66.4	83.4	81.2	173.0	119.3				316.0	113.2	100.0	93.2	35.3
Messah	540	18.0	150.0	26	x	148.8	92.5	61.4	32.9	5.1				5.6	34.6	49.6	113.6	545.6
					cv	55.0	60.5	94.0	152.0	162.0				301.5	90.0	87.3	76.5	35.0
Shahat	621	9.0	171.0	33	x	127.4	79.0	64.5	24.1	9.0				10.8	59.9	67.5	112.5	562.5
					cv	51.6	68.0	55.8	131.9	154.9				144.4	120.5	62.3	66.6	27.2
Safsaf	658	11.0	177.5	22	x	103.2	59.9	61.0	22.2	5.6				4.6	30.5	48.5	77.5	415.6
					cv	56.1	100.5	70.5	105.1	226.0				195.0	92.9	93.0	74.8	34.2

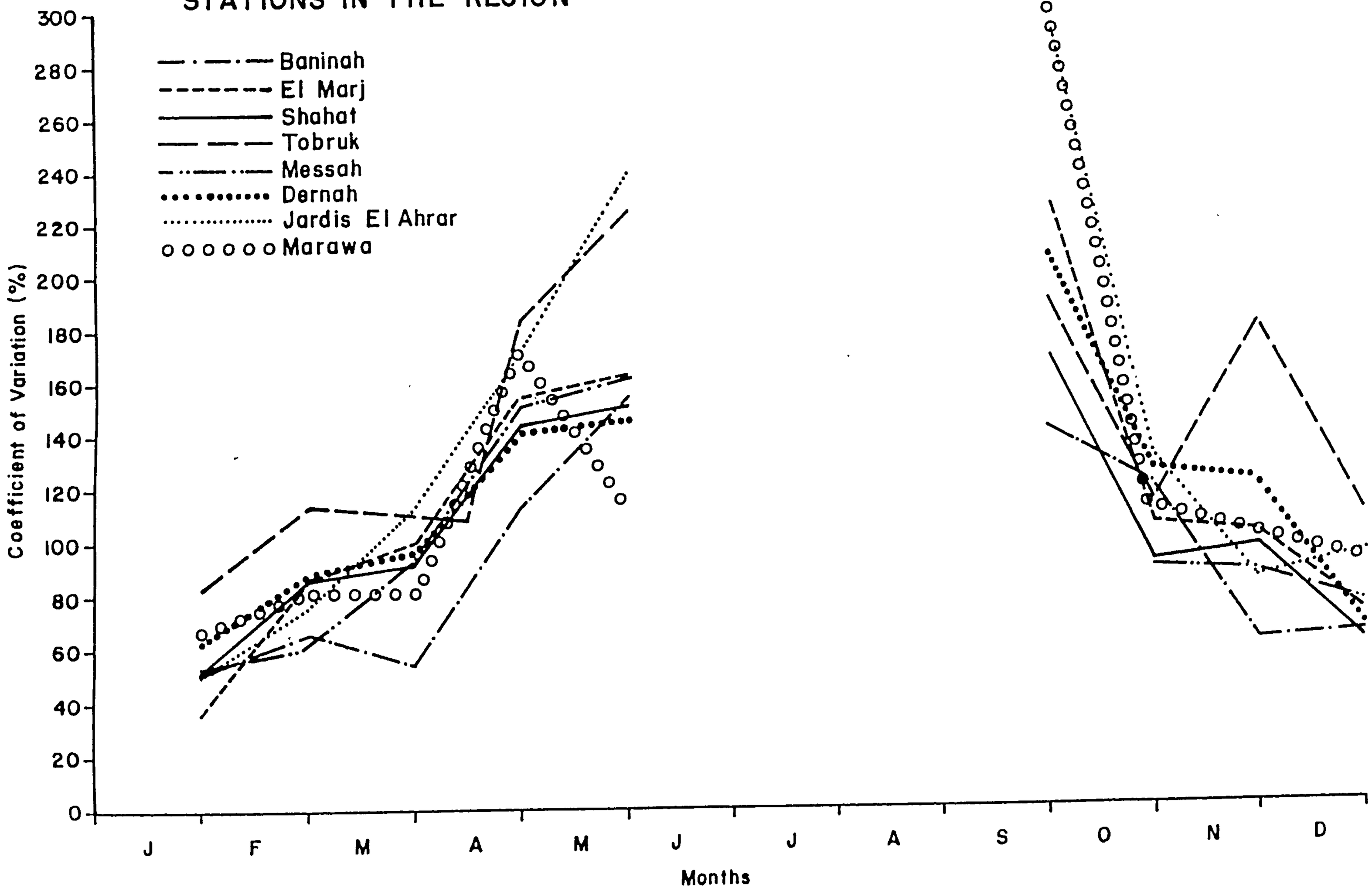
The variability difference between selected stations is illustrated by a comparison during 1964, a year of great variability. It was 208 mm at Jardis El Ahrar, while at Marawa 141 mm which is situated 43 km to the east. At Shahat it was 490 mm. Nevertheless at a distance of 12.5 km to the east at Safsaf or Labrag it was 185 mm. This simply illustrates a well known fact, particularly important in a semi arid region, that the variation increases with decreasing mean annual values. Table 3.6 is an example of this.

Temporal Rainfall Variability:

The long term average annual precipitation for selected stations in the region such as Dernah, Tobruk, Beninah and El Marj indicate a trend towards decreasing annual rainfall with time. The decrease from the highland to the coast is much more marked as is expected. At El Marj the average annual rainfall between 1956 and 1975 was 352 mm while it was 480 mm during the period of 1921-40. So in order to reduce the great effect of extreme value in a short period, the long period equal 1921-40 and 1956-1977 have been used, 399 mm.

Table 3.6 repeats values from Table 3.1 to show the monthly mean rainfall for the years of data available. From these values the coefficient of variability (standard deviation/mean) as a percentage is also shown monthly. Figure 3.6 graphs the monthly coefficient of rainfall variation. Again, high mean values have lower variability and vice-versa as has just been discussed.

Fig.3·6 MONTHLY DISTRIBUTION OF THE COEFFICIENT OF VARIATION AT SELECTED STATIONS IN THE REGION



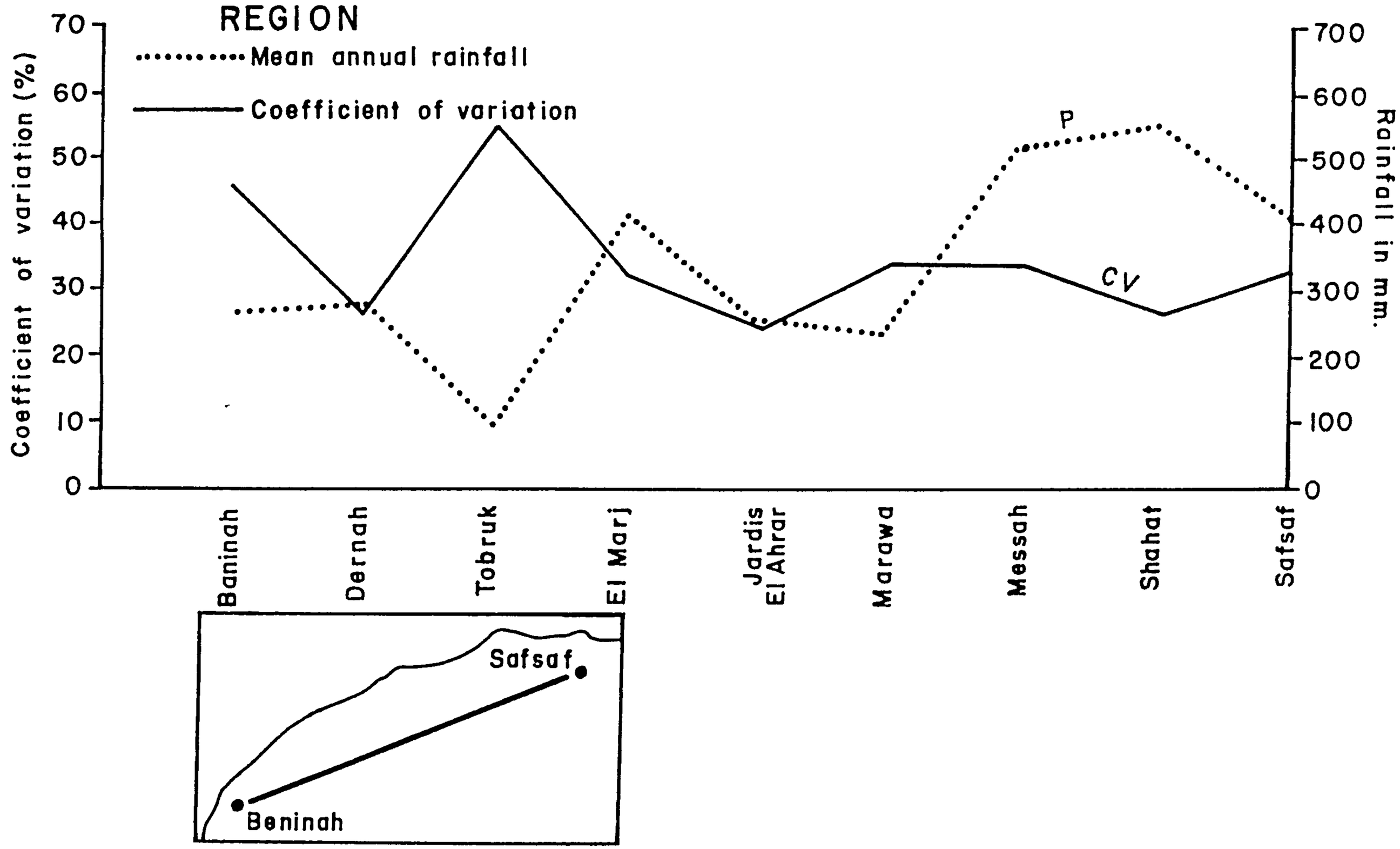
Spatial Rainfall Variability:

There is great variation between stations even those adjacent and with averages shown in Figure 3.7. Annual totals of rainfall indicate correlation coefficients decreasing dramatically eastwards from a value of 0.74 at 16 km to a value of -0.24 at 169 km east, as introduced in the section on rainfall distribution, but monthly values of rainfall are revealing.

Table 3.7 shows correlation coefficients of mean monthly values (for the period 1964-75) of El Marj with stations 16 to 165 km east shown in Figure 3.8. This method has been discussed by Jackson (1974); Sharon (1972; 1974 and 1980).

Figure 3.8 indicates that even for stations less than 55 km, correlation of monthly data is low for the four months October, November, February and March. In December and January all the stations have a large correlation coefficient due to the uniform distribution of precipitation over the region in those periods. In the October, November and February period, the correlation decreases significantly for distances less than 53 km east. This results from the beginning of the wet season in the first two months, and the decrease of precipitation in February at the end of the wet season, which shows a great variability in space and time. Further to the east, the correlation coefficient increases dramatically to more than 0.50, because of the influence of permanent factors of relief and prominence. The land meets the westerly wind-bearing rain. Wherever there is absence of relief factors, the correlation coefficient slopes to less than 0.50 further to the east.

Fig.3·7 DISTRIBUTION OF ANNUAL RAINFALL IN RELATION TO ANNUAL COEFFICIENT OF VARIATION FOR SELECTED STATIONS IN THE REGION



The outstanding feature of the correlation coefficient for March precipitation is the gradual rise for a distance of 73km east and fall gently eastwards at 108km. It decreases sharply further east, to a value of 0.54 at 108km and then to a value of about 0.31 at 169km as a result of physiographic factors.

The monthly and annual values of the correlation coefficient are, in general, greater than 0.54 over the stations 73-108km distant from El Marj - an intermediate distance class. During the rainy season when rainfall is localised correlations are even greater than further east, 110km away. As Sharon 1974 and Jackson 1974 suggest, that general area of rain could lead to an increase in correlation with distance beyond a limited minimum value. Thus, stations of a certain distance, between 73-108km, are more highly correlated than those closer together, between 16-53km.

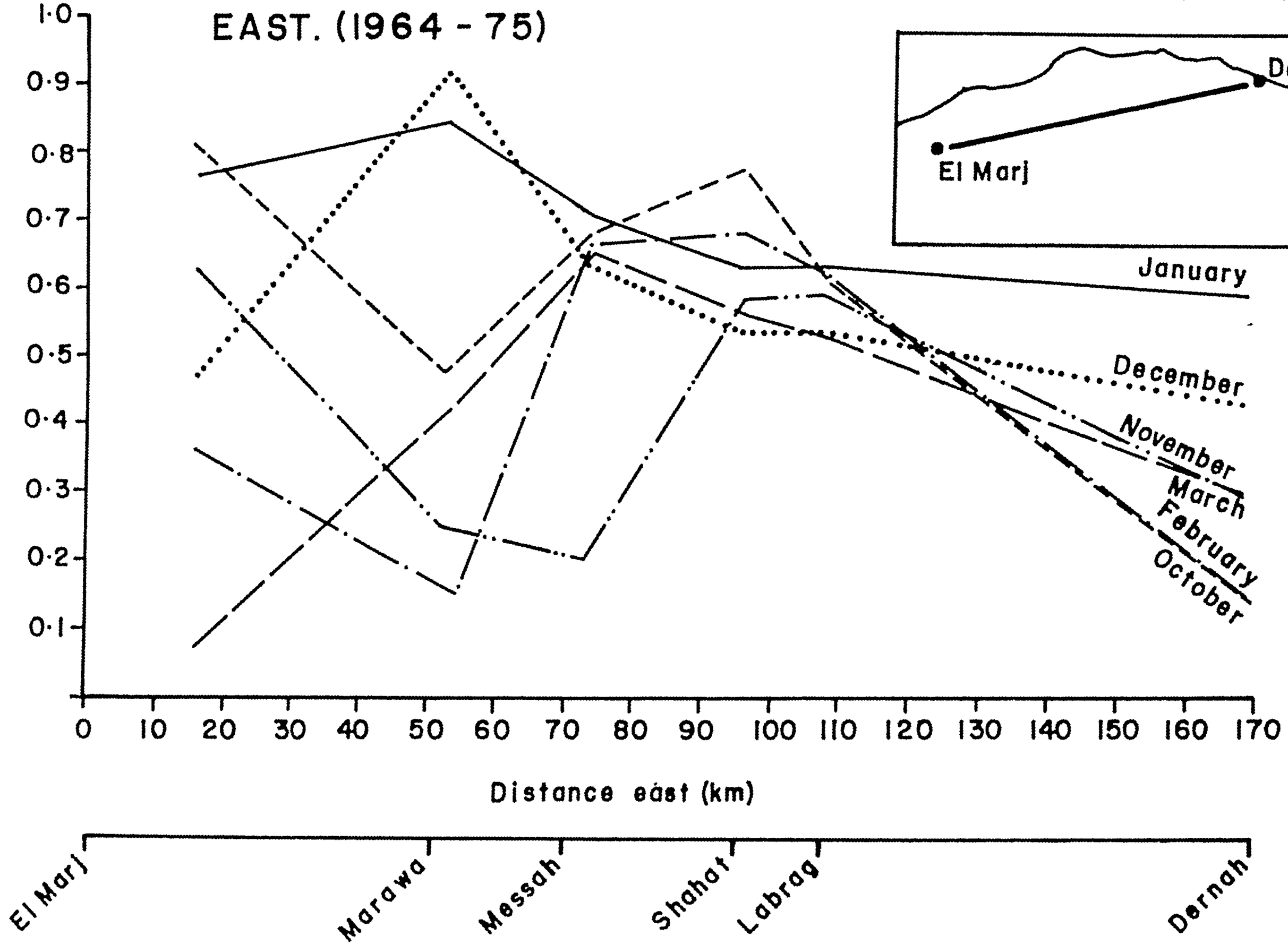
The significance of this discussion is of great importance as rainfall amounts in an individual month or growing season may differ considerably between nearby locations having similar average totals. Spatial variations of rainfall in terms of time are more important, particularly at the start of the rainy season (November to December) or at certain short, critical periods of crop growth, at February and March with increasing temperature. This means the difference between success and failure of the crop yield.

Differences in rainfall variability patterns exist between adjacent locations. Subsistence agriculture, particularly of the small scale farmer in much of the region is of great importance to economic activity. On the other hand, the rainfall regime in both low coastal land and on the high plateau varies from west to east. Consequently

TABLE 3.7: Correlation Coefficient of Mean Monthly Rainfall (1964-75) for selected stations in the region:

Stations	Distance Km East	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Annual
El Marj / Jarvis	16.0	0.77	0.37	-0.07	0.96	0.81	0.63	0.47	0.74
Significance level		<.001	N.S.	N.S.	<.001	<.01	<.05	N.S.	<.01
El Marj / Marawa	53.5	0.85	0.16	0.46	0.97	0.48	0.26	0.92	0.76
Significance level		<.01	N.S.	N.S.	x.001	<.1	N.S.	<.001	<.01
El Marj / Messah	74.0	0.71	0.67	0.66	0.96	0.69	0.21	0.63	-0.67
Significance level		<.05	<.05	<.05	<.001	<.05	N.S.	<.05	<.05
El Marj / Shahat	96.5	0.64	0.69	0.57	0.96	0.78	0.59	0.54	0.63
Significance level		<.05	<.05	<.06	<.001	<.01	<.05	<.06	<.05
El Marj / Labrag	108.0	0.64	0.63	0.54	0.71	0.62	0.60	0.54	0.51
Significance level		<.05	<.05	<.06	<.05	<.05	<.05	<.06	<.05
El Marj / Dernah	169.0	0.60	0.16	0.31	0.88	0.15	0.31	0.43	-0.24
Significance level		<.05	N.S.	N.S.	<.001	N.S.	N.S.	N.S.	N.S.

Fig.3·8 MONTHLY DISTRIBUTION OF THE RAINFALL CORRELATION COEFFICIENT BETWEEN EL MARJ AND SELECTED STATIONS AT DISTANCE EAST. (1964 - 75)



there is only one cropping season of about 5 months in the northern high plateau, and 4 months in the coastal area. The major constraints on reliable dryland farming and greater variation of yield production are explained however by the uncertainties in the onset and cessation of rains, and the significance patterns of spatial variability.

Rainfall Probability:

The amount of rainfall (399mm) at El Marj is about average for the high plateau, and the seasonal pattern of rainfall in El Marj is typical of the rainfall distribution on the second terrace plateau. Dernah station with 260mm can be considered to represent the coastal area. It is expected, therefore, that the result of analysis of rainfall probabilities for El Marj and Dernah will be representative of the rainfall probabilities on the high plateau and coastal belt respectively.

Since monthly rainfall amounts are approximately normally distributed through the rainy season, the probabilities of occurance of a selected value over the normally distributed data is easily read from the area under the curve, cut off by the number of standard deviations that the selected value is away from the mean, ie. the Z deviate scores where $Z = \frac{\bar{X}-X}{\sigma}$. Therefore, the probability of rainfall is shown in Table 3.8.

The probability of receiving 100mm or more rainfall in October is low (4.5% and 12.9% for El Marj and Dernah respectively), but the probability of receiving 50mm or more of precipitation in the same month is high, 35% at El Marj and 43.2% in Dernah. The monthly probability

TABLE 3.8: Probability of receiving given rainfall amounts or more at selected stations:

	Probabilities of receiving rainfall amount (in %)							
	El Marj				Dernah			
Rainfall in mm:	50	100	200	300	50	100	200	300
October	35.0	4.5	0.0	0.0	43.2	12.9	0.0	0.0
November	41.0	8.1	0.1	0.0	30.5	3.3	0.0	0.0
December	74.0	46.0	6.1	0.0	48.0	8.2	0.0	0.0
January	92.8	62.0	1.9	0.0	56.6	8.8	0.0	0.0
February	63.0	30.0	1.2	0.0	31.0	1.5	0.0	0.0
March	38.0	5.4	0.0	0.0	13.5	0.7	0.0	0.0
April	11.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Annual	99.4	98.5	92.4	77.5	99.9	98.7	78.0	25.7

percentage is higher at El Marj in November than October, but it is lower in Dernah in November compared to October. However, the agricultural significance of these results is that an annual crop which requires a minimum of 50mm of monthly rainfall at seedling stage for good development may be planted in October in coastal and upland areas, but not an annual crop which requires a minimum of 100mm of monthly rainfall at seedling stage. Such an annual crop should be planted in December in an upland area like El Marj. Since some cereal crops, such as barley require a minimum of 100mm of monthly rainfall at seedling stage, the month of December is regarded as the beginning of the cropping season in the upland area, but this differs from the coastal area which does not suit the crop requiring this amount of rainfall, so there is need for supplementary irrigation.

Table 3.8 indicates that the probability of receiving 100mm of rainfall or more in December is 46%, implying that there is a 54% chance of getting less than 100mm of rainfall in December. The results suggest that crop failure is highly probable, so supplementary irrigation facilities are advisable. If they are not available, land use should be changed to crops tolerant to soil moisture deficiency such as barley or lucerne.

As long as the 200mm value is the minimum amount of rainfall necessary for rainfed cereal crops in semi-arid land (Wallen and Perrinde, Brichambant, 1962) crop growing will cease where expected rainfall is less than 200mm. This is worrying for new projects being constructed based on mean rainfall. Thus the risk as far as agricultural activities is concerned is certainly very great.

However, the rainfall to meet that needed by evapotranspiration

Table 3.9: Probability of two successive years having rainfall greater than evapotranspiration at El Marj Station

	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Rainfall (P) mm	35.6	40.4	94.2	112.4	69.0	38.2	16.9
Evapotranspiration (PE) mm	107.6	61.8	46.8	45.0	42.0	69.7	99.0
Standard deviation (O)	37.8	42.5	68.5	42.5	58.6	38.5	26.8
Rainfall probability %	2.9	30.4	75.5	94.4	67.7	20.9	0.11
Probability of two successive wet years	0.4	9.0	57.0	89.0	45.0	4.4	1.2
Probability in 2 successive one wet - the other dry	5.6	42.0	37.0	10.0	44.0	33.0	19.6
Probability of two successive dry years	94.0	49.0	6.0	1.0	11.0	62.6	79.2

(P.E.T.) (calculated in chapter Water Resources) is shown as mean monthly values in Table 3.9. It is fairly obvious that Dernah on average has not sufficient rainfall to meet the P.E.T., but El Marj is more favourable, although the spread of values shown in Table 3.1 suggests that some years could be inadequate in the monthly rainfall required.

Table 3.9 shows that probability of rainfall greater than evapotranspiration at El Marj in November is 30.4%. This is being reasonable for the start of the season. The probability of not having adequate rainfall in November is 69.6%. A table shows (the method which is really using the binomial frequency distribution $(p + q)^n$, Gregory (1978). Table 3.9 include wet years which means rainfall > evapotranspiration, while dry year = rainfall < evapotranspiration.

Table 3.9 shows the probability for two successive wet years is quite reasonable in December and January only and having the successive dry years for October, March and April is very high, but low for December, January and February. This means that there is a very limited period of growth possible without irrigation for two successive dry years.

Briefly, a farmer on marginal land with only limited irrigation may be able to cope with any one year falling below the required rainfall, but two many dry years in succession could drive the farmer off the land.

TEMPERATURE AND HUMIDITY REGIMES

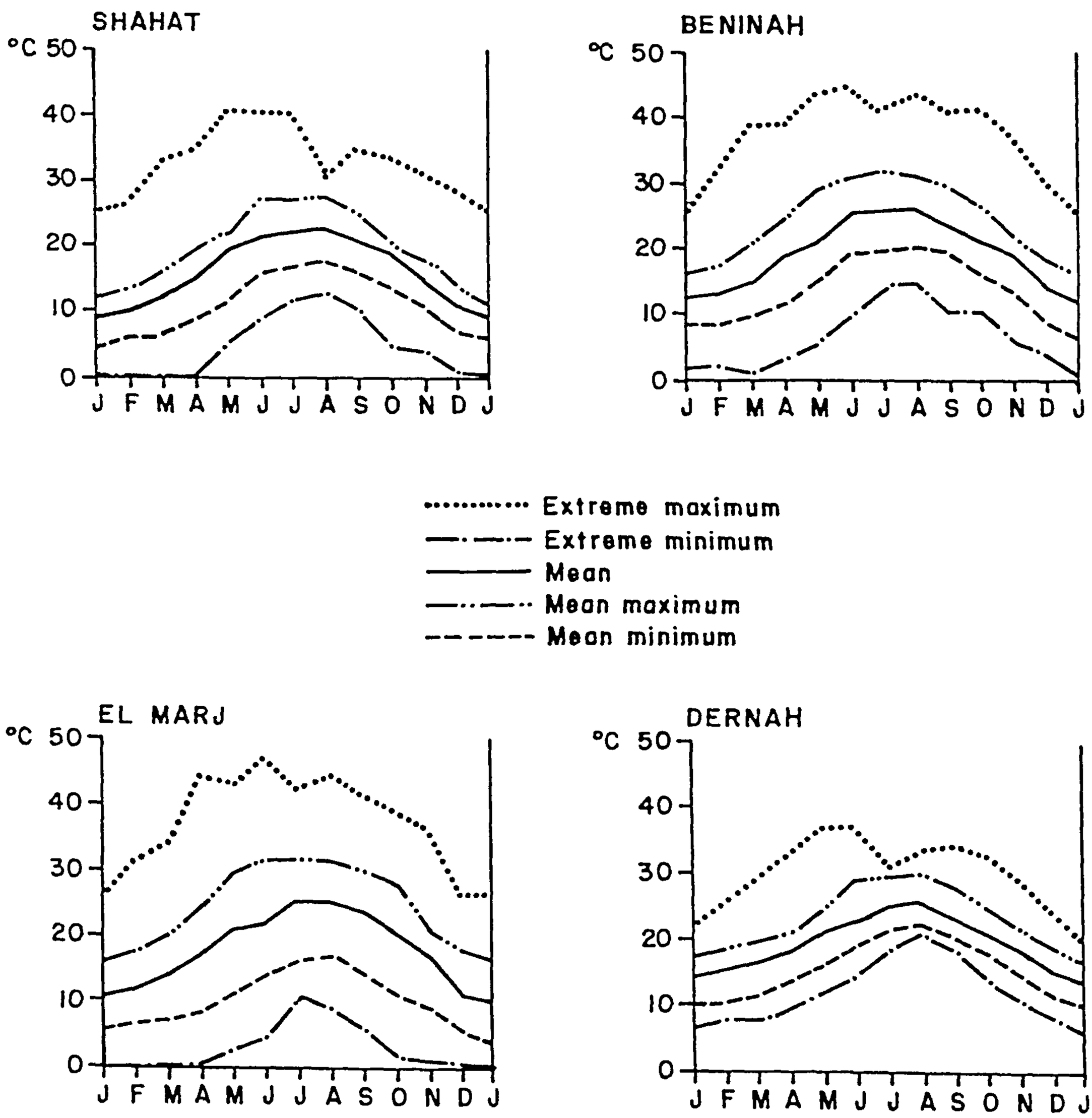
Jebel El Akhdar area receives high and practically uninterrupted amounts of solar radiation, and, high temperatures and evaporation rates

TABLE 3.10: Mean monthly temperature at selected stations:

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean	Period of Observation
Coastal plain														
Beninah	18.4	13.0	14.0	18.6	22.3	25.4	25.4	26.4	24.8	22.2	18.4	14.1	19.8	33 years
Tolmeitha	14.0	14.3	15.2	18.3	20.2	23.2	25.0	25.7	24.0	22.6	19.8	15.7	19.9	15 years
Dernah	14.1	14.5	15.6	17.8	23.1	23.4	25.3	26.3	24.9	22.3	19.4	15.8	19.1	33 years
Tobruk	11.8	12.9	14.7	18.1	21.4	24.8	25.5	25.9	14.0	21.2	17.3	13.0	19.2	33 years
El Marj	10.5	11.0	12.9	15.9	20.0	22.7	23.7	23.8	22.8	20.2	11.6	12.3	17.7	25 years
El Abayer	10.0	11.0	13.4	17.4	22.1	22.3	25.5	25.2	24.0	21.0	17.1	11.6	18.4	16 years
El Gubbah	9.1	9.5	10.6	14.7	20.6	28.4	21.4	20.1	19.6	16.1	13.1	10.0	14.7	
Jardis El Ahrar	8.5	9.2	11.7	15.6	19.5	22.7	23.7	23.9	23.1	19.5	14.9	11.1	16.9	9 years
Marawa	9.5	10.2	12.9	16.4	20.1	23.7	24.2	24.5	23.0	20.3	16.0	11.5	17.7	11 years
Shahat	8.2	9.1	10.7	14.0	17.9	20.9	22.0	22.2	20.8	18.5	14.7	10.9	15.8	25 years

Source: Fantoli A (1968): Contribution Alfa Climatologia Della, Cyrenaica, Rome;
Ministry of Communication, Meteorological Department,
Monthly and Annual Climatological Data for Libya, Tripoli, (undated).

Fig. 3·9 MONTHLY TEMPERATURE AT SELECTED STATIONS



as high as 1270mm per annum have been recorded. The temperature curves reflect the persistent high intensity of insolation. Table 3.10 and

Figure 3.9 show the March temperature at selected stations in the region, which are representative of conditions in the northern plain and highlands. Insolation in the region is most intense when the sun reaches the northern solstice. Maximum summer daytime temperature between 44°C and 32°C are common.

Temperature varies with proximity to the sea and the latitude. Table 3.10 shows the coastal station of Dernah and Tolmeitha have an average annual temperature of 19.1°C and 19.9°C respectively whereas inland at El Abayr and El Marj 282 m.a.s.l. on the upper terrace, temperatures are 2.2 and 0.7 lower, respectively than the figures for Tolmeitha and Dernah.

The Mediterranean climate region has winter from November to April, but December, January and February are the coolest months; the summer extends from May to October with June, July and August being the hottest months of the year.

There is a greater thermal uniformity during the high sun season than in winter when the temperature shows a greater variation Table 3.11. Daytime temperature in the winter is lower than in the summer, and the night temperature drops to low levels, sometimes below freezing point, as at Shahat. In January the mean temperature is 9.3°C, while the maximum and minimum recorded are 25.4°C and 0.0°C, respectively. Nevertheless, Benina and Dernah have a summer maximum of 44°C and 34.1°C respectively. This difference is due to distance from the sea, and the ground layer heating by the continental tropical air masses from the

TABLE 3.11: Comparison of temperature and relative humidity data for coastal and inland stations in North East Libya

Station	Km from Coast	Altitude m.a.s.l.	Minimum Temperature °C Winter Extreme	Winter Mean	Summer Extreme	Summer Mean	Maximum Temperature °C Winter Extreme	Winter Mean	Summer Extreme	Summer Mean
			Actual Recordings							
Beninah	20	122	1.7	8.3	14.4	20.6	26.3	16.6	44.0	32.2
Dernah	0	8	7.2	10.6	20.5	23.2	22.5	17.5	34.1	29.1
Tobruk	8	155	0.0	6.5	14.9	20.2	25.5	17.1	44.7	31.6
El Marj	20	282	2.0	5.1	8.3	16.0	27.0	15.8	44.0	31.5
Shahat	9	621	0.0	6.1	12.5	17.7	25.4	12.5	32.8	27.9
			Difference between Dernah and other stations							
Dernah	0	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beninah	20	122	-5.5	-2.3	-6.1	-2.6	3.8	-0.9	9.9	3.1
Tobruk	8	155	-7.2	-4.1	-5.6	-3.0	3.0	-0.4	10.6	-2.5
El Marj	20	282	-7.2	-2.3	-12.2	-7.2	4.5	-1.7	9.9	2.4
Shahat	9	621	-7.2	-4.5	-8.0	-5.9	2.9	-5.0	-1.3	-1.2

			Mean Relative Humidity Winter	Summer
Beninah	20	122	77.5	65.9
Dernah	0	8	71.8	75.9
Tobruk	8	155	68.7	67.7
El Marj	20	282	76.2	63.9
Shahat	9	621	79.2	69.5

Source: Ministry of Communication. Meteorological Department
Monthly and Annual Climatological Data for Libya. Tripoli (undated).

desert, which has more effect on Beninah.

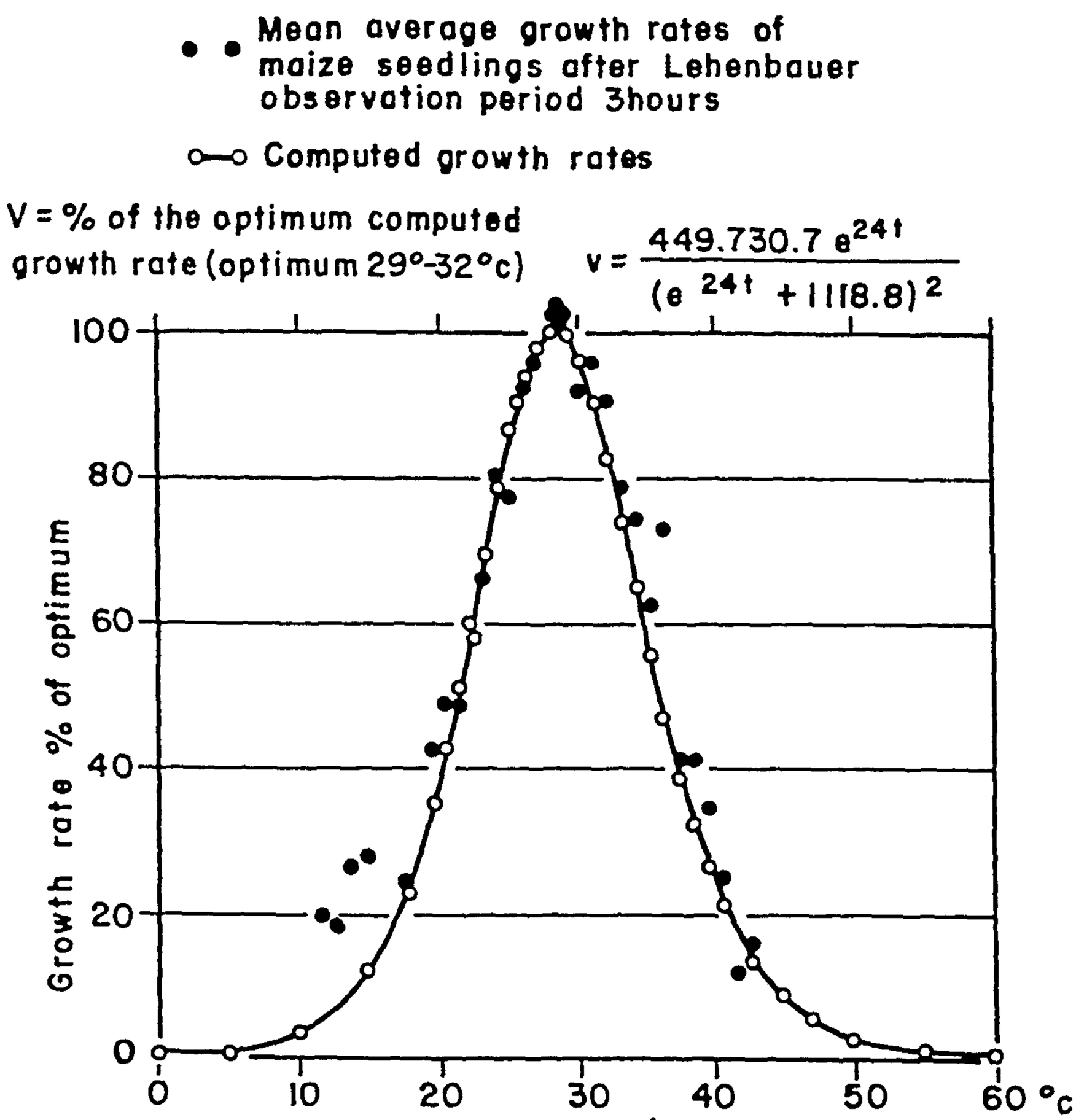
At El Marj a maximum mean winter temperature is 15.8°C, the maxima and minima temperatures are 2°C and 4.1°C in January and 44.0°C and 31.5°C respectively in August. This is due to the location and El Marj on the second terrace at a slightly higher elevation. Also the north easterlies reach the basin of El Marj in the summer with little modification in their characteristics even though El Marj is situated further inland.

Further, a distinctive quality, and one of ecological significance is the high relative humidity which is characteristic of the upland area (over 600m) of the Jebel El Akhdar, particularly near the influence of the sea in the west. Stable maritime air masses and hill fogs envelop these upland surfaces during the early hours of the day, which has an effect on some of the crops, particularly cereals.

Monthly average values of relative humidity for selected stations are given in Table 3.11. In general, it varies between 60 and 80%. The minimum is in the month of August and the maximum in January. It decreases with increasing distance from the coast, and increases with elevation above sea level.

Relative humidity of the region is generally low in part affected by the extremely dry and hot desert wind "Ghibli" blowing from the south. This causes severe damage to crops during the critical growth stage. In addition the water requirement of plants is increased since evaporation increases greatly during 'Ghibli' weather. This plays a major role in reducing the small amount of available moisture even more which then has to be corrected by irrigation. Furthermore in the spring, cold winds come from the east causing excessive foliage and poor

Fig. 3·10 MAIZE GROWTH RATES



°c	V
0	0·36
5	1·19
10	3·88
15	12·33
20	35·52
25	78·60
28	98·27
30	99·69
32	90·30
35	64·56
40	26·32
45	8·76
50	2·72
55	0·83
60	0·25

Source: Thornthwaite 1948 'An approach toward a rational classification of climate' Geographical Review, Vol. 38 p.63

fruit yield.

Temperatures are high enough for crop production at the coast, but are further raised inland causing very high transpiration which if met gives high growth rates. There is a greater thermal uniformity during the high sun season than in winter when the temperature shows a greater variation, which adversely affects the cultivation of seasonal crops.

Thornthwaite (1948) quoting Lehenbauer (1914) has indicated for maize (a summer crop in Libya) (Allan, 1971), how growth rates can be restricted by temperature (Figure 3.10). The optimum temperature for growth of most plants is 30°C. The extreme temperature limits for growth vary, but the minimum is approximately 0°C and the maximum above 40°C. In areas such as Shahat in Jebel El Akhdar, the maximum temperature in winter falls to 0°C, critically can be harmful to early crops. Frost damage to crops occurs, between February and April, especially at high altitude. The same condition in the El Marj area restricts growth of some crops in winter, but is compensated to a certain extent by green houses.

The maximum temperature in the summer is over 40°C at the Beninah, in El Marj and Tobruk areas which has more effect on some plants and increases deficiency of water. This is corrected by irrigation, especially for summer yield. In addition dry farming and people with pastoral economy are more affected by extreme temperature.

The most important point is that the difference in temperature between coastal stations and high altitudes affects the date of ripening in each particular zone of agriculture. Cereal and leguminous plants ripen in Beninah and El Marj areas before the same plants in the Dernah region. This phenomenon gives the advantage for early ripening of crops

to the lower area allowing these farmers the benefit of high early-season market prices.

ARIDITY INDEX

The great rainfall variability is one of the major causative forces behind the aridity index of Cyrenaica and the consequent failure of crop production. The seasonal and annual variations have been observed but it is also important to analyse the aridity index to evaluate the balance of water and its relation to economic usage.

Ahlman (1930) and Fantoli (1952) have coined labels for climatic areas based upon the annual aridity index i for selected stations in Libya using the deMartonne formula (see deMartonne 1927).

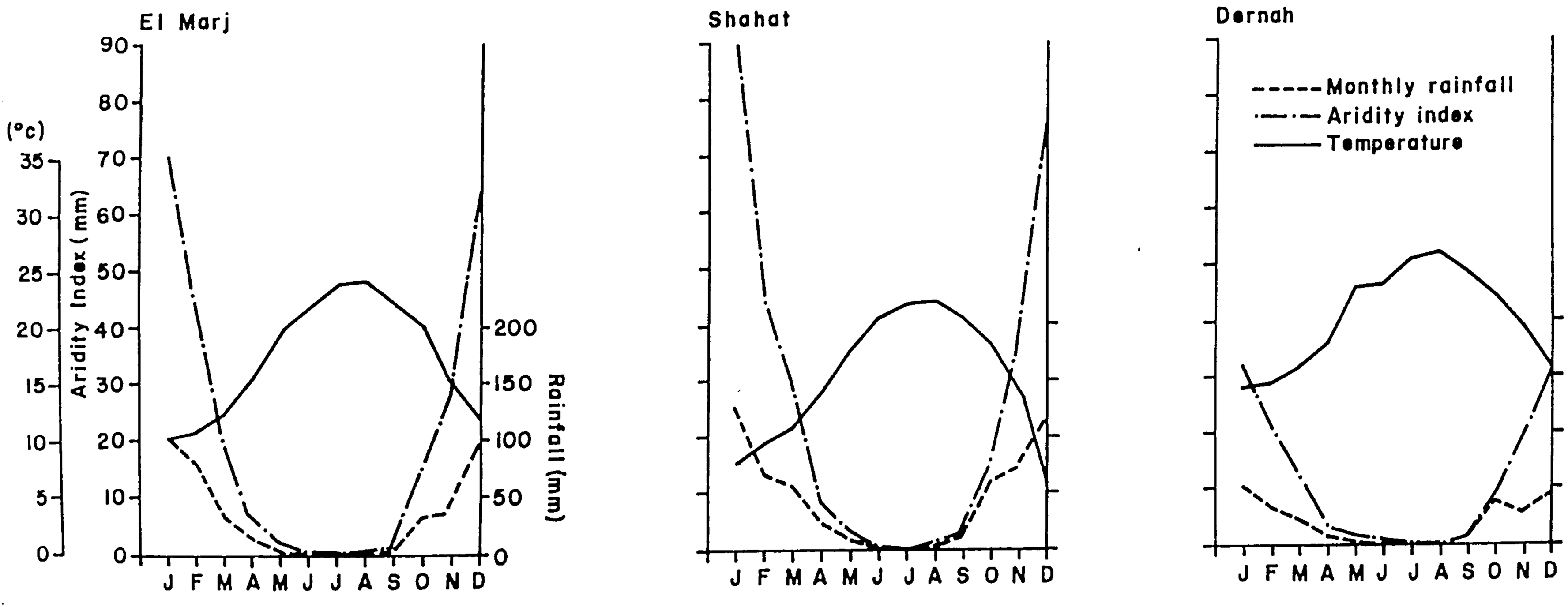
$$i = \frac{p}{t+10} \text{ mm. } C^{\circ}$$, where i = aridity index.

p = mean annual rainfall mm.

t = mean annual temperature C^{o}.

The aridity index in the "exoreic" Shahat station is 25, which includes Dernah with its aridity index of 11, taking into consideration the run-off towards the sea. Then in 'endoreic' regions El Marj has an aridity index of 14, where the karstic formation complicates the picture of the run-off water flow. Further, in the "areic" humid regions Benghazi in 9.2. But Fantoli dealt with the aridity index for these

Fig. 3·11 RELATION BETWEEN DISTRIBUTION, MEAN MONTHLY RAINFALL AND TEMPERATURE TO MEAN MONTHLY ARIDITY INDEX IN SELECTED STATIONS



stations as follows : Shahat 22.6, El Marj 17.5, Dernah 10.3, Benghazi 8.8 and El Regima 8.

The monthly aridity index is important since the Mediterranean climate dry season coincides with the season of high temperature (Fig. 3.11).

Table 3.12 indicates the three months, June, July and August which have an index below one and the six months from April to September, which have an index of less than 7 for Benghazi, Dernah and Tobruk. It is more than 7 at El Marj for the same period with an average of 17.5, Figure 3.11 whilst Shahat has a monthly aridity index of about 17, although its annual index of aridity is 21.6.

The importance of the aridity index for the winter season where it relates to the groundwater supply for the vegetation, depends mainly upon the aridity index of the previous winter season such as the winter mean aridity index for Benghazi is 19.3, Dernah 20.8, Tobruk 10.7, El Fatayah 26.1, El Marj 40.8 and Shahat 48.5.

According to Pioger (1959) the aridity boundary of index 10 for the winter season seems to follow rather clearly the general borderline of shifting cultivation of cereal crops and also defines the boundary line for the growing of olive trees. It is located somewhere between 10 and 15 of the seasonal index, except in the case of the lowland, particularly wadi beds, where groundwater is of shallow depth similar to Ayn Marrah and wadi Dernah areas.

The index 20 delimits the region most favourable for the dry farming of cereals and for reforestation. El Marj is located on the boundary of this curve, but Dernah is situated outside of it where irrigation farming is essential for good economic return. The

TABLE 3.12: Monthly aridity index for selected stations:

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Benghazi	31.3	19.9	8.9	1.9	0.8	0.1	0.0	0.0	1.0	6.1	18.9	31.1	8.8
Dernah	33.5	22.8	13.2	4.4	2.4	0.3	0.0	0.0	0.5	7.8	18.0	30.0	10.3
Tobruk	20.0	12.8	4.7	1.7	1.0	0.0	0.0	0.0	0.2	2.6	7.6	16.8	4.8
El Marj	71.2	49.2	20.8	6.4	2.4	0.4	0.0	0.3	1.4	13.9	27.5	62.4	17.5
Shahat	90.8	45.3	31.4	8.7	4.3	0.4	0.0	0.3	3.1	14.7	35.5	73.4	22.6

Source: Fantoli, A. (1952). Le pioggie della Libia, Roma; 228

cultivation of some plants, such as lucerne, which are as a general rule very tolerant of high temperature and droughts is possible. It is therefore possible as regards water requirements to point the need for the study of new irrigation projects, both from the technical and economic standpoints, as a function of the climate.

EVAPOTRANSPIRATION

Evapotranspiration is the water lost to the atmosphere by evaporation from the soil and transpiration from the plant. For optimum plant growth the precipitation must be sufficient to supply the evaporation. The difference between source of precipitation and soil evaporation is a water budget.

Many terms are used by agronomists, eg. consumptive use is the amount of water evapotranspirated plus that used for building plant tissue, Chow (1964). The relation between precipitation, which replenishes the soil with water and evapotranspiration which depletes it, it is important in determining the availability or scarcity of water. Thus, the water balance is discussed in the chapter of hydrology.

CROP ECOLOGY

Influence of temperature on crop growth

Apart from chemical and physical inadequacies of the soil, the principal environmental elements limiting plant growth in practice are temperature and water supply. In the area under consideration the temperature range is an important feature for plant growth which is

TABLE 3.13: Basic temperature points for growth of seedlings, °C:

Crop	Minimum Maximum	Optimum Minimum	Maximum
Barley, oats, wheat	0 - 5	25 - 31	31 - 37
Maize / corn	5 - 10	37 - 44	44 - 50
Pumpkin	10 - 15	37 - 44	44 - 50
Melon, cucumber	15 - 18	31 - 37	44 - 50

Source: Haberlardt (quoted by Allen, 1971: 93)

restricted to that part of the year in which the average range exceeds 6°C, though the degree of temperature for plant growth and tolerance can be obtained from Table 3.13 which indicates the minimum, optimum and maximum temperature for some seedlings in Libya.

Moreover, the tropical species of "maize" some of the more drought tolerant ones, eg. Sunflower, can grow and develop at lower a temperature, up to 20°C, before they will germinate or grow vigorously (Bunting, 1961).

Plant growth in the upland area rarely suffers from lack of moisture, but the temperature regime, and the exposure of such habitat provide climate limitation to pasture-growth and preclude arable farming except at moderate latitudes. As this study indicates, temperature alone does not prevent plant growth, even at 780 m.a.s.l., but the damaging and desiccating effect of strong winds make conditions unfavourable, except where there is topographic shelter such as in the Ayn Marrah area and on the wadi Dernah terraces.

The high day temperature and low night temperature cause intense damage to the maturing wheat and barley, particularly at the "milk" phase of their growth. Furthermore, extreme variation in temperature during the flowering phase of the orchards can cause serious losses in quality of the fruits, particularly when the night temperature nears freezing point.

More interesting features are the depressed intensities of growth with a reduced summer peak of temperature (Table 3.14) which indicates that the phenomena of the summer regime are more critical than winter extremes of cold which are not necessarily so severe as those in some unfavourable lowland depressions or valleys.

TABLE 3.14: A comparison of minimum, optimum and maximum temperatures for selected crops, with mean minimum, mean and mean maximum temperatures in the Jebel El Akhdar region:

				Dernah				Tobruk				Shahat				Benina				El Marj			
				Coldest Month		Hottest Month		Coldest Month		Hottest Month		Coldest Month		Hottest Month		Coldest Month		Hottest Month		Coldest Month		Hottest Month	
	Min	Opt	Max	M.Min	Mean	Mean	M.Max	M.Min	Mean	Mean	M.Max	M.Min	Mean	Mean	M.Max	M.Min	Mean	Mean	M.Max	M.Min	Mean	Mean	M.Max
Barley, Oats, Wheat	0 - 5	25-31	31-37																				
Maize, Corn	5 -10	37-44	44-50																				
				10.6	14.1	26.3	29.1	6.5	11.8	25.9	31.6	6.1	8.2	23.9	27.9	8.3	12.4	26.4	32.2	5.1	10.5	23.8	31.5
Pumpkin	10-15	37-48	44-50																				
Melon, Cucumber	15-18	31-39	44-50																				

Source: Crop Data - Harbelardt (quoted by Allen, (1971)) Meteorological Data, Ministry of Communications, Deptartment of Meteorology, Tripoli, Libya (undated).

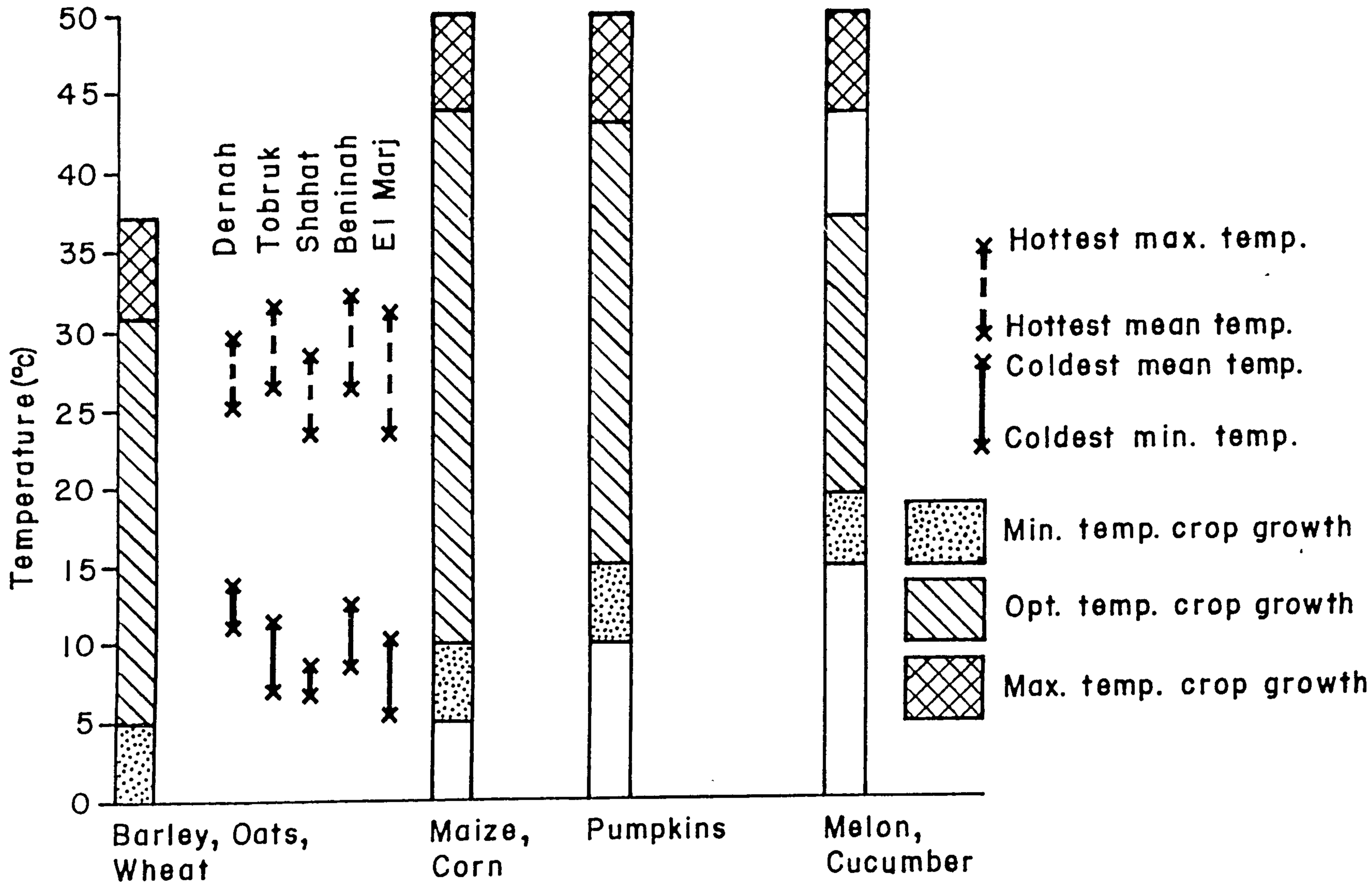
There is no definite cold season capable of causing a prolonged interruption of vegetation growth, especially for winter crops and that is why the development potential of the second terrace depends to a considerable degree on the coolness in summer, as well as the difficulties of impeded drainage. To this extent, the maritime environment of the region is less favourable climatically to a considerably greater degree for plant growth of winter crops, than inland conditions at a similar altitude in the west of Libya, which is discussed by Allen 1971.

Analysis of Table 3.14 indicates the range of temperature for plant growth. Comparing the ideal temperature points for growth of seedlings in centigrade (Fig. 3.12) shows there are some places more favourable to the growth of some species of plants than others. For example, Dernah is considered the best area for the cultivation of pumpkin, which could be confined to Tobruk and Beninah, where those areas are suited for melon and cucumber under irrigated farming. But those plants extend to specific localities at Dernah. El Marj and Shahat have limited optimum temperature for growth of certain plants, but are not the most favourable places for maize, corn and pumpkin, as a summer crop. In spite of this limitation, farmers in fact cultivate them and that is why these plants are retarded in their ripening and their yield reduced.

Bearing all the above points in mind, it could be possible to a certain extent to delimit the suitable area for specific crops rather than to make a combination of different species which eventually will obtain the opposite result.

Furthermore, the importance of other elements of the climate should be noted which have significant influence on crop ecology. This

Fig.3·12 RELATION BETWEEN CROP GROWTH TEMPERATURE AND TEMPERATURE AT SELECTED STATIONS



phenomena can be observed in the Jebel El Akhdar and places south of the region such as south of Tacnis and Marawa.

Water Relation to Plant Growth

Whilst plant growth is dependent upon heat and water, water availability is the major control in semi-arid areas. In the plant water maintains essential lurgidity (keeps the plant upright), it flows through the cells taking salts from the roots and it evaporates from the open leaf, cooling the surface such that it retains its green colour, essential for photosynthesis (see Bernstain, 1955; Jackson, 1977).

In this way, water has a leading role in regulating the rate of plant growth and a water deficit has a great impact upon plant development. It is especially significant is the reduction of photosynthesis, since photosynthesis increases with light intensity, and solar radiation is the major factor influencing transpiration. In addition, the deficit of water causes a vital change to take place in the form of cells, which is affected by turgic pressure. Thus the plant growth is directly related to degree and duration of turgescence of plant tissues. Water loss from plants by transpiration brings about a tensional stress within the plant which is counteractive to the prevalence of turgor pressures in expanding cells. This internal tensional stress is eased by water absorbed from the soil (Peter, 1960). Thus it seems that in semi-arid lands, dew has a considerable importance in plant growth which is proved by D. Duvderani in the coastal plain of Israel. In addition, some scientists have discussed the growth of a number of annual plants during the dry season in southern California due to the effectiveness of dew (Went, 1955). This condition could be

applied in the region under consideration, particularly on high land and in the south of the region where the amount of dew is higher in the dry summer than in the wet season. Moreover, the importance of dew at places which have a little rainfall, especially coastal areas towards the east, is that heavy dew can carry the crops to maturity in dry farming, particularly summer vegetables, such as tomatoes, beans and other vegetables.

The importance of dew to crop production in arid and semi-arid lands of the world must be emphasised in the absence of other moisture sources (Walliam, 1967; Monteith, 1975). It is a clear, desert area south of latitude 28 N, where Desio had noted the importance of dew in the Libyan desert to maintain surface watertable by the condensation of dew, particularly in the many closed basins of the interior (Little, 1964).

Moreover, fog and mist could be important to plants and influence some sort of vegetation, where fog occurs almost daily in a mountain or under line oaks as at Shahat - El Beda areas. The importance of the actual condensation of fog droplets in fog area can be seen in several places along the Mediterranean coast. Just behind Oran in Algeria rises a plateau with a rainfall about 225mm, enough for some pines, but not enough for holly oak. Oaks are found only along a strip 10 feet wide, that follows the ridge of table land against the places where fog hits most, and where the water supply is more important.

Wilting Point and Field Capacity

The rainfall does not compensate for the high values of heat input so water available to the plant is supplemented by irrigation,

safeguarding against drought. It is necessary on the fine-textured soil with low rainfall zone, similar to the El Fatayah area where the soil characteristics are more favourable to crops having a shallow root range. Even so, the soil water is often not replenished by rain or irrigation over a period of days or weeks. Hence the soil acts as a moisture reservoir for the plants, particularly in late summer, at least to some degree of PWP, to protect the growth of plant from temporary wilting.

But permanent wilting occurs when the soil moisture can not redress the crop water deficiency. This condition is in poor soil aeration, high moisture tension or salinity at the eastern zone of Jabel El Akhdar and southern area and might impair the capacity of roots to absorb water so that moisture tension in the plant is not adequately alleviated. This may reach the state where the plants lose turgidity.

Other areas with medium textural soils such as the northern coast of the region are favourable for deeper-rooted bushes and trees which obtain water from deep soil moisture. Some kind of crops (Palms) an the coastal plain of Benghazi are greatly affected by the degree of salinity either in the soil or the influence of sea breezes which are affecting the quantity and quality of its yield.

Furthermore, a deficit of water flow becomes more acute for growth, particularly at the stage when plant growth is developing more slowly. It should be noted that lack of water can restrict plant shape and limit yield in its form and production, as in rainfed cereal production (wheat) during the stage of pre-shooting and growth. As a result, the effectiveness of precipitation on plant depends mainly on intensity, duration and frequency of its occurrence (Jackson, 1977), for which it

will satisfy the needs of transpiration and consumptive use by supplying that during the commencement of the dry season. So the deficiency of water leads to the production of small cells and saturated plants (Bernstain, 1955).

Method of Alleviating Water Shortage

Alternatives must be created in different ways, like increasing the storage capacity of the soil for moisture, crop rotation with the frequent use of grasses and legumes, improving the soil structure and strengthening its moisture retention by applying organic manure as needed. By these practices the soil becomes more absorptive and less water is lost.

Crops that use less water should be selected. Crop schedules, should be changed, such as earlier planting, so that the plant obtains benefit from the precipitation at the beginning of the rainy season. The benefits of this method have been proved by the results of a chickpea trial at El Marj. It used three different sowing dates (16 December, 15 January and 17 February). The highest yield was for the December sowing, and the yield was reduced by 60% and 80% in the January and February sowing respectively.

Thus, the fact that the yield for legumes (chickpeas) decreased sharply from mid- December to mid-February confirms the superiority of early winter planting at El Marj (Khalif, 1984).

Eventually the water deficiency must be made up by a combination of improved traditional methods and especially adapted and partial mechanisation. This could increase the acreage and the yield as expansion of irrigation is practicable. Thereafter it is important to

determine how much and when to apply water for irrigation farming (Thornwaite, 1947 and Taylor, and Slater 1955).

But the native vegetation has undergone further modification to enable its survival. Some species of shrubs and grass may have extensive and well developed root systems, and relatively limited to growth. They afford a greater water absorbing system in relation to more limited transpiration surface. Moreover, they usually have small leaves and in some species a profuse growth of hair shields the stomatas and sometimes reduces evaporation by retarding the loss of vapour from the surface of the plant because high evaporation induces physiological response in natural vegetation and economic plants, tending to accelerate wilting and cause death.

Therefore, chicken cuticles may be produced and frequently stomates are depressed. This feature is clearly seen at the epidermis of many grasses and some species of vegetables, if they are poorly adjusted ecologically to a shortage of soil moisture and if the dry period is protracted.

Finally, trees never grow very tall in climates where the air is dry and strong winds flow during the growing season (Hayes, G.L. 1955). That could be the main reason for restricted growth of some species of trees in the El Fatayah area because trees grow tallest in environments where rates of transpiration are low, and they also grow larger on sheltered mountains. That is the main reason for the suitability of Ayn Marrah zone and Dernah city for different kinds of trees which have various requirements for moisture. For instance, Dernah's city agriculture was famous for banana production, and the terraces of Dernah wadi and the Ayn Marrah areas have some of the tallest trees such as pear trees.

CONCLUSION

The major elements of climate as the pattern of rainfall conditions on the region have thus been described, analysed and interpreted in the light of existing meteorological knowledge and concepts. Apart from any purely climatological value, such an investigation is of primary importance to the economic development of the region where the great majority of the population rely upon agriculture as the only, or major, source of income.

Predominant influences upon present day agriculture are the intensive and relatively lengthy dry season, leading to a period of marked water deficiency every year; the distribution of the rains of the wet season, without any reliable short dry season within them; the torrential but short-lived thunder storms of the dry and late rains leading to extension or a contraction of the wet and dry season.

Amongst the many factors that require investigation to ensure agricultural expansion and development, the maximum utilisation of the country's abundant water resources which by irrigation allow dry season agriculture, stands high.

From the preceding discussion, variability and reliability permit an evaluation of fluctuation from mean conditions. The areal pattern of fluctuation between regions indicates those areas that are likely to experience good or bad years at the same time. Apart from this, the expansion of each crop from its present restricted distribution requires that they are not introduced into areas in which rainfall conditions are likely to experience good or bad years at the same time. Apart from this, the expansion of each crop from its present restricted distribution requires that they are not introduced into areas in which

rainfall conditions are likely to be inhibiting.

The timing of the onset of the rains, their intensity at different periods within the wet season, the length of the dry season for ripening and harvesting, all are relevant for different crops. Furthermore, other climatic features, including temperature, are lowest in the highest rainfall zone of the Jebel El Akhdar, resulting in lower evapotranspiration rates. This means in effect that a unit amount of rain is more effective in this zone then anywhere else in the north of the region. In the highest rainfall zone humidity is further increased by higher cloudiness and occasional morning fog during the summer and also by less pronounced 'Chibli' conditions - light frost may occur in the highest region.

Due to these climatic conditions, the high rainfall zone is the area with the highest potential for crop production under dry farming. But even here the scarcity of summer rain does not permit the cultivation of summer crops, and the pasture vegetation ceases to grow towards the end of May as a result of soil moisture exhaustion. Only grapes and fruit trees, having deep root systems, are able to grow during the summer on deep soils of sufficient capacity for storing winter rain. However, the major problem is the inefficient use of the limited rainfall in the agricultural land. Deep soil capable of storing a maximum amount of winter rain is very limited in extent such as the area of El Marj and El Fatayah which have ferriosiallitic soils or Terra Rossa with its characteristic reduced soil moisture storage capacity and depth of rooting of crops. In addition, potential evapotranspiration rates are higher in those areas due to higher temperature than in the central region as at Shahat. Consequent to that, moisture supply

becomes more critical in the first area to meet the water requirement of the plants at all times which is the difference between actual and potential evapotranspiration, as has been discussed before.

This deficiency can be compensated for, through spacing such crops sufficiently far apart, in order to allocate to individual plants a soil volume to permit each plant to extract the required amount of soil moisture during the rainless summer. The existing vineyards and orchards of apples, pears, and stone fruit are proof that these crops can be grown successfully, provided they are planted on deep soils with proper spacing. However, a rainfall of 400mm at El Marj is still sufficient to satisfy the water requirement of a wheat crop, provided it is properly distributed over the winter and spring months but rainfall less than average is not quite sufficient to produce a full grain crop unless it is exceptionally well distributed, although moisture supply is considered insufficient to produce economically any crops other than cereals.

Besides agro-climatic constraints of rainfall variability and moisture stress, pests, diseases and weeds, and workability need to be taken into account to quantify what is agronomically attainable for agricultural land use in the region.

CHAPTER FOUR

WATER RESOURCES

Perennial water sources have played a crucial role in the siting of settlements and the growth of economic activity in the region. Water resources development, now as in the past, generally takes place at a local level with the aim of supplying immediate agricultural and domestic needs from either surface or ground water.

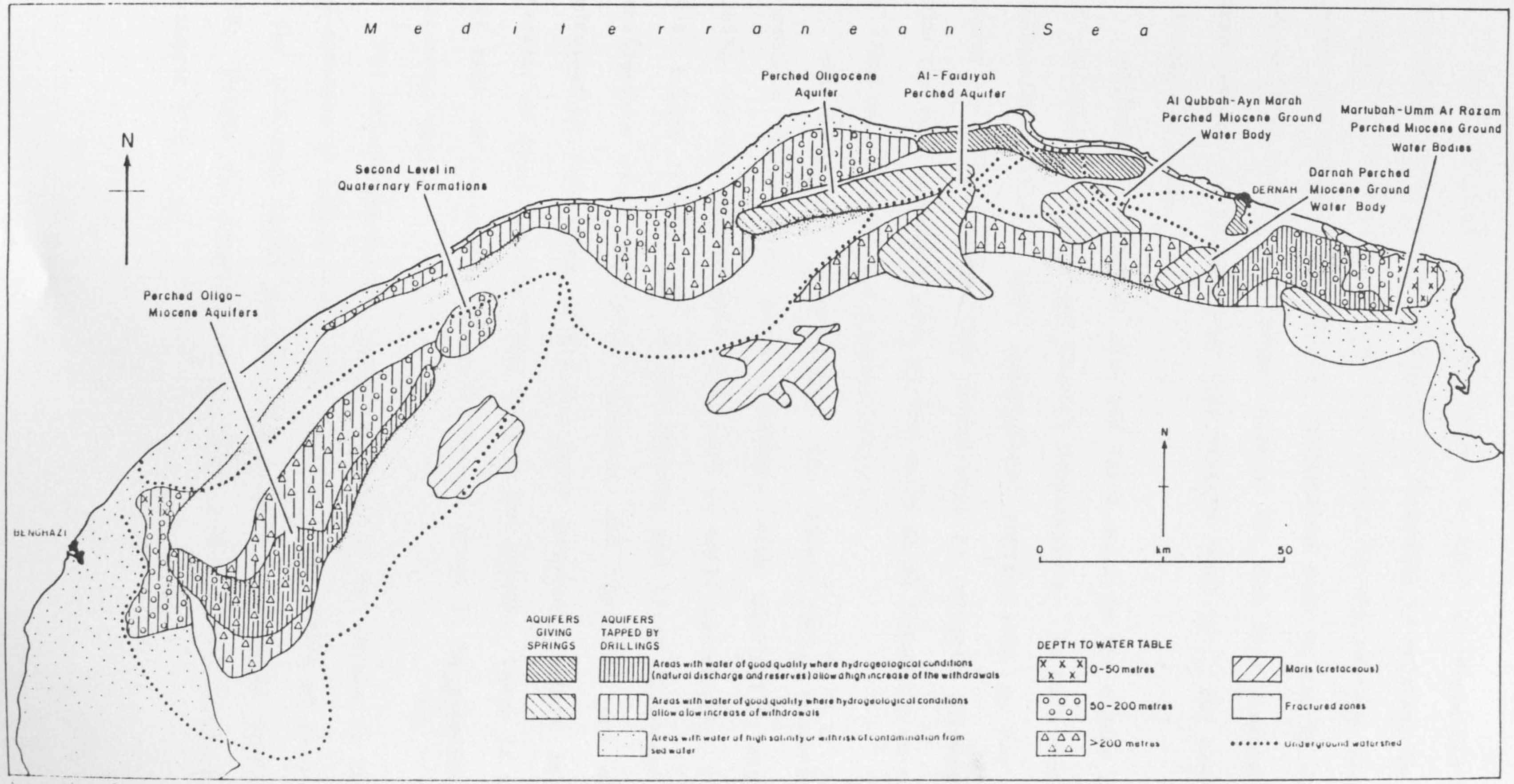
Stratigraphy and Water Bearing Characteristics

Copious springs are concentrated in the eastern part of the Jebel El Akhdar and wells tap deep underground water across the Jebel area, while on the coastal plain water of low quality is found rather nearer to the surface. Rainfall is lost through as evaporation, runoff or infiltration through permeable rocks.

The hydrogeological formation of the region outlined in Figure 4.1 shows that the prevailing geological horizons of the Jebel are Cretaceous, Eocene, Oligocene and Miocene rocks, with specific areas overlain by Quaternary deposits.

The physical character of the region is divided by Marchette (1938) into two groups: (i) impermeable or mildly permeable rocks and (ii) permeable rocks. The first consists of layers of marls, with the addition of marly limestone which is mildly permeable. They form a thin horizon extending over a fairly extensive area to constitute water bearing strata.

Fig. 4 1 GENERAL WATER RESOURCES



Source: G.P.L.I. 1972, Surface and Water Resources Survey for Hydro - Agricultural Development, Eastern Zone, Tripoli

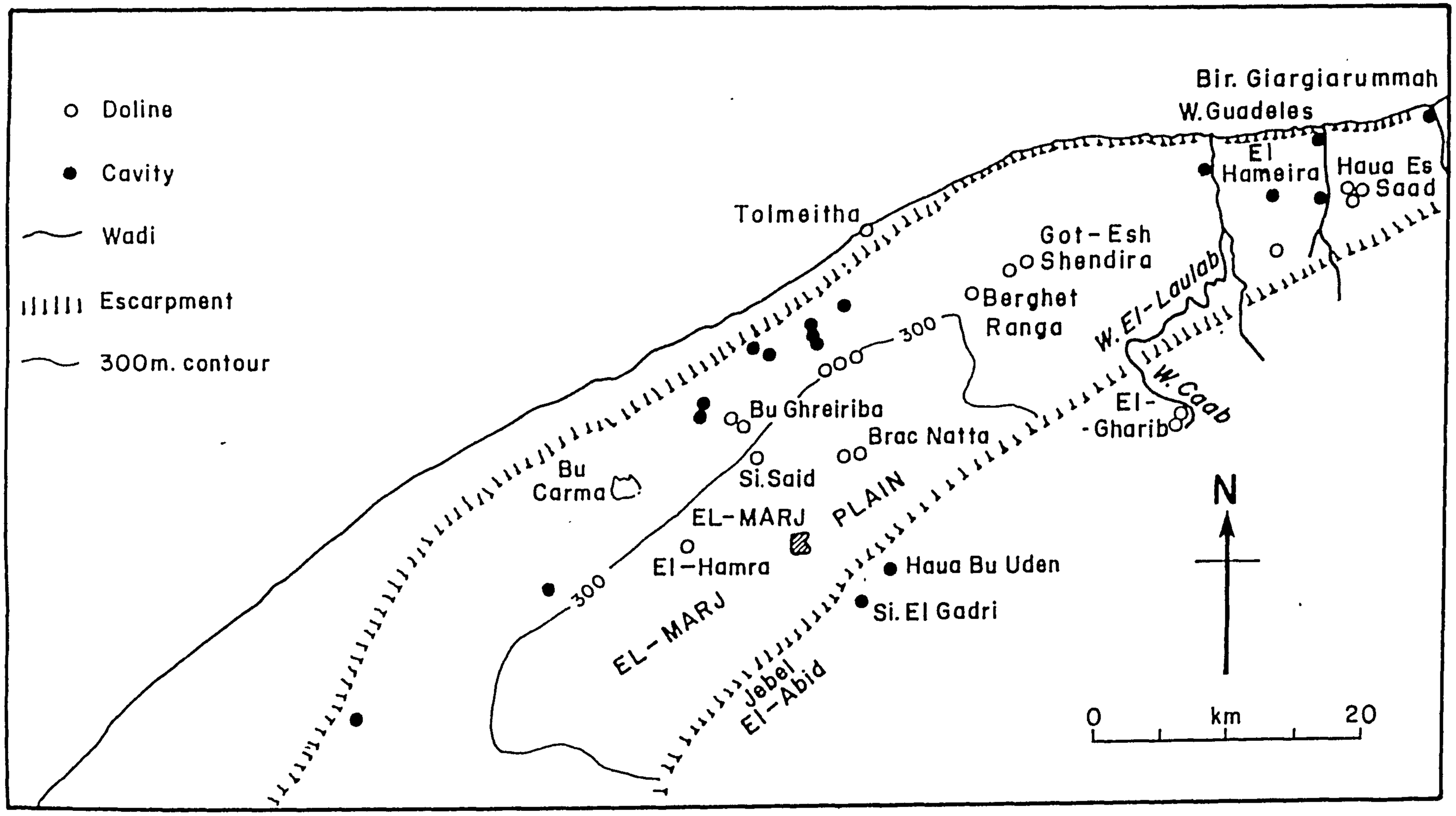
The lower Langhian of the Miocene, to which the formation of one of the richest water bearing horizons of Cyrenaica is related, is the most typical lithologic feature of this strata in the eastern part of the Jebel, and consists of strongly argilaceous sand in the El Gubbah-Ayn Marrah area, although it merges more in the east into greenish clay at Ummar Rezam. It extends also into western Jebel to the eastern part of Benghazi plain.

Aquitanian calcareous clay and marsh occur in the middle and south of the Jebel at Shahat and Chaulan respectively. In such wadi gravels collecting galleries were constructed, particularly as far as east Timimi to Bardia, where they constituted an entirely different group from the dune aqueducts such as the wells of El Munastair on the coast of Benghazi (Addison, and Shotton,1946).

The Oligocene, particularly its lower part, contains other permeable rocks which occur sometimes with distinctly argilaceous facies, and are usually made of by marl or marly sandstones. The rocks which belong to the base of the Miocene and Lower Oligocene have a considerable water retaining capacity, and therefore are of great hydrological importance (Fig.4.1), Their peculiar feature is of the presence at their base of flint nodules and streak. There is also the soft marl of the middle and Lower Eocene where it is associated with Cretaceous marl.

The second group, the permeable rock, is not common in the Jebel and consists of mainly Quaternary deposits. The effect of permeability on the lithology is in the solution on a large scale (see Sparks, 1968; Wright and Edmunds, 1972). It produces frequent Karst phenomena (Fig. 4.2).

Fig. 4·2 THE KARSTIC FEATURES AND PHYSIOGRAPHIC UNITS OF EL MARJ PLAIN AND THE ADJACENT AREAS



Source : Buru, (1964)

Marchetti observed that the lithoclast compactness and elasticity of lithology varies, and that Oligocene and Miocene strata are more densely fissured or karstified than Eocene horizons which are more compact (F.A.O. 1963; Little, 1945) as has been pointed out by Guerre (1978) in a study of the coastal karstic springs of Ayn Az Zayanah on the Benghazi plain.

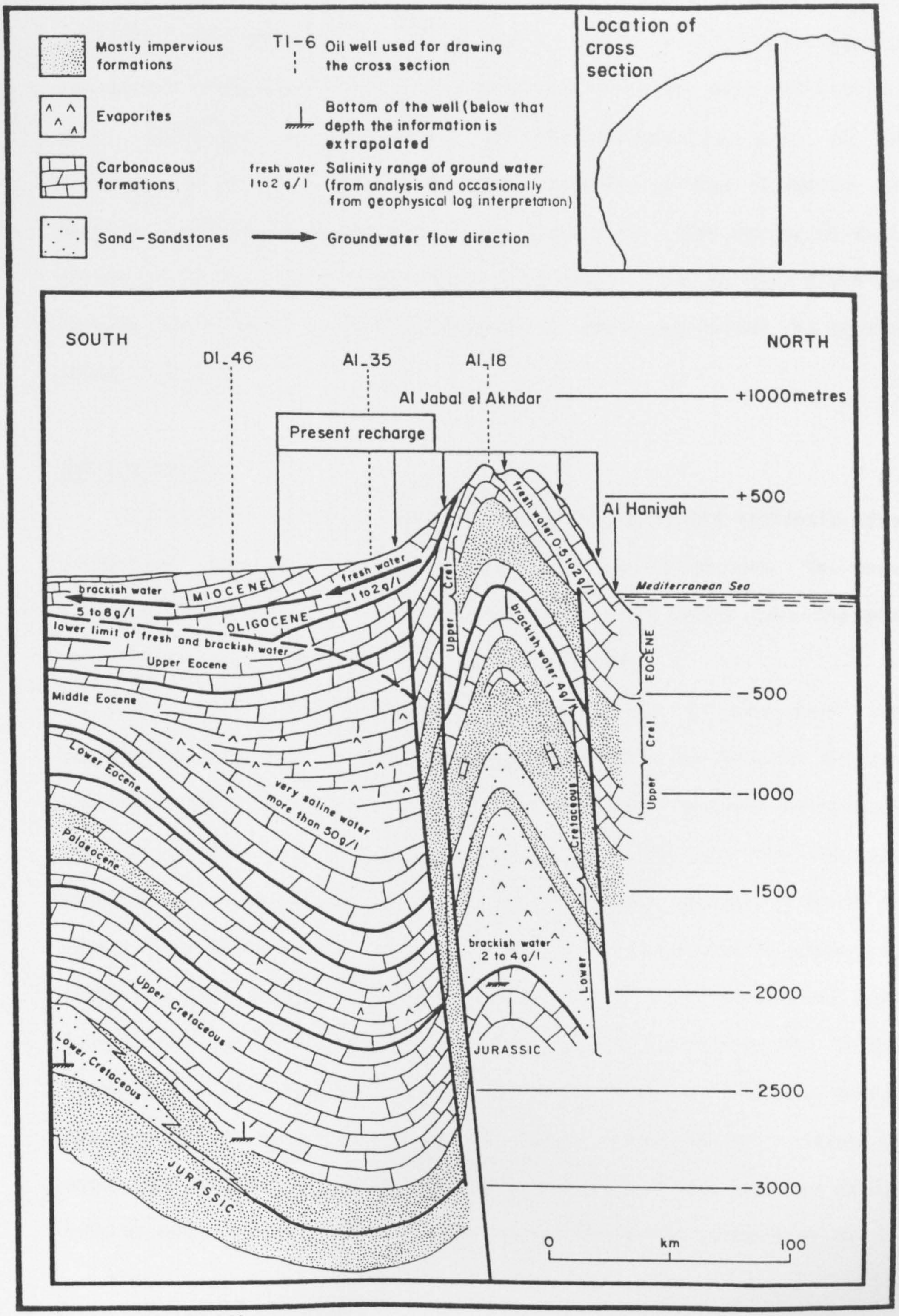
The aforementioned generalised summary of the stratigraphic units and their relative importance as aquifers, needs special emphasis for the hydrology of the Jebel and its relation to land use.

Structure and Effects on Hydrology on the Jebel

The basic structure of the Jebel is anticlinal with the East-West axis following the line of the highest points (Fig.4.3). Dissected terraces lie to the north with some wadis which probably have a tectonic origin such as Wadi Al-Kuf where discontinuity is caused by faults (Fig.4.4).

The most important topographic features show the trend of the main faults and some of the lesser dislocations as far west as the El Marj plain a basin in the second terrace, which contains an important group of deformations (Hey, 1968). This is proved by GEOZAVOD, which stated that geoelectric work indicates a crossed pattern of normal fractures to be common, with some of them parallel to the coast (Noble, 1966). All of these phenomena have been confirmed by the recent earthquake of 1963. This indicates the area is still active, and data available from recent drilling by G.E.F.L.I. (1978) indicates a variable lithology over a relatively short distance.

Fig. 4·3 NORTH-SOUTH HYDROLOGICAL CROSS SECTIONS FOR JEBEL EL AKHDAR



Source: Pallas (1980)

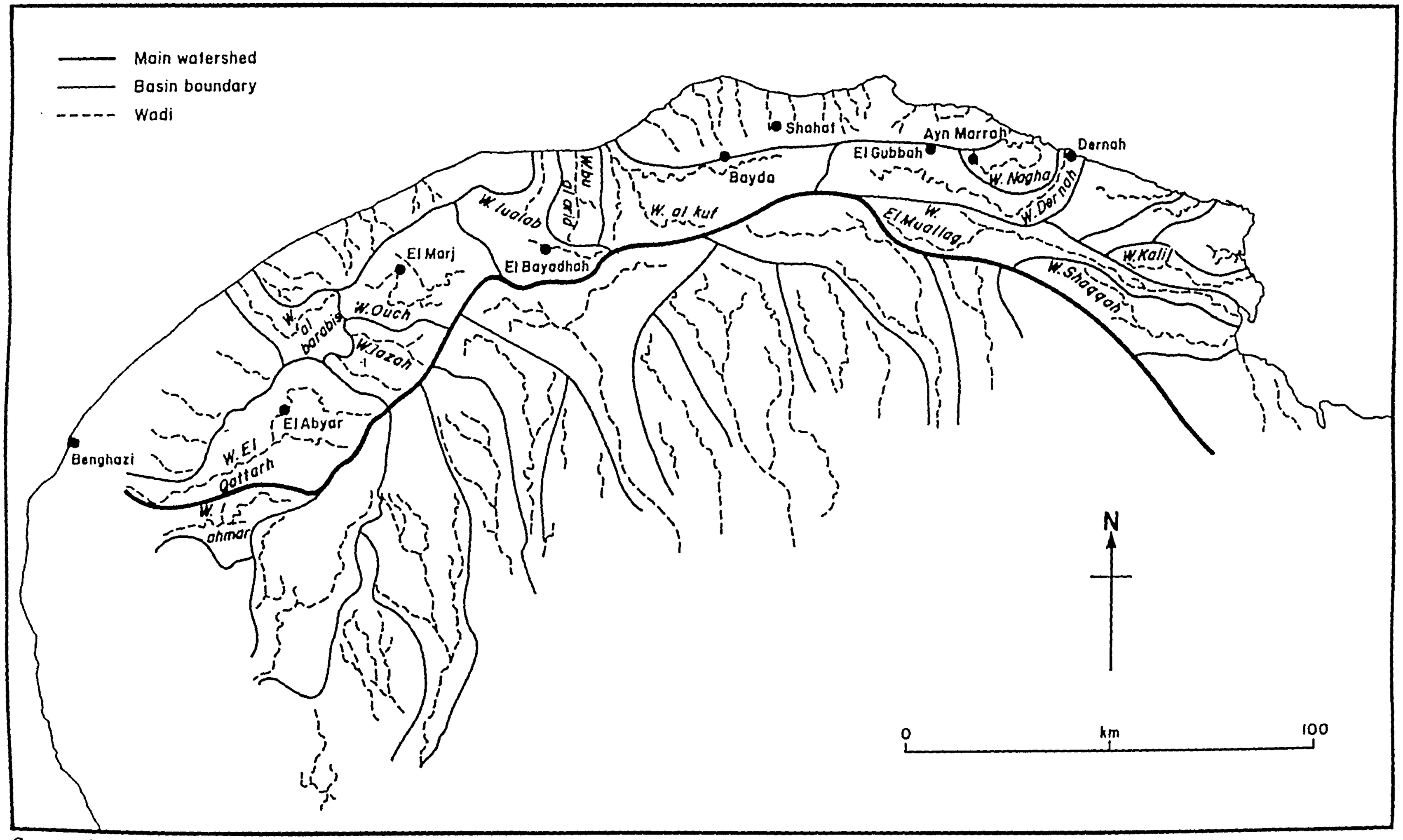
The tectonics are clearly defined but there is normal faulting, producing favoured paths for ground water. There is coincidence between the general east-west trend of fractures and the north east and westerly major discharge of groundwater so far recognised, such as the interruption of water bearing formation between springs at Marrah and springs at Ummar Razam by Wadi Dernah (Fig. 4.1). The spring of Anjil in the centre of Jebel is the result of a fault. The El Marj plain and terrace fault are of differing lithologies, which sub-divide the aquifer (Noble, 1966).

SURFACE WATER:

Discharge of water in the wadis occurs abruptly and violently after torrential rainfall, and sometimes only lasts a day or two. The water of large wadis north of the watershed (Fig. 4.4) empty into the sea, while the others terminate into closed depressions.

The scarcity of permanent streams is due to the fact that precipitation is low on the whole (250 to 600 mm, see Chapter III) and the rocks generally porous. Karst phenomena is doubtless responsible for the disappearance of wadis. Nevertheless there are some temporary water sources which flow for a long period on the northern face of the Jebel, like Wadi Dernah. The runoff has special features in this area; there are deep gorges and because of the Karst topography there are a large number of closed depressions in water basins such as the El Marj basin (Hey, 1968) and its lower portion, El Garigh, where the surface inundations are large due to the low rate of percolation. Since the water evaporates slowly because of moderate temperature (average 25°C) a body of water remains until as late as June before it evaporates or

Fig.4·4 SURFACE WATER DRAINAGE



Source: Doxi (1978)

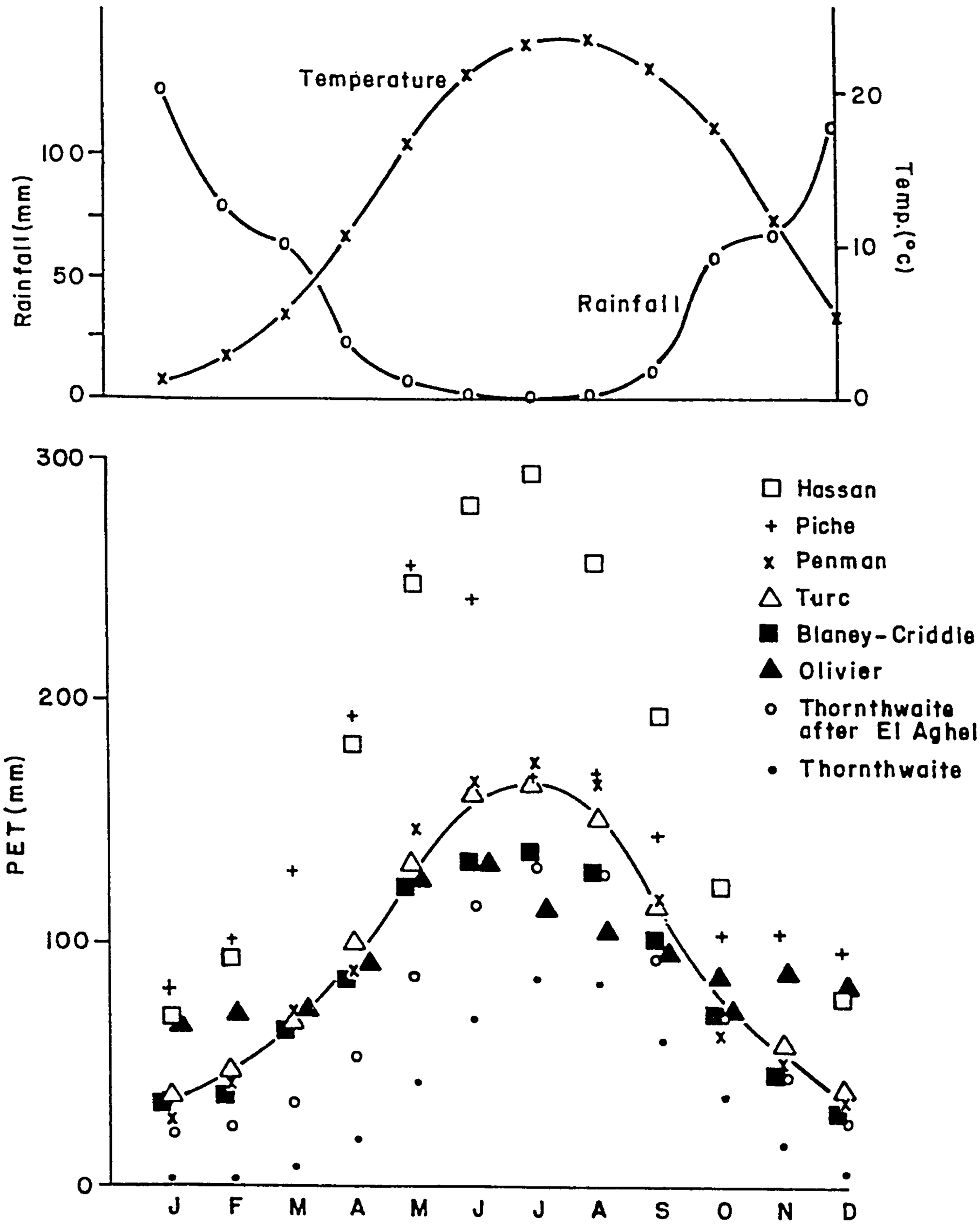
drains from its south western end by Wadi Zazah and Wadi El Qud.

In small basins, some of which are only a few metres in diameter, temporary lakes are formed during the rainy season, such as Brak, Natla and Berghet Oranga in El Marj plain (Fig.4.2). However, whether the water forms in this manner or disappears more quickly, the soil is always moistened to a considerable depth as in the bed of the wadis. Consequently there are much more thickly growing vegetation areas around the depression of the El Marj plain, making it suitable as a grazing area.

Of greater importance in the Jebel is its supply of ground water, some through canals conveying excess water to the lowest points after storms, but more from wells with irrigation canals leading off them. In a great many places, the impermeable strata are revealed (Pioger, 1952). Permanent streams are to be found in only a very few wadis, most of them along the northern coast between Sussah and Dernah, but a considerable runoff does take place in response to higher intensity storms, and it is apparent that much of these concentrated volumes infiltrate into the wadi beds. The overflow of the spring Ayn Dabussia, in Wadi Seghi, re-enters the ground within ½ kilometre. Similarly, a small sink reinfiltrates part of the flow of Ayn Marrah occuring in the highest part of Wadi Naga. The same situation is found in the lower part from Wadi Dernah. There is also a perennial river fed by springs of Wadi Dernah where the flowing water disappears into the gravel and sands of wadi beds as a recharge to the phreatic strata of Dernah's wells.

A special concentration of surface runoff from Wadi Al Qud and a number of small wadis from all directions collects in El Marj plain in a large depression. Most of the water that accumulates in this pond seasonally is related to storms, and some of it evaporates.

Fig 4·5 POTENTIAL EVAPORATION PER MONTH AT SHAHAT FROM WEATHER DATA AVERAGED TO MONTHLY VALUES 1945-1976



Evapotranspiration!

Critical criteria for an agricultural economy are water and heat. Rainfall and temperature have been shown in the chapter on climate to give the Jebel El Akhdar region a semi-arid climate with a marked water shortage, except in the winter months. In this chapter hydrology values are estimated of the runoff which offsets the dry spring and summer after storage in the aquifers discussed in the section on stratigraphy.

Effective rainfall is the rain depth left after evaporation. To decide on which expression(s) seems most valid for calculating evaporation across the Jebel, the meteorological data for the most representative station, Shahat, has been tried with a full range of expressions for evaporation when plotted in Figure 4.5 from which a compromise curve is shown. Figure 4.5 shows the range of values from different approaches to evaporation, explained in Appendix 2 'Evaporation', and available as a civil engineers guide in the reference work edited by Chow (1964). The separate approaches are outlined below:

The Penman expression for evaporation is probably the most successful and has been widely used. It combines a heat balance and an aerodynamic approach using standard meteorological data. The Hassan expression also has evaporation caused by radiation and by a product of wind speed and humidity but is empirical. Values shown are taken from the report by SDWR (1978) for Shahat. They are very large values, clearly above all others except the Piche values for January to May, also given in the SDWR report. The Piche is a simple instrument indicating a measure of evaporation. The sudden fall in June and even more so in July, shows the second half of the year so very different from the first, and makes these given Piche values rather hard to

believe.

Thornthwaite's international classification of climate was based upon the comparison of monthly rainfall with the potential evapotranspiration indicated by a heat index calculated from monthly mean temperatures. Temperature values are commonly available, so Thornthwaite's tables and monograms have been widely used across the world to indicate water deficiency or surplus. In semi-arid regions, Thornthwaite's values of evapotranspiration seem too small (Hanna, 1974). This seems to be the case here in the Jebel, as indicated in Figure 4.5

The Thornthwaite evapotranspiration values given by El Aghel (1979) are a little higher because his temperature values (1961-1976) were a little higher. The Thornthwaite evaporation values are very sensitive to small changes in temperature for high values of the heat index, i.e. for regions of moderately high temperatures.

Stanhill (1961a and b) and Jackson (1977) found both Thornthwaite and Blaney-Criddle values underestimated evapotranspiration in a semi-arid region. Blaney-Criddle, like Thornthwate uses mean monthly temperture but also includes day length and latitude to indicate the radiation effect. A coefficient is included to indicate the water requirement by the particular crop that month.

A soil factor and a crop factor are required with monthly precipitation values to calculate evaporation using an expression by Turc. The French report by G.E.F.L.I. (1972d) gives monthly values of evaporation so calculated from data over 7 years in the 1950s. The plotted values in Figure 4.5 are seen to lie very close to the values which have been calculated by the Penman method.

Olivier (1961) worked on irrigation problems for many years with the large firm of consulting engineers, Alexander Gibb and Partners. He found that evaporation as measured by tanks (American Class A Pan) and similarly by Piche correlates very significantly with the wet bulb expression. We can expect this from Dalton's law on vapour transfer as a function of air humidity below saturation values. (This drying power is inherent in Penman's aerodynamic approach). Olivier, however, also correlated with evaporation the deviation from the annual mean of the ratio of the incoming radiation to the vertical radiation; i.e. variation with season and latitude. The expression by Olivier and by Blaney-Criddle give very similar values in Figure 4.5.

The spread of values of evaporation using the methods outlined above (expressions and derived values are given in Appendices 2 and 3) are seen in Figure 4.5 to be quite unsatisfactory. Such is not an uncommon result, particularly where the true values are not known, as for example the evapotranspiration through the growth stages of different crops in different periods in the Shahat area of the Jebel El Akhdar region.

Stephens and Stewart (1963) found a similar spread over results of nine differing approaches applied in Florida. They did not like the method of Thornthwaite, preferring the modified Blaney-Criddle method, or (though giving a higher average) the Penman method, if measured values of radiation are available.

Jackson (1977) after similar trials of different expressions using data from East Africa found that the Penman method gave the most consistent results. He suggested that the Thornthwaite, Olivier and Blaney-Criddle formula showed a smaller range through the year, with

values closer to Penman during winter months. This is very similar to the results here in Shahat as in Figure 4.5.

A compromise seems unavoidable in selection of evaporation values as calculated from the different workers using the Shahat data. An arbitrary mean curve has been drawn in Figure 4.5. The Penman method seems the most acceptable and has been used here for the Jebel El Akhdar data available i.e. the four stations shown in Figure 4.6.

Soil Moisture:

An F.A.O. report (Chanduri, 1978) gives soil moisture as a precent of dry weight through the range of soil tension of "0" close to field capacity to 15 bars (close to wilting point). The sampled clay soil dominant across the Jebel showed an approximate 15% range of soil moisture between those field limits. Weights are not given in the report but if a bulk density of 1.5gms cm^3 is assumed as common for a clay soil, this gives a moisture content 15% x 1.5 = 0.225g cm^3 of water in each cm depth of soil. The curves of moisture content shown in the report do not change very much from the 15% so if 1.5g cm^3 soil density is acceptable over the 0 to 60 cm depth analysed in the report, the moisture content at field capacity is 60 x 0.225 = 13.5cm water depth.

This value is rather different from the SDWR (1976) report which gives max values for RAWS (Ready Available Water Supply) as 25 mm for El Marj - Al Abyar Benghazi area. Other reports (FRANLAB, 1976 and GEFLI, 1972d) recommend 20 mm available water for some stations in the area. The SDWR report later recommends 25 mm for the entire oriental province except the plain of El Marj which is given 100 mm. The range of values through these 3 reports could probably be elucidated by the

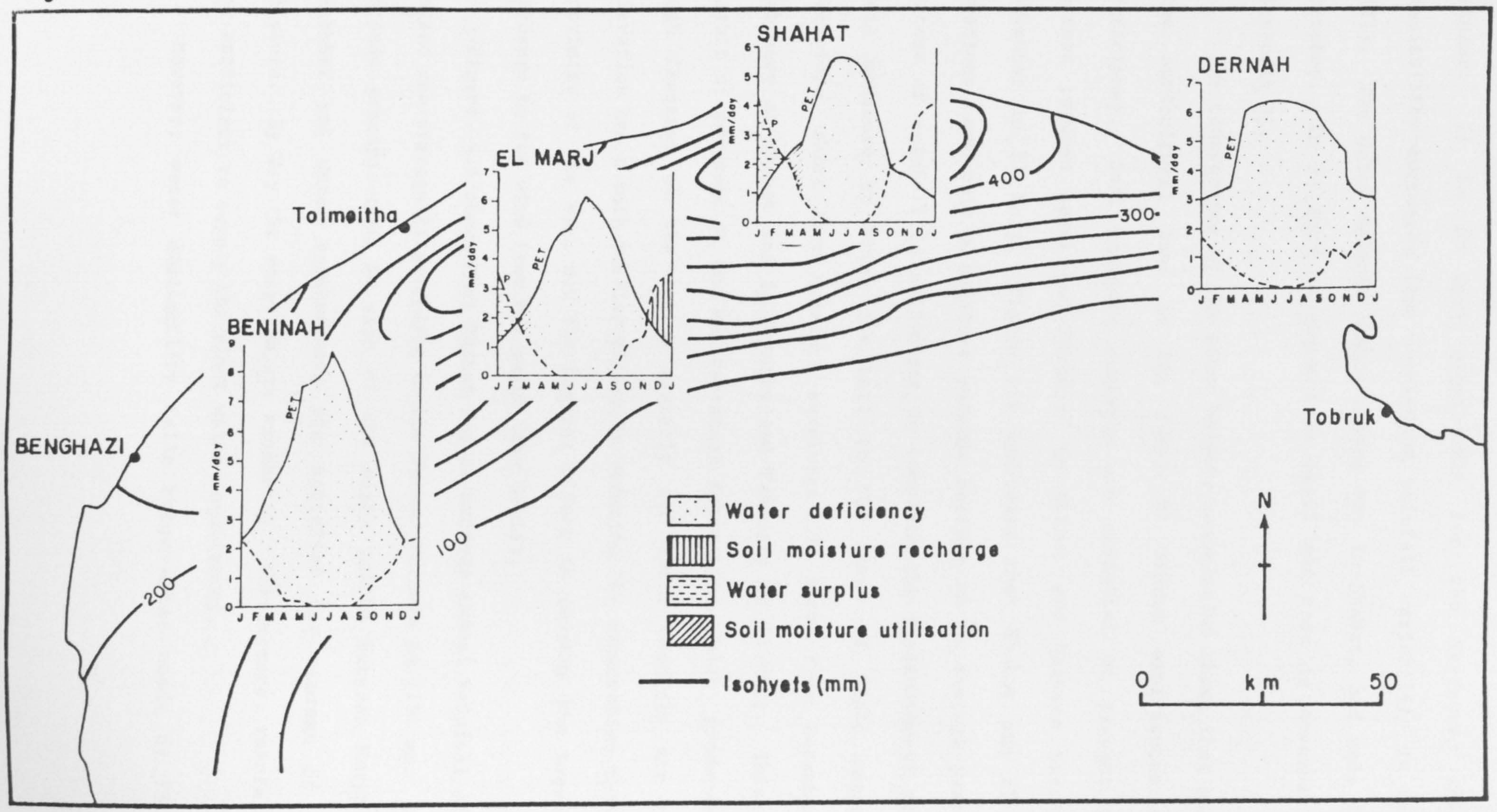
investigators if brought together.

Many of the crops (e.g. grapes and grain) root to one meter, but only in the El Marj Plain is a much greater soil depth available. There is less than 60 cm of arable soil in some places in the El Fatayah area, though generally there is great variety in soil depth. Jackson (1977) for clay soil gives rather less than 80 mm water in the 80 cm of soil. This value provides a compromise on the very wide values available for soil moisture in the somewhat conflicting reports and is supported by the writer's experience of family farming in the region. The sudden shower characteristic of rainfall across the region frequently results in an intensity greater than the percolation rate into clay silt soil, resulting in localised runoff. Such a process is a further reason for taking a soil moisture limit less than the general value for this type of soil. Hence a value of 80 mm of water depth has been used for correlation of rainfall evaporation and runoff.

Effective Rainfall

The value of 80 mm soil moisture retention is being used for the region's soil, as just mentioned (Appendix 3). In this semi-arid land, crops depend mainly on the soil moisture reserves, especially during early growth and particularly in an area where there is limited rainfall during the growing season (Hanna, 1983). Moreover, the critical period is in July when drought reaches its highest peak. The location of the lowest water deficit is Shahat which reaches a peak of 173 mm in July. In El Marj, the peak is also in July but higher, at 186 mm. At Beninah and Dernah, there is a water deficit all year round (Fig. 4.6). It is caused by the Gibli wind from the desert warming to the east of Jebel El

Fig. 4·6 WATER BALANCE AT SELECTED STATIONS BASED ON PENMAN FORMULA



Akhdar. It is in part responsible for the increased rainfall variability eastwards (see section on rainfall variability in Chapter III). The water deficit begins during May in Shahat, and ends during October. In El Marj it appears in April and ends in November (see Appendix 3).

The consequence of the water balance calculation shows that most of the agricultural land in the Jebel El Akhdar experiences water deficiency. Soil moisture reserves are essential to prevent water stress between April and November in Shahat and between March and December in El Marj. Figure 4.6 indicates that Shahat and El Marj stations have only a moisture surplus because in an average year the excess of rainfall is sufficient to complete the replenishment of the soil moisture to bring the soil to the level of field capacity. Therefore, short term moisture surpluses can occur from December to February at Shahat and in January and February at El Marj. This is a result of movement of the Mediterranean depression, which produces the high freqency of the strong westerly and north westerly air flow. Elevation has a much smaller effect in reducing the evaporation than the proximity of the sea, but the biggest effect in raising the losses is exposure to the wind from the south (the Gibli).

Figure. 4.6 shows that Shahat has an average annual rainfall of 565 mm and the average Et according to the Penman formula is 1154 mm. So Et exceeds precipitation in each of the eight months between March and December and water requirements are satisfied for storage of soil moisture. By May the reserves are exhausted. Furthermore, rainfall is not sufficient to supply the plant water requirement.

However, water availability falls below water needs by 731 mm

during the period between May and October, and it is not until November, when rainfall exceeds Et that the recharge of soil moisture reserves begins. This continues to the end of March and after that there is storage of soil moisture of 6.9 mm until the middle of April.

There is no great difference in the El Marj area, where the water deficit exists between April and November. In December soil moisture recharge begins and it attains field capacity by January. The runoff starts with small amounts up the end of February. After that there is soil moisture up to the end of March. Water deficit begins in April, hence irrigation should be applied after this period.

Water deficit is greater at Dernah in the east and Beninah in the west of the region than in the El Marj area. Soil moisture conservation cannot make dry farming profitable. Therefore, irrigation is an absolute necessity. Summer crops are possible with irrigation and in addition the crop calendar can be readjusted to take advantage of winter rains by growing crops that are planted in the Autumn.

The great variability of rainfall and hence of water need has an influence on the average yield, such that the wheat yield in Dernah area is approximately 300 kg/ha., but is 120 kg/ha. at Tobruk in the same climatic region. Generally, farmers in the Tobruk area, as well as Dernah and Beninah receive low returns from their work on the land, partly because of high drought incidence during the growing season. As Thornthwaite (1946) states that "The march of precipitation through the year never coincides exactly with the changing demands for water in any part of the world".

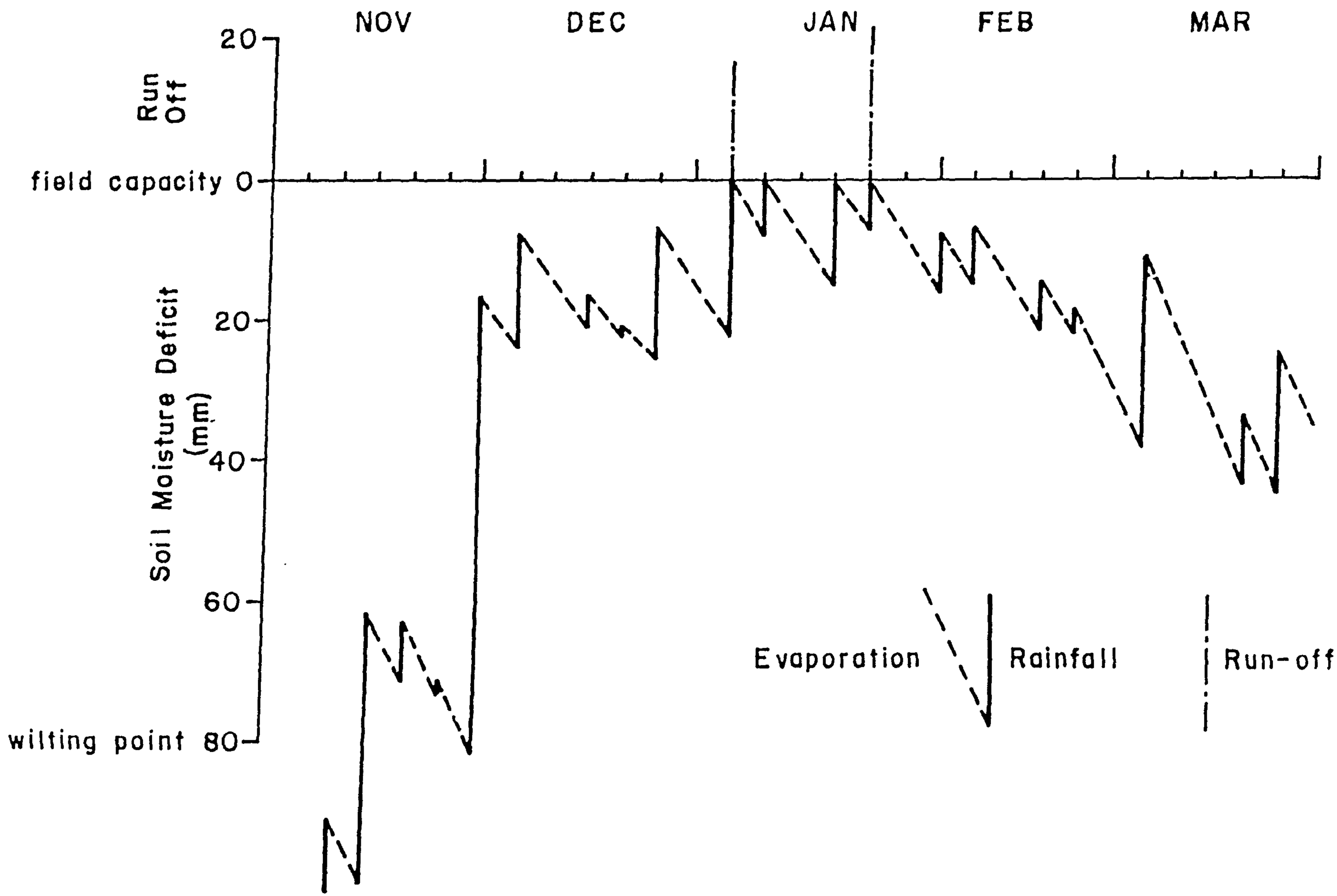
A sample irrigation budget in El Marj Plain

The monthly water budget can be made more realistic in terms of the farmer by taking 5 day periods assuming plants could survive a 5 day dry period. For El Marj daily rainfall has been summed for 5 days to compare with the 5 days of evapotranspiration as shown in Figure 4.7 for the 4 months of rain in 1983, the only year for which daily data was available. It will be seen how runoff occurs twice and only in January, whereas (Appendix 3) based on 1945-76 monthly data shows runoff in January and February. Such variation is inevitable, particularly with the sudden shower charactistics. The 5 day week water budget shows clearly when and how much irrigation is necessary. It is generally not wise to irrigate up to field capacity because rain can fall in the next day or so. Irrigation to 1 or 2 cm below field capaity is the aim. Figure 4.7 begins in early November assuming only hygroscopic water in the soil, i.e. at or below wilting point. Late in November rain brings the soil up to near field capacity. December, January, February and early March are then productive without irrigation. After March the dry season would compel full irrigation.

Infiltration in El Marj Plain

In a semi-arid region, crop survival is very much a function of soil water availability. Reduction in the store of water means a shortening of the growing season. Conversely, a smaller store of water increases the runoff, which, since none is lost by drainage to the sea, can be bulked into one runoff figure for each rainfall area. It is not important here whether the 'supplies' rainfall reaches the water table below the soil water store, as through flow and infiltration or seepage

Fig.4·7 SURFACE WATER SHEET BALANCE FOR EL-MARJ PLAIN



from streams in the wadi floor. Such wadi discharge is only in the El Marj area (Table 4.1).

Table 4.1 is summarised from the SDWR report (Guerre and Raju, 1977) and shows the product of each of the 3 concentric areas of the El Marj basin and the rainfall total of 335 mm to give a water volume available in each area. 78% is given as lost to evaporation leaving a "rainfall surplus" of 22% which is divided into runoff and infiltration. The runoff largely evaporates leaving the infiltrated water finally to recharge the Eocene (the lowest) aquifer. This infiltration expressed as a water depth is 70 mm which is similar to the 68 mm calculated here as runoff (from a 80 mm available soil moisture store) in the El Marj water balance as shown in Appendix 3. Near agreement in the two approaches is gratifying.

It should be pointed out that SDWR report, as in Table 4.1, could be misleading in that infiltration and runoff in the inner area have been superposed because a separate extraction figure from the perched aquifer has been equated to the infiltration figures. This seems reasonable because the shallow wells continue to give water (see section on shallow wells). Infiltration can be expected initially into the suspended aquifers and perhaps further into the deeper Eocene aquifer.

Table 4.1 gives the estimated water balance from the SDWR report. The balance of input with output, though most desirable, seems very doubtful. The water level measurement in the El Marj plain discusses and shows the falling level of the deeper wells now seriously requiring repletion.

Table 4.1: Hydrological Balance for El Marj Units:

Hydrological Unit	Area Km^2	Rainfall $\times 10^6 m^3$	Actual Evap. $\times 10^6 m^3$	% of Rainfall	Rainfall Surplus $\times 10^6 m^3$	% of Rainfall	Runoff $\times 10^6 m^3$	Infiltration $\times 10^6 m^3$	Infiltration mm	INPUT: Direct Infiltration	INPUT: Seepage of run off	INPUT: Leakage perched aquifer	OUTPUT: Ground water flow	OUTPUT: Ground water production	OUTPUT: Ground water outflow
El Marj Sub Unit (1)	40	13.4	10.4	78	3.0	22	2.9	0.7	72.5						
El Marj Sub Unit (2)	100	33.6	26.2	78	7.4	22	0.4	7.4	70.0						
El Marj Sub Unit (3)	220	74.0	57.7	78	16.3	22	0.7	15.6	70.0						
Total Area	360	121.0	94.3	78	26.7	22	4.0	23.7	70.0	15.6	0.7	0	10.3	10.3	13.4
											23.4			23.4	

Source: Guerre and Raju (1976) El Marj - Al Abayr, Phase I Study, ground water Balance attempt, Benghazi Report 7, Tables 2, 3, 4: 13, 25 and 26, respectively

Runoff and Annual Runoff Coefficient:

The main source of data is a study of groundwater basins in western Jebel by staff of the Secretariat of Dams and Water Resources (SDWR) 1976. Investigations by different companies have been drawn upon, as listed in Table 4.2, which summarises the runoff measurements for the El Marj plain. They indicate in the case of Wadi Zazah and Wadi El Qud in the El Marj area (Fig. 4.4) that the surface runoff varied from about 0.04 to 1.5 x $10^6 m^3$ per year. The flood decreases in the downstream Table 4.2 direction, instead of increasing by additional inflow. This seems common in semi arid areas (Yain and Lavee, 1985). This is due to the high permeability rate into all the beds of the wadis; losses occur mostly at the outlet of the wadi into the plain of El Marj, or with infiltration into the alluvial debris at the foot of the first slopes of the Jebel.

In the area from the first escarpment to the coast the surface runoff in the wadis is quite low and varies from about 0.01 to 0.12 x $10^6 m^3$ per year. The surface runoff reaches the sea only very rarely because of the low topographic gradient, the vegetation cover, and the generally low duration, intensity and varied distribution of rainfall.

The Annual Runoff Coefficient

The annual runoff coefficient is the ratio of the annual runoff to the annual rainfall; these values are presented in Table 4.2 which shows how very small is the runoff. The annual coefficient lower is around 1 - 3% for the El Marj but a little better at 5% in the coastal area. The value for specific runoff per sq.km of the catchment varies by a factor of 3 but rainfall in these areas varies only a little.

Table 4.2 Annual Run-off and Run-off Coefficient Values for El Marj:

Wadi Name	Catchment Area Km^2	Year	Annual Rainfall mm	No. of Floods	Run-off $10^3 m^3$	Run-off mm	Annual Run-off Coefficient	Specific Run-off m^2 / km	Notes
W. Al Qud	123	1971/72	320	8	91.2	0.75	0.0023	747	G.E.F.L.I.
Up Stream	123	72/73	280	6	44.0	0.36	0.0013	358	S.D.W.R.
W. Salim	123	73/74	333	13	139.24	1.13	0.0034	1132	S.D.W.R.
W. El Qud	154	71/72	320	7	117.18	0.76			G.E.F.L.I.
Middle		73/74	333	8	56.48	0.37			G.W.A.
W. Al Qud	159	71/72	320	3	39.37	0.25	0.0008	248	G.E.F.L.I.
Down Stream		73/74	333	4	126.22	0.79	0.0026	794	S.W.D.R.
			Average basin of Wadi El Qud				0.0021	673	
W. Zazah	180	71/72	300	8	137.36	0.76	0.0026	763	G.E.F.L.I.
		72/73	209	4	104.45	0.58	0.0028	580	G.W.A.
		73/74	267	4	180.30	1.00	0.0037	1100	G.W.A.
W.Zazah Down Stream	202	74/75	358	6	378.33	1.87	0.0052	1873	C. LOTTI
W.Dukhan	139	74/75	250	6	175.08	1.26	0.0650	1259	C. LOTTI
W.Buwayrijah	118	74/75	372	5	1523.10	12.90	0.0347	12907	C. LOTTI
			Average for basin of Wadi Zazah				0.009	3063	
W. El Ajren	49	74/75		1	8.63	0.18			C. LOTTI
W. Bywayrat	38.5	74/75	283	4	59.30	1.54	0.0054	1540	C. LOTTI
W. Barabis	49.6	71/72	350	6	55.54	1.19	0.0034	1121	G.E.F.L.I.
		72/73	326	7	95.20	1.92		1919	G.W.A.
		73/74	388	19	117.48	2.37	0.0061	2373	G.W.A.
			Average for basin of Wadi Barabis				0.0048		

Source: Guerre and Raju, 1976, El Marj, Al Abayr Phase 1 Study, Ground Water Balance attempts, Banghazi (7) Table 15, 38

Examination of the consultancies and years observed shows differences which cannot be explained in terms of rainfall and geology. Average values are given only as an indicator; caution is essential in any interpretation of these.

UNDERGROUND WATER

The most important water bearing horizons are the Middle Miocene of the Benghazi plain and the northern Middle Miocene and the Eocene of the Jebel, outlined in the secion on stratigraphy (Fig 4.1). Possibly part of the Oligocene could also be included, such as that giving rise to Wadi Dernah's springs, where the richness of spring horizons seem often to be governed by the appearance of a marly lithology underlying a permeable member. This may not be entirely the case in the Eocene of the El Marj plain, where there is an absence of an impermeable layer (Pallas, 1978).

Springs There are numerous springs in the Jebel which owe their origin to greater rainfall in the Plastocene. Impervious beds dipping gently towards the sea reach the surface of the ground and produce lines of springs on different geological horizons (Little, 1945).

(1) Langhian stratum — El Gubbah, Ayn Marah level

(2) Aquitanian horizon — Chaulan springs

(3) Oligocene formation — Aquifer of Shahat Cyrene

(4) Eocene aquifer — Wadi El Athrun perches

(5) Cretaceous bearing water formation such as springs of east Tolmeitha (Fig. 4.1).

The strata mentioned above are indicated in relation to respective

impermeable or mildly permeable stratum at the base, and the quoted spring sites are divided according to the different acquifers to which they belong. Their utilization depends on their capacity and quality. they are the first springs captured for public supply, for example, the ground water flowing out from Oligocene springs (3 above) in the vicinity of the second escarpment and its hinterland cannot be used even in the fortunate area around Shahat, other than for local water supply to farms, livestock and for irrigation of some land surfaces, the size of which is reduced mainly by the poor capacity of springs in the dry season.

Then there are those springs used for irrigation purposes like those of the perched Miocene aquifer, and the springs of Marrah and finally springs serving domestic and livestock supply at different localities in the Jebel, particularly outside important settlements. There are more than 300 springs in the north eastern part of the Jebel El Akhdar, mainly at Baladiyah of El Beida, Shahat, El Gubbah and Dernah (Figure 4.1). All main sources of spring water have a flow rate in the winter months of more than 10 l/sec providing significant resources for hydroagricultural development as shown in Table 4.3.

The last four springs listed in Table 4.3 can be grouped as coastal with discharge approximately 350 l/sec. over a coastal strip 70 km from Soussa to Dernah and 3 km width giving an equivalent 53 mm water depth per year on this 210 km^2 area. A typical rainfall of 265 mm as at Dernah (see section on Climate) is greater by a factor of 5. Ignoring evaporation, the springs would seem to be recharged and supply small

TABLE 4.3: Springs of North Eastern Jebel El Akhdar Flowing more than 10 l/sec

Spring	Rate of Flow l/sec	Location
Ayn Dabussiah	200	Dabussiah
Ayn Marrah	40 - 80	Wadi Nagah (dw.Sarrah)
Ayn Stewah	15	Wadi El Mhabul at 300 m.a.s.l
Ayn Kersah	30	Wadi El Angel 230-235
Ayn Blad	130	Wadi Dernal 180 m.a.s.l
Ayn Bumansur	195 - 230	Wadi Dernah 177 m.a.s.l
Ayn Balanj	10	Messah 450 m.a.s.l

Source: El Shadle, M.M. (1978) Survey of Springs in El Gamahiriyah (Third zone) SDWS, Benghazi 9 (in Arabic).

plots of traditional farming. Evaporation cannot be ignored and is shown as 1811 (see section on effective rainfall and Figure. 4.6). The GEFLI 1972d Report gives a Piche value totalling 1825 mm for the year. Such high values cannot be met, and some are in limited areas of irrigation. The rainfall is generally in sudden bursts of less than half an hour and hence runoff from the storm rainfall recharges the springs' source. There is good evidence of this in the change in colour and taste of the spring and shallow well water coincident with storm rainfall.

Ayn Marrah Springs: Ayn Marrah springs are for human use and to irrigate small plots (gardens) which are usually known as 'sania'. The

most important collection of springs on the Miocene aquifer is the group of springs of Ayn Marrah. These receive water from the high part of Wadi Nagah at one of its tributaries in Sarrah wadi. Thus, Ayn Marrah water was available from five springs at a combined flow rate of 140 l/sec in 1965 (Leueberger, 1965) but as the climate interpretation implies (section on effective rainfall), there is a water shortage; hence at present its flow rate is approximately between 40-80 l/sec (El Shadli, 1973).

These springs make up the discharge points of three Esafa springs, springs of Maghara and spring of Shaib. The rate of flow is given by GEFLI, 1975 and others showing that the total flow of Ayn Shaib (Fig. 10.2) is between 15-31 l/sec, of which 7 l/sec is used for irrigation purposes and the remaining quantity is lost because of karst features and evaporation. The flow is as high as 24 l/sec from Maghara and three Esafa springs, which originate in an aquifer in the upper Oligocene. The main utilization of these springs is for irrigation (GEFLI, 1975b).

The Ayn Marrah springs (Table 4.3) discharge 60 l/sec over a cultivated area of 43 ha. which equals a depth of 4.4m. Evaporation is measured by Piche (GEFLI, 1975 d) to a total of 2099 mm. This leaves 2.1m, a very large equivalent depth of water consumed domestically. The recharge of the aquifer supplying this seems impossible from present rainfall and it appears that long term historical reserves are being tapped, which is a potentially dangerous situation.

The water for use is derived either by gravity or by pumping from springs or by individual pumping from the shallow aquifer. The process of multiplication of dug wells equipped with small rotary pumps, now applied by owners, is still the best solution for local water supply for

irrigation, additional to the reservoir of $4000m^3$ (GEFLI, 1975a). The water is collected and stored during night pumping.

There were of some attempts in the past, during the Italian period for the best utilization of these resources, and a pipeline was designed to carry water from Ayn Marrah to agriculture in villages extending to the Barce plain. This was called "Il granda acquedal to Cirenaica", the great Cyrenaica aqueduct (Pioger, 1959), but this project had to be abandoned because of the second world war and also because of a decrease in the capacity of discharge in the area.

However, from the standpoint of general agricultural production, efforts should be concentrated on developing the Ayn Marrah water system so that water will remain available for local agricultural requirements, because the discharge rate of Ayn Marrah springs has decreased to about 40 l/sec. Irrigation systems in the area should be developed and discharge of the Ayn Shaib controlled to increase the productivity of other springs. Also the digging of deep wells in Pleistocene acquifers should be carried out to increase water productivity for further agricultural development.

Wadi Dernah Springs The water from springs of Wadi Dernah is being used partly to supply the Municipalities (Baladiyat) of Dernah and Tobruk, as far east as 170 km and on a limited scale for irrigation purposes in the gardens of Dernah city.

Figure 4.1 shows the site of natural discharge in the lower Oligocene and Eocene formation, the Bu Mansure and Blad spring system, which is found downstream of Dernah Wadi. From the point of view of the local geology, it is preferable to select one discharge level of one

aquifer. GEFLI stated in 1972 that the spring Ayn Blad probably causes at, least in part, a resurgence of the spring Ayn Bu Mansure. The two sites connect with Ayn Marrah spring. Only a minor part of the outflowing water from Bu Mansure is 65 l/sec, the total discharge rate is 195 l/sec which actually drains towards Dernah settlement (GEFLI, 1972a; Shadlig 1978).

However, Bu Mansure spring is situated 12 km from the sea and is 177 m.a.s.l. It originates in an aquifer in the lower Oligocene and its yield per day is 180 l/sec, and only 20% of the water is used (El Shadli, 1978); the remainder infiltrates or evaporates. The used 20% flows in an uncovered channel at the waterfall (Shallal) (Plate 4.1). Thereafter, the channel follows the eastern bank of the wadi at 35 m above the wadi bed and the water is diverted for irrigation purposes to irrigate about 15 ha. of arable land in the eastern part of Dernah city. This uses 2400-5400 m^3/day. Regrettably, the irrigation duration of the last decade has been irregular, leading to the destruction of banana gardens in the area.

On the other hand, the spring of Ayn Blad is located 4½ km from the sea at the base of the western bank of the wadi and its yield is used for agricultural and domestic purposes and the supply of water to Dernah, Emmer Azzam, Tamimi and Tobruk. A controlled rate of discharge has reduced its yield to 1.5 m gallons/day in 1977.

The two springs (Table 4.3) at Wadi Dernah discharge 300 l/sec used over 15 ha of vegetable farming through the year. This spring irrigation equals a depth of 6940 mm depth, supplying the 1551 mm water deficit (PET = 1811 mm). The area of the aquifer and hence the drawn down effect cannot be given with any reasonable accuracy. The

Plate 4. 1a Wadi Dernah waterfall Shallal"

Plate 4. 1b Wadi Dernah down stream of waterfall

impressive figure of a water surplus of 4.3 m has encouraged its use to supply domestic need. Much of this water must return to the aquifer.

The water use is divided between Dernah city, about 3000 m^3/day, and settlements between Dernah and Tobruk, using 2000 m^3/day. The remaining quantity is distributed to agricultural land in the west terrace of wadi Dernah and farms of west Dernah city, and added to water flows from the perennial streams in the lower part of wadi Dernah. Certainly, Ayn Blad needs redevelopment of its distribution system for best utilisation.

As a general rule the encouragement of agriculture must be through the hydro-agricultural development of the area. This has started by choosing a spring interception at Bu Mansure and the construction of a drainage gallery following the course of wadi Dernah about 1000 m long. This interception tunnel with a height of about 2 or 3 m is expected to be built on Eocene rocks on the left bank of the wadi 8 - 10 m below the level of its beds, as this is a spring site and groundwater gushes up at several points from alluvial deposits, in this case directly from tertiary rocks (Hydroprojeck, 1971).

However, the exploitation of spring water at Bu Mansure, at an expected rate of 195 l/sec, may lead to a decrease in the capacity of Ayn Blad to 130 l/sec (Doxiadis Associates, 1978a). So if such a possibility occurs, the exploitation of drilled wells for water supply to Dernah will also be affected, as well as dug wells inside the town, exploiting the underground water that flows to the Bu Mansure. Ayn Blad spring system is replenished by a similar same underground water basin at Ayn Az Zayanah in the Benghazi plain which connects with the basin of

El Marj area (Fig. 4.1). A strong decrease in undeground water flow rate will lead to rapid contamination of the wells, particularly of the drilled wells with a high pumping rate. Near to the coast, the equilibrium of the aquifer will be destroyed.

Within the context of these objectives the necessity emerged for the development of wadi Dernah which aimed at developing water resources for agricultural use by utilising spring water, seasonal surface water and underground water. One of the aims of this project can be achieved, i.e. the expansion and development of Ayn Bu Mansure and Ayn Blad for public supply and irrigation purposes. It is worth noting that an intensive form of agriculture has developed in the narrow and terraced patches of land alongside the wadi. The construction of Bu Mansure and Dernah dams located at 15 and 2 km respectively from Dernah, aims to provide storage capacities of about 2 million m^3 for both dams. The dams also provide other functions such as controlling flood waters, soil erosion and increasing water infiltration to maintain the balance of groundwater (Pallas, 1978).

Dabussiah Springs One other important spring is Ayn Dabussiah, which has 200 l/sec flow, and distributes water to the villages and farm houses between El Gubbah and El Bayyada. The main target is to utilise the source at Ayn Dabussiah as fully as possible, because much of it runs to waste and the use of water should be restricted to human consumption and watering of livestock. The construction of the scheme indicates the importance of hydro-agriculture development, especially for the potentially more fertile area between the middle of Jebel El Akhdar. It is also a positive step towards the resettlement of the

nomads and semi-nomads in the Jebel.

The Western Springs There are numerous springs at different localities in the whole region which are utilised with low efficiency in the irrigation of some small patches. Meanwhile the remaining large springs of Messah, Gubbah and Sussah are being used to feed small local water supply schemes. The majority of small springs are being exploited in much the same way as was the case during the Greco-Roman period, some as livestock troughs and some with a small reservoir from which a garden is irrigated. A good example of this latter is found at Ayn Karsah west of Dernah and the Spring of Bashara west of El Gubbah, whose capacity is 0.04 l/sec, in dry season (GEFLI, 1972a). The Bashara spring has a reservoir to create an important water reserve by nightflow and this is a better and more rational use of water for irrigation of the neighbouring garden (1 ha.). Small springs occur in the western part of the Jebel such as springs east of Tolmeitha. These springs are Ayn Brur (270 m.a.s.l.), 13 km east of Tolmeitha, Ayn El Meleca (100 m) 18 km east, and Ayn Habbun (70 m) 21 km east of Tolmeitha. The level of the horizon occurring in this locality decreases from southwest towards north east which indicates the underground flow and forms a small spring-bearing horizon restricted to this area (F.A.O. 1963). As a general rule, the discharge at Ayn Brur is given as "small", that of Ayn El Meleca in wadi Gelugh and Ayn Habbum in wadi Habbum west of El Marj plain, as "abundant". These springs are used for the local supply in the vicinity of Tolmeitha (Buru, 1964).

From the practical point of view it seems necessary to develop the modes of utilisation which may lead to a certain increase of

agricultural yields but there is no possibility of obtaining much higher yields from this poor water formation, on account of its low capacity at the present time. It is absolutely useless to consider the possibility of extension of land irrigation by means of this specific ground water body unless it can be combined with other resources, such as deep wells, to develop a method of irrigation system (drop or surface irrigation) to maximise water use and minimize depletion.

Wells

Shallow Wells Groundwater resources are known to exist in the coastal plain in the form of a shallow layer of fresh water floating on sea water and, inland of the Jebel, as perched groundwater bodies of shallow depth (20 m) of varying quantity and quality that have been exploited during the past.

However, the regional water table is very deep, and therefore the depth from the land surface to the water table depends on the relative altitudinal difference between physiographic units for the region. As an example, wells of the el Marj area vary from a few metres to more than a few hundred metres (200-300 m from Eocene aquifer) although near the salt marshes on the coast and at a few perennial spring heads, the water table crops out at the surface as well as in the vicinity of the spring of wadi Dernah. Furthermore, on a sand dune corridor along the shore, the water table is generally within 2 to 6 m of the land surface, although elsewhere in the coastal plain, depths of water generally range from about 5 to 40 m. These form shallow wells in the area (Newport and Hadder, 1963). Wells in Dernah city revealed the existence of phreatic water with discharge of some litres 6 l/sec per well on average

(Doxiadis Associates, 1978a). They are often rich in chlorides from the solution of calcareous rock lodged upon impermeable strata, and most of them could satisfy the irrigation requirements of hundreds of hectares of land on the outskirts of Dernah city, particularly when there is some limitation in the utilisation of the springs of wadi Dernah. On the other hand some wells were formed where necessary at Ayn Marrah area to best exploit the phreatic water. This is replenished partially by the springs of Ayn Marrah of the north west part of the farming area where there is high capacity and difficulty in channeling water from springs (Fig 10.2).

The capacity of shallow wells does not permit arable land to exist on a large scale in the northern part of the region. Indeed among hundreds of such wells dug prior to 1940 (F.A.O.1963) some were barren, others produced salt water, particularly at the plain of Benghazi, and only a few are still active. Fresh water wells, such as those of Dernah and the El Marj plain, all with low efficient discharge, are inadequate for irrigation apart from a limited area such as a small garden.

Deep Wells The deepest water level observed in the land of the Jebel is generally more than 100 m depth (Everdingen, 1962) such as the water table in the El Marj area, which fluctuates with changes in the level of the ground water reservoir and depends on the equilibrium between the recharge and discharge. The water table, however, is seldom stationary for long periods, particularly in the El Marj basin because of the rapidly expanding agricultural production, and as the population is expected to increase by as much as one-eighth, so water demand will increase rapidly. Similarly agricultural development and the expansion

of irrigated land has resulted in the drilling of a large number of wells to satisfy the irrigation requirements. Also, there is much industrial and housing construction in process, and all of this expansion depends primarily upon groundwater from a number of wells drilled during the last few years to compensate for the lack of natural springs.

Table 4.4 and Figure. 4.8 show the increase in wells and ground water expliotation for El Marj area. The number of wells has increased from 59 wells in 1967 to 258 wells in 1976 giving a water production rate of growth of 41.3% simple or a true (i.e. exponential) growth in production of about 17.2%. The water use is subdivided between agriculture 62%, domestic supply 34% and industry 4% (Fig. 4.9).

The significant proportion of agricultural water use is more than growth of irrigated land during this period i.e. above the traditional irrigation system.

The Aquifer Tapped or The Well Sources: The water from different wells extracted from the Quaternary aquifer is less than 70 m deep; the average is of 28 m and gives a small amount of water compared with the main Eocene aquifer tapped by deep wells ranging between 100 to 300 m the average depth of which is 215 m with average capacity of 6 l/sec. (SDWR, 1976).

Thus, serious consideration should be given to the boring of deep wells in order to allow hydro-agriculture development in the whole region, as well as in the El Fatayah area by construction of a reservoir with a capacity of 14,000 m^3. Water will be pumped from 15 wells that are to be drilled in Magar zone at the bottom of the middle course of

Table 4.4: Growth of Ground Water Exploitation in El Marj Area:

Year	Before 1967	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
No. of new wells drilled each year	39	20	5	14	11	10	20	31	45	50	13
Cumulative No. of wells by year	39	59	64	78	89	109	129	160	205	245	258
New exploitation capacity	199	2013	259	190	389	373	1183	1073	2128	1705	935
Yearly production in $10m^3$	199	2212	2471	2661	3050	3423	4606	5679	7807	9512	10447

Source: SDWR (1976a)

Fig. 4·8 EVOLUTION OF GROUNDWATER EXPLOITATION IN EL-MARJ AREA

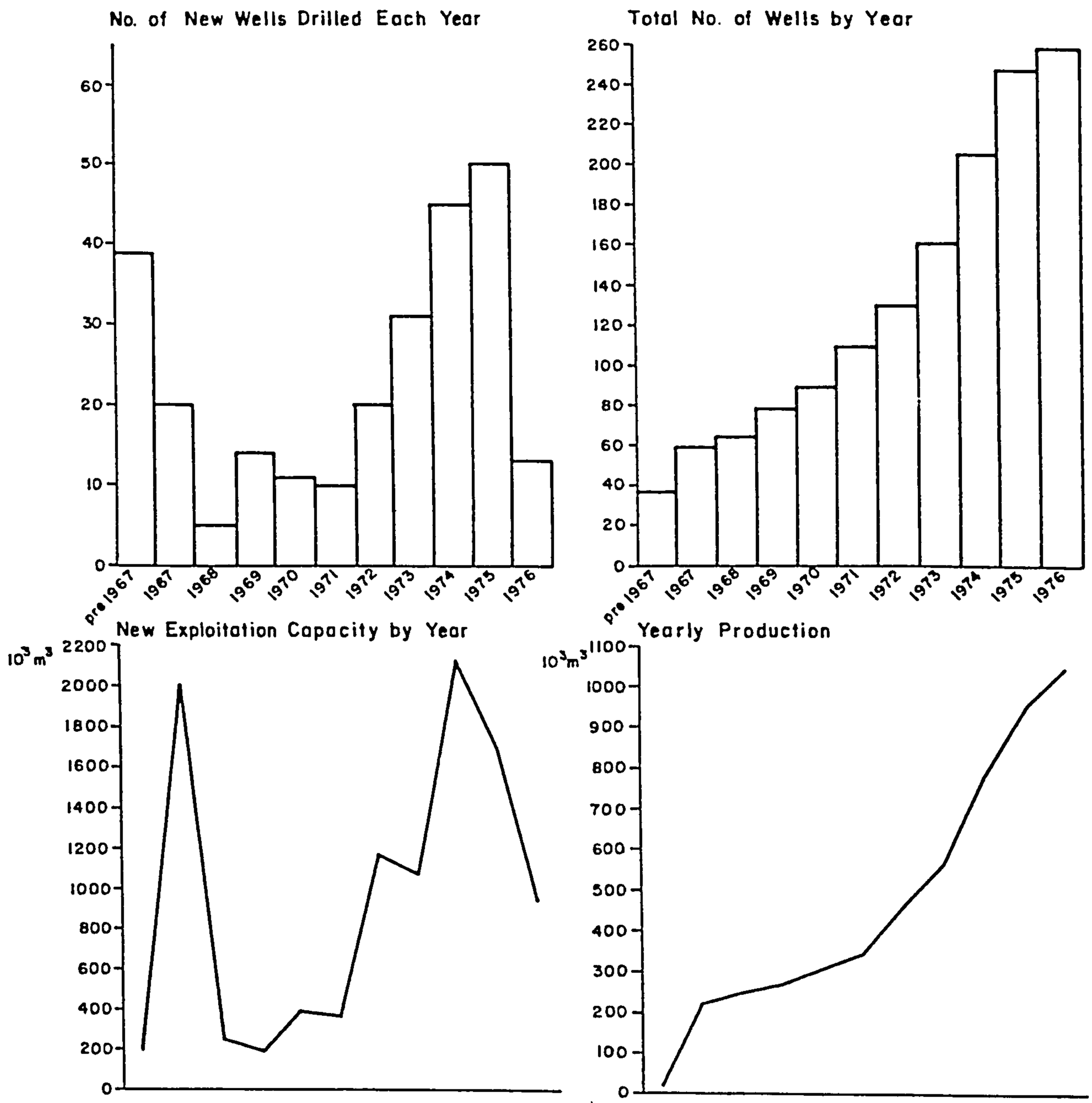
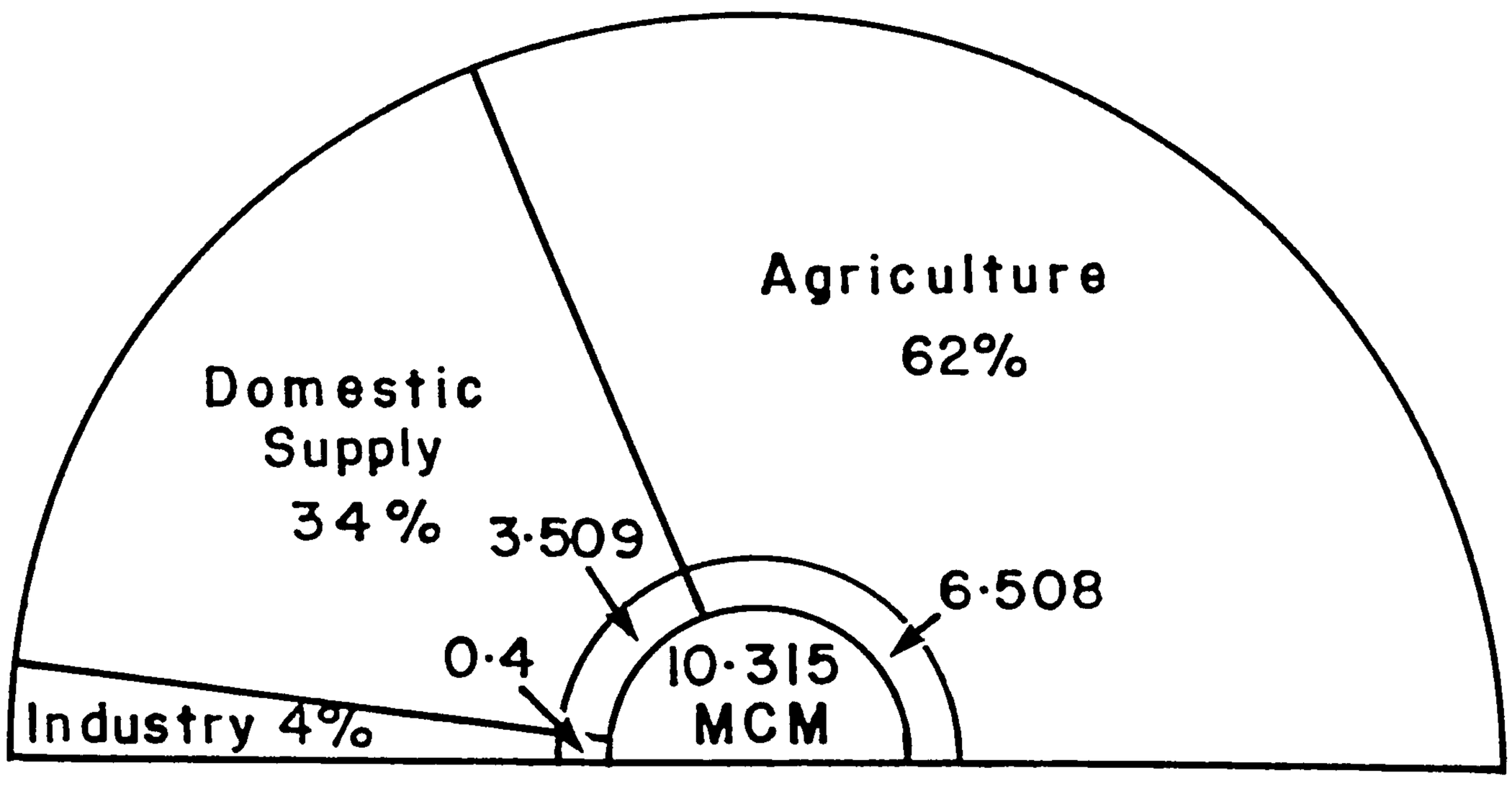


Fig.4·9 WATER USE IN EL MARJ AREA



Source : S.D.W.R. (1976)

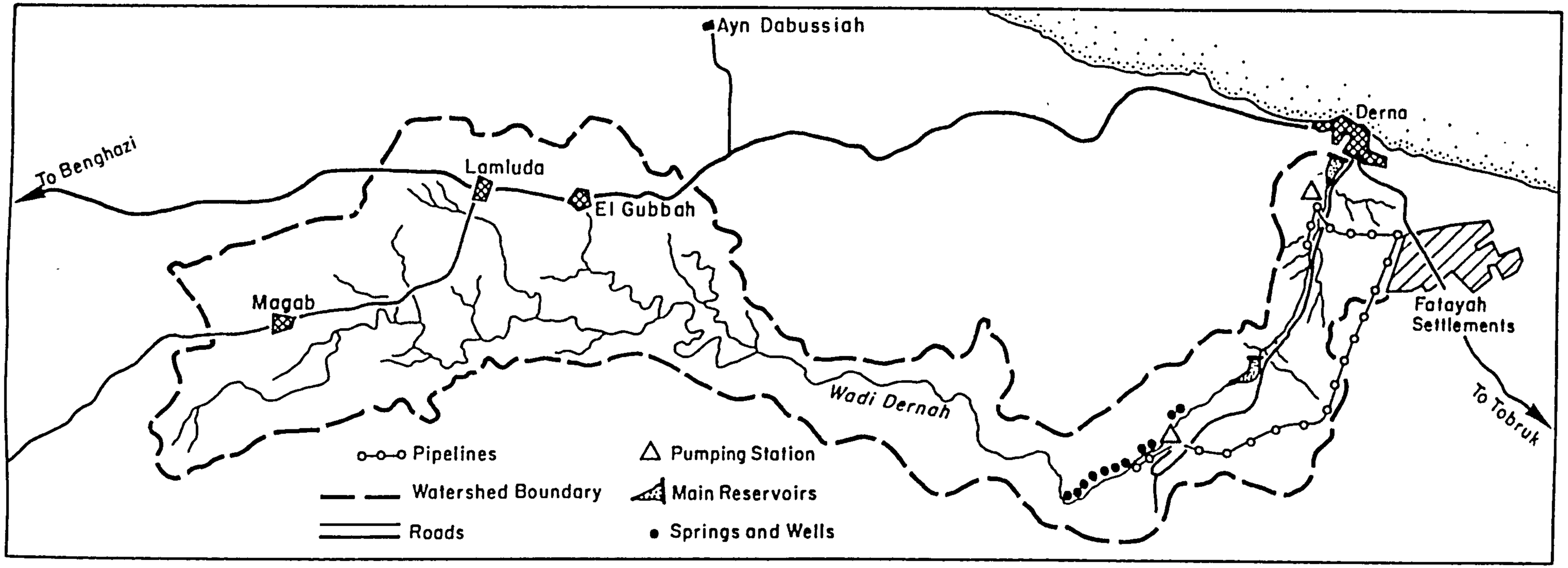
wadi Dernah (Fig. 4.10), ranging in depth between 100-150 m and transported to the Fatayah reservoir by gravity along a cast iron pipeline, 25 km long, with a capacity of about 400 l/sec from all wells, which is sufficient for the irrigation of about 1,480 ha in El Fatayah (Hydroprojekt, 1971).

The 400 l/sec over the 1480 ha gives 852 mm water depth in the year. A rainfall of 265 mm added to this gives a total depth of 1112 mm to meet a P.E.T. demand of 1811 (see section on effective precipitation). The deficit of 894 mm will be met from springs. The water budget of this scheme then seems to be near balance, but replenishing the supply is still a long term problem. Until this time, farmers have used about 15 wells in different localities in the main site of the farms. This water is transported by tanker (see Plate 4.12) which does not suit farming practices. The other areas have started to exploit 46 wells at Martubah east of the El Fatayah farming area. They vary in depth between 200-270 m from a perched aquifer of the lower Oligocene and the Eocene, each well having a capacity of 5 l/sec covering an area of 900 ha, suitable for irrigation to produce grain crops and forage (GEEL[T], 1972c). The critical point of this competition in the one basin is briefly drawn in the critical view of agricultural development.

SDWR endeavoured to find out the pattern of connected ground water basins as a hydro-geological unit within the limit of the Ayn Az Zayanah basin (Figs. 4.11 and 4.12) in the west of the Jebel. This consists of water bearig formation as follows (SDWR, 1976):

- The main Eocene aquifer
- The local perched Quaternary aquifers of El Marj area

Fig. 4·10 WADI DERNAH PROJECT



Source : Hydroprojekt (1972)

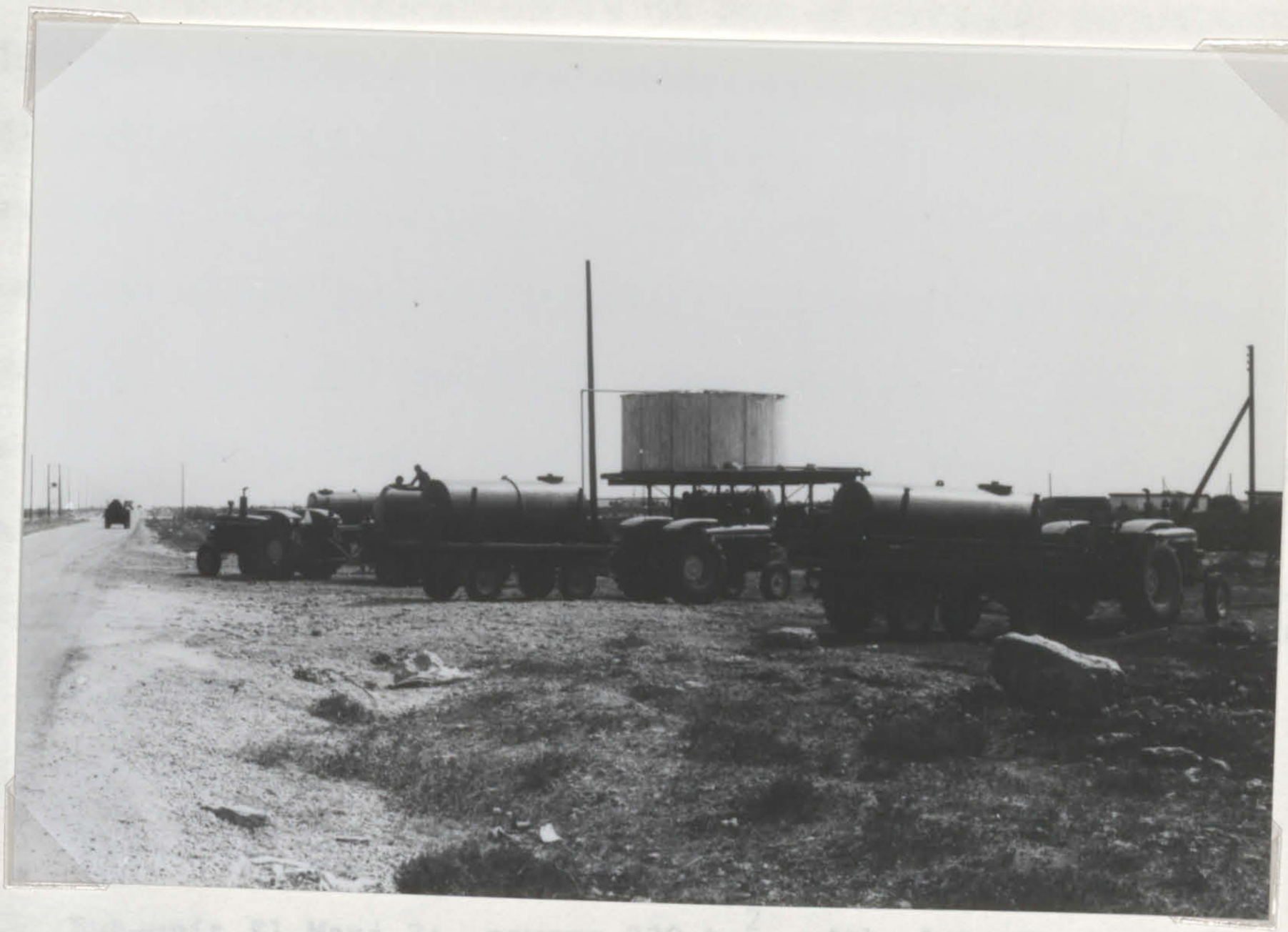


Plate 4. 2 Water storage and delivery tanks used on El Fatayah project

- The local perched Miocene aquifers of Al Abay.r area, and
- The Miocene aquifer of the coastal plain which is in hydraulic equilibrium with the Eocene aquifer in this area.

Groundwater Balance

Groundwater balance for the El Marj plain For the purpose of groundwater balance calculation some of the units have been split into sub-units to take into consideration the perched Eocene and Quaternary aquifers (Figs. 4.11 and 4.12). They form the main underground water resources for El Marj. The El Marj unit area of 360 km^2, comprises a case study area with sub-units as follows:

(1) Sub-unit El Marj 1; an area of 40 km^2, represents Upper Quaternary aquifer;

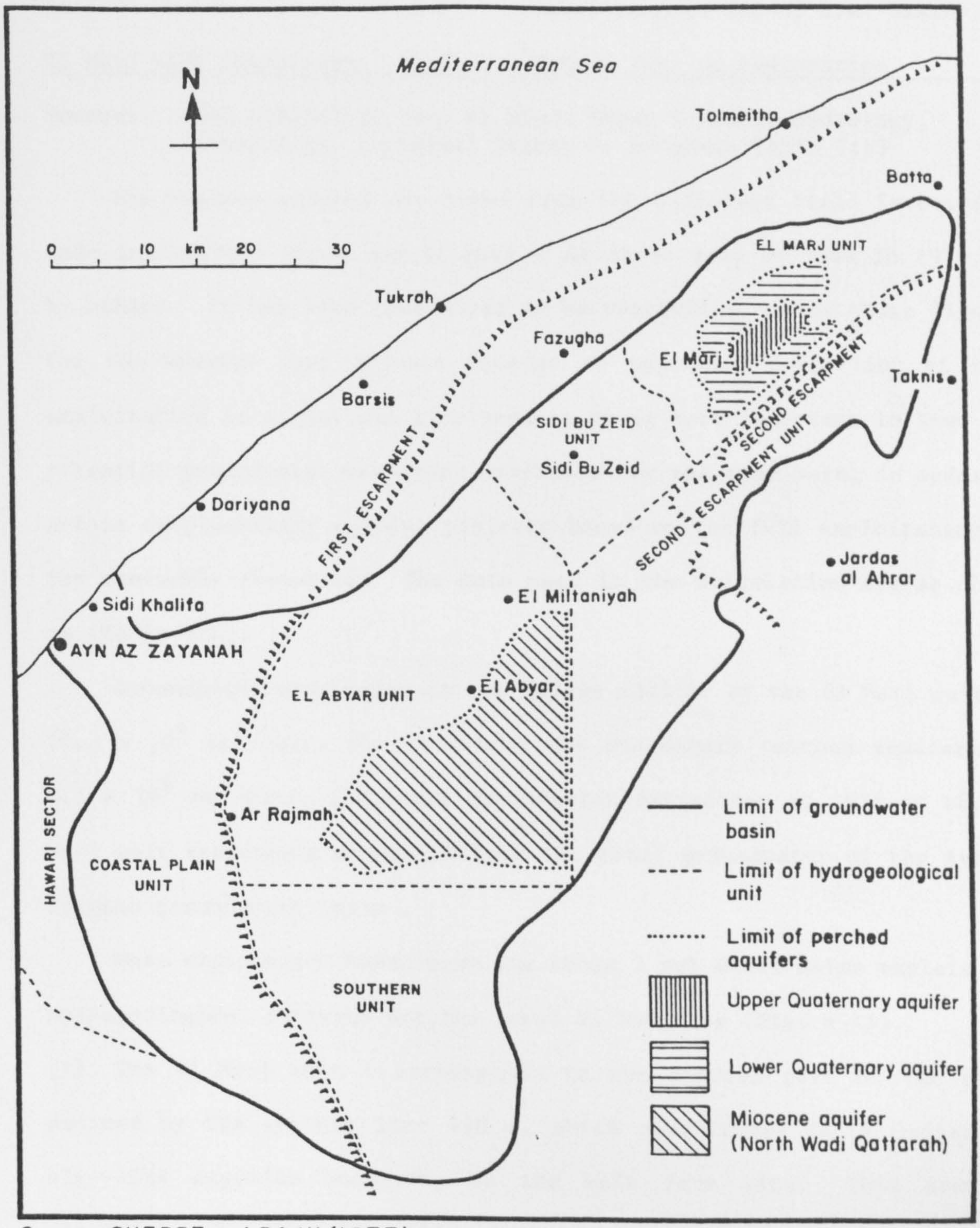
(2) Sub-unit El Marj 2; consists of 100 km^2, sited on the lower Quaternary aquifer;

(3) Sub-unit El Marj 3; covers 220 km^2, with characteristic Eocene outcrops (SDWS, 1978).

The El Marj basin constitutes 5% of the total area of Ayn Az Zayanah ground water basin 4180 km^2 (Fig.4.11). The rainfall and runoff for the wadis of the El Marj area have been calculated in Table 4.2 because surface water, by infiltration, supplies some ground water.

The section on effective rainfall and Penman Fig.4.6 show the two stations of Shahat and El Marj which have a higher rainfall (generally >300 mm), supplying a small amount to ground water. The values of runoff from Table 4.2 are given in Table 4.5 for the central part of the El Marj closed watershed. All such runoff generated is lost by evaporation much facilitated by the very thick and clay-like Quaternary deposit.

Fig. 4·11 HYDROGEOLOGICAL UNITS OF AYN AZ ZAYANAH GROUNDWATER BASIN



Source : GUERRE and RAJU (1977)

Table 4.5: Runoff value Calculated by Section of Watershed (in mm)

Hydrological Unit	x $10^6 m^3$	Runoff
El Marj wadi upstream sectors	0.4	Toward lower Quaternary aquifers and then to Eocene
Wadi El Laulab	0.2	Runoff export out of G.W. basin
El Marj wadi downstream	3.5	Runoff lost as evaporation

Source: SDWR (1976c) El Marj Al Abyar Phase I Study, Hydrology, Climatology, Technical Report 6, Benghazi Table 2;13

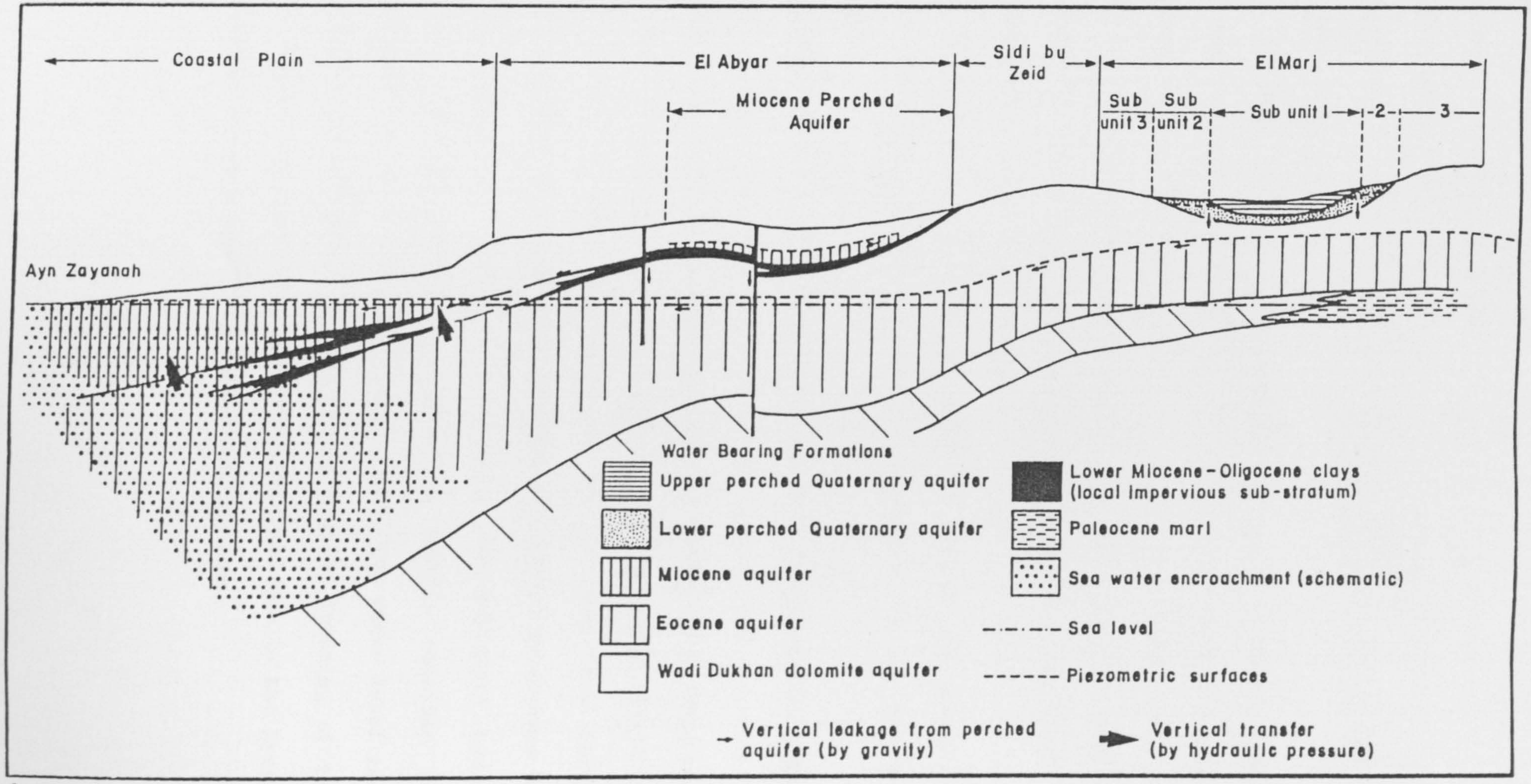
The figures adopted are taken from the different field inventories made in Benghazi plain and El Marj - Al Abyar area by SDWR in 1976 and by others. It has been considered to be worthwhile to use these figures for the average year balance because an important proportion of this exploitation is recent and also because it is more important to know the potential groundwater resources available for the time being in order to define complementary pumping projects based on the full exploitation of the renewable resources. The data used in the calculation are as shown in (Table 4.1).

Groundwater extraction in the Eocene aquifer at the El Marj unit is 10.3 x 10^6 mm^3/year, the flow from the Quaternary perched aquifers is 0.1 x 10^6 mm^3/year, the total groundwater extraction in 1976 at the El Marj unit represents about 11% from the total groundwater of the Ayn Az Zayanah groundwater basin .

More explanation based upon the above 3 sub units helps explain the hydrogeological patterns for the total El Marj are (Fig. 4.11).

(1) The El Marj unit 1 corresponds to the central part of the plain defined by the contour line 280 m, which constitutes thick Quaternary clay-like deposits occurring on the main farm site. This area is flooded by the two wadis (Fig. 4.4) almost every year, but because of

Fig. 4·12 SCHEMATIC HYDROGEOLOGICAL CROSS-SECTION



Source: Guerre and Raju (1977)

the thick clay soil (see Chapter VI) there is no deep percolation toward the Eocene aquifer. The percentage for the infiltration in this clay upper perched Quaternary aquifer is equalled by the groundwater extraction ($0.1 \times 10^6 m^3$) and all the remaining surplus is considered to be lost by evaporation.

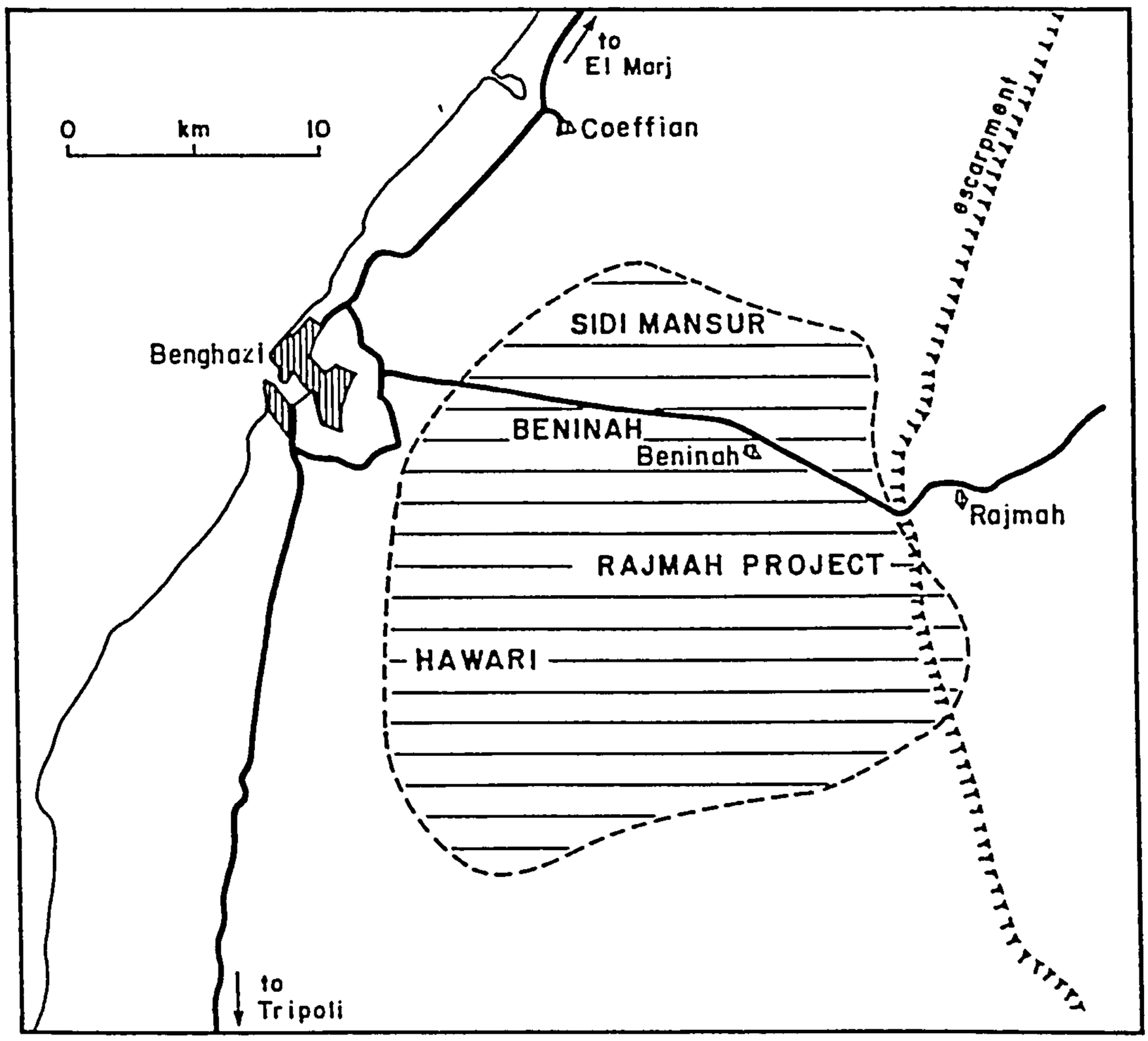
(2) El Marj unit 2 is represented by areas located approximately between the contour line 280 and 300 m where thinner and coarser grained Quaternary deposits occur. This is considered by SDWR (1976) to be the area of recharge of the lower perched Quaternary aquifer, from which the groundwater production is negligible because the water finally percolates to the underlying Eocene aquifer.

(3) El Marj sub unit 3 is the boundary zone of the plain where the Eocene outcrops and where direct infiltration to the Eocene aquifer occurs.

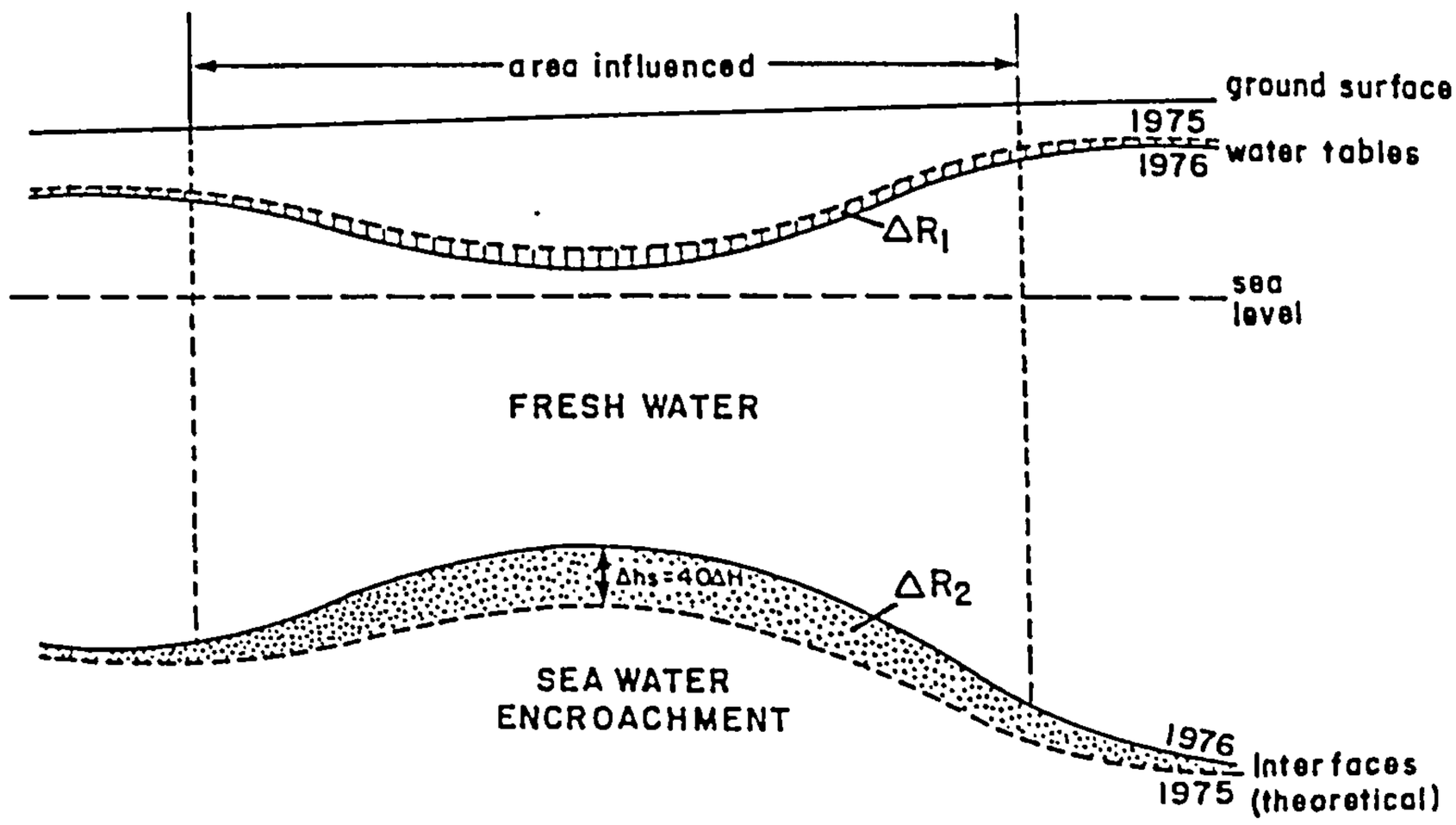
However, it should be kept in mind that runoff coefficients for sub units 2 and 3 have been taken as 1% in Wadi El Qud and Wadi Zazah in (Table 4.2); also the natural groundwater outlet of El Marj unit is to the west of Sidi Buzied unit. The second escarpment fault shown in (Fig. 4.12) is also considered to be an impervious barrier for transverse flow of groundwater between the second escarpment unit and the El Marj area. Table 4.1 indicates the estimated hydrological balance, although particular supporting results obtained by GEFLI measurement in 1972 showed imbalance. Data from water level records in the El Marj area confirm a gradual and regular lowering of the water level in the main aquifer. This produces imbalance in the hydrological basin which needs more care in management and use.

Fig.4·13 EVALUATION OF RESERVES VARIATIONS IN COASTAL PLAIN UNIT

Location Map of the Area where an Important Lowering of the Water Table has been Measured



Hydrogeological Sketch for Estimation of Reserves Variations



Source: GURRE and RAJU (1977)

Recharge and Depletion of the Aquifer in Beninah Area:

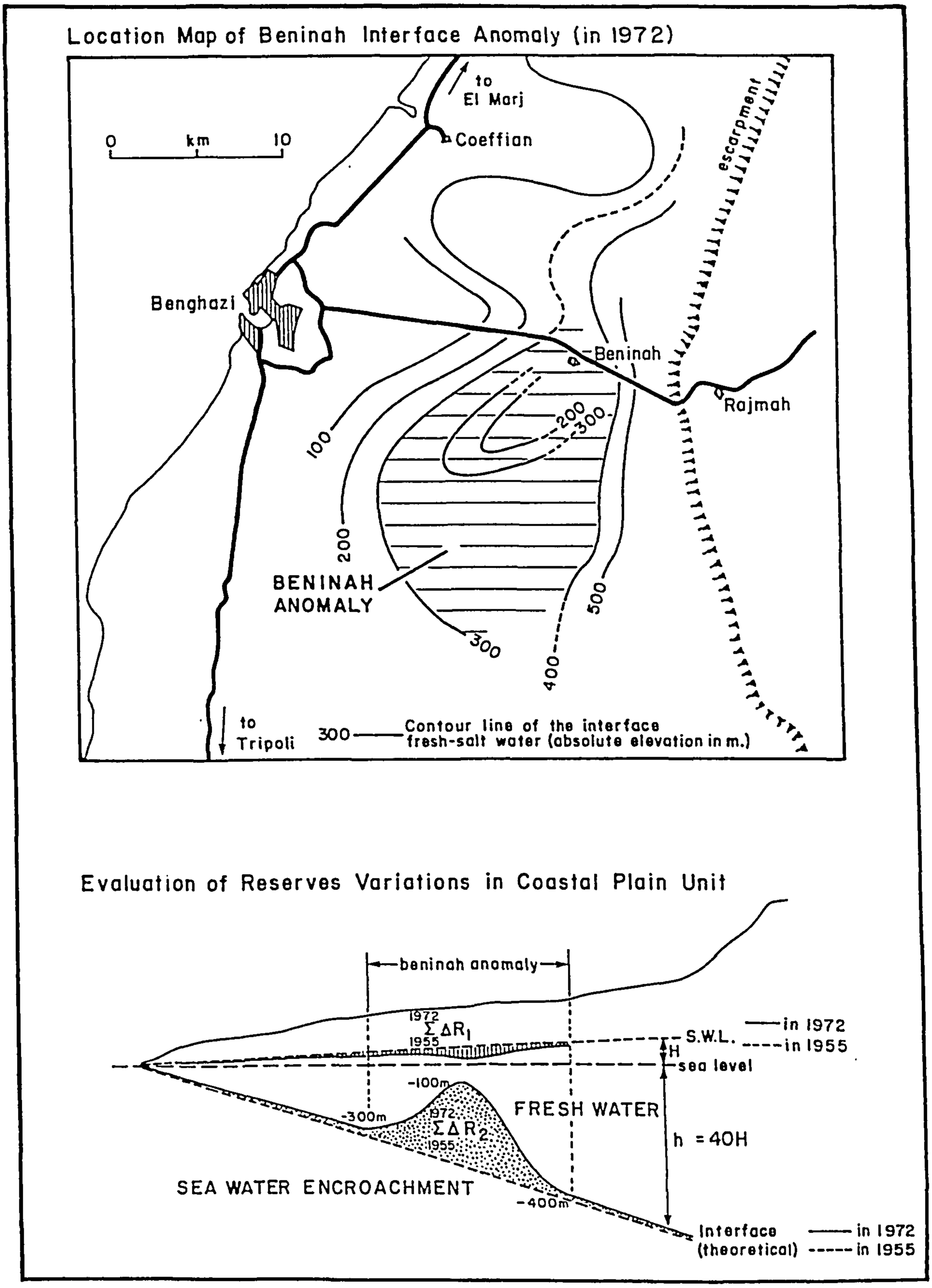
The rate of withdrawal has always varied regionally with high rates of decline of the water table in areas of intensive utilisation, especially at some distance from the coast such as on Benghazi plain (Fig. 4.13). The effect of mismanagement is clearly seen in aspects such as the cost of irrigation water which has increased because of the additional height to lift water from progressively deeper levels and also as a result of the cost of replacing dry wells.

The decrease in available groundwater in the Jebel generally and in the Benghazi area in particular is indicated by the section in Figure 4.13 which shows the shrinkage in thickness of the fresh water section caused by salt water intrusion on top but more marked below the aquifer.

The Ghyben-Herzberg concept equates the pressure of a column of fresh water (of height equal to the total vertical extent of the aquifer) to the pressure of the salt water in contact under the surface (of height equal to the interface depth below sea level). The required depth is found from a ratio of salt and fresh water densities and the height of the water table above sea level (Todd, 1964). Figure 4.14 shows the application of this salt water intrusion calculation here indicates a lentical or cross section of the aquifer, a shape assumed from 1955 when the water was on the surface, to 1972 when the water level had fallen to 2.1 m below the surface.

The total drawn since the beginning of the pumping in Beninah well field in 1955 until the date of the geophysical survey in 1972 is 80 x $10^6 m^3$ (SDWR, 1976a). About 30% of the water withdrawn comes from the reserves of the aquifer and the remaining 70% from the renewable resources. This last figure is not supported by the analysis here (Section of effective rainfall).

Fig.4·14 EVALUATION OF RESERVES VARIATIONS IN COASTAL PLAIN UNIT



Source: GUERRE and RAJU (1977)

The lowering of the water table has occurred since the beginning of ground water usage; the associated rise of the salt water/fresh water interface is alarming. Great attention must be paid to variation of such storage reservoirs. This situation could threaten much of the Jebel region, although the situation in the El Marj area is less unstable, reflecting the limited demand and relative balance, particularly when water is utilised from the El Garigh flood.

Recharge of El Marj Plain Aquifers

The El Marj plain is now a well studied hydrogeological system, a number of inputs and outputs of the system have been estimated and records have been assembled of rates of decline in the water table in the past two decades. Infiltration has been discussed related to rain depth. It is reintroduced here in terms of recharge and exploitation. As a general rule, for the El Marj and El Abyar areas the recharge of the Eocene aquifers is estimated to be of 108.3 x $10^6 m^3$, of which 12.0 x $10^6 m^3$ is exploited in an average year, i.e. 11% of the available renewable resources, which is quite a low flow. However, this average ratio for El Marj - Al Abyar area covers a great disparity due to the heterogenous distribution of the pumping everywhere in the El Marj unit. The recharge in the El Marj unit is estimated to be 23.7 x $10^6 m^3$, and when compared with the 1979 ground water drawn of 10.3 x $10^6 m^3$, the exploitation ratio becomes 43%. The exploitation ratio is only 2% for Al Abyar area. Again these data seem very optimistic, particularly on the recharge possibilities.

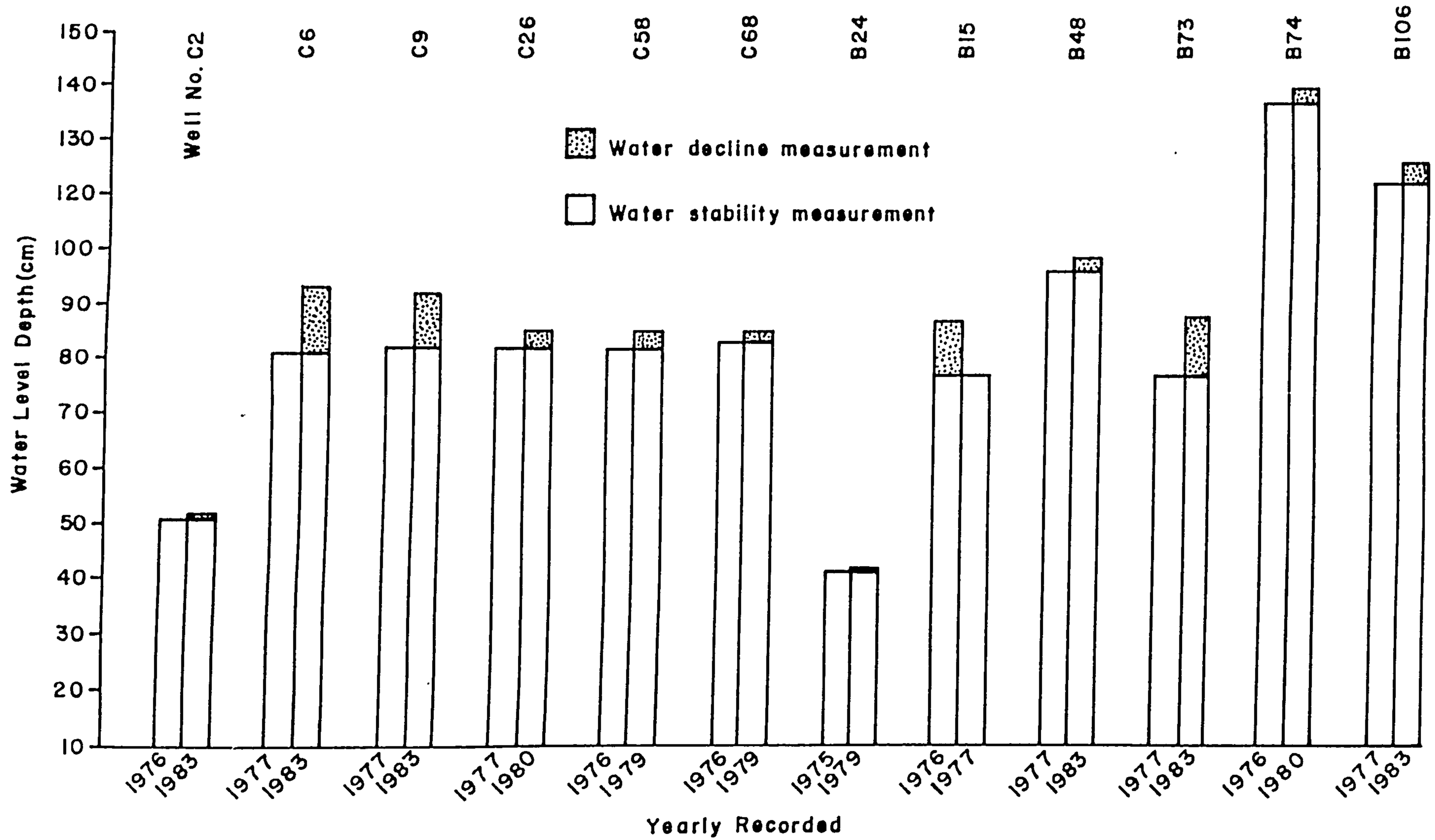
Furthermore, the perched aquifers had an estimated recharge of 15.4 x $10^6 m^3$ for Al Abyar Miocene aquifer and 7.4 x $10^6 m^3$ for El Marj

Quaternary aquifers where the exploitation was only 1.2 x $10^6 m^3$ and 0.1 x $10^6 m^3$ respectively (Guerre and Raju, 1976). This shows that the increase of ground water production must be concentrated in Al Abyar area and further development in El Marj basin must be limited until the adjustment of the ground water balance has been improved by best utilisation and management.

Data on water resources is very imprecise and the volume of recharge and withdrawal is inadequate but tentative estimates show the decline in the water level has been nearly 1 m from 1976-83 in El Marj area (Fig. 4.15).

Water Level measurement in El Marj Plain In El Marj plain 29 wells were selected for regular observation of water levels by the Department of Water and Soil after completing the well inventory in 1976, but measurements could be continued on 14 wells only because of pump installation work and filling up of the wells. Almost continuous water level hydrographs are available from 1976 to 1979, a summary of which is in (Appendix 5 and Fig. 4.15). There is a wide spread of values and the draw down effect at a well is greater than the average fall of the water table. Approximations indicate declining underground water levels in the El Marj plain by an average of a meter and a half in the period 7 years 1977-83 (Appendix 5). Prior to 1977 there was an approximate balance of recharge and water pumped as shown in Table 4.1. The Eocene aquifer is the biggest unit and had 15.6 x $10^6 m^3$ infiltration from a total of rainfall depth of 330 mm over an area of 220 km^2 i.e. 73 x $10^6 m^3$. These two volumes indicate an annual runoff coefficient of 21% which seems high for this semi-arid climate (see Chapter on Climate).

Fig. 4·15 WATER LEVEL MEASUREMENT FOR SOME WELLS AT EL MARJ PLAIN



Source: S.D.W.R. (1984) Unpublished data

Even granting this generous infiltration, which has support in the SDWR report (1977), the fall in water level after 1977 is approximately five times the annual repletion supply.

Present Water Policy Based on such an alarming increase after 1977 in the exploitation of the ground water, the Secretariat of Agriculture and Land Reclamation issued Law No.99 for the year 1984 to emphasise restricted

digging of new production of water wells in both Benghazi plain and El Marj plain (Fig. 4.16) until further study had been carried out on availability of underground water and improved utilisation.

Coastal agriculture must operate water conserving methods, particularly in western Libya (Allan, 1971). The stress is nearly as great on the El Marj area with complete restriction on new production wells. The control of the natural outlet of a ground water basin at Ayn Az Zayanah (Fig. 4.11) is to protect the area from continuous lowering of the water table and deterioration of the water quality by the rising of the interface with the sea water encroachment (see Fig. 4.14). The measures for reducing water use can be summarised:

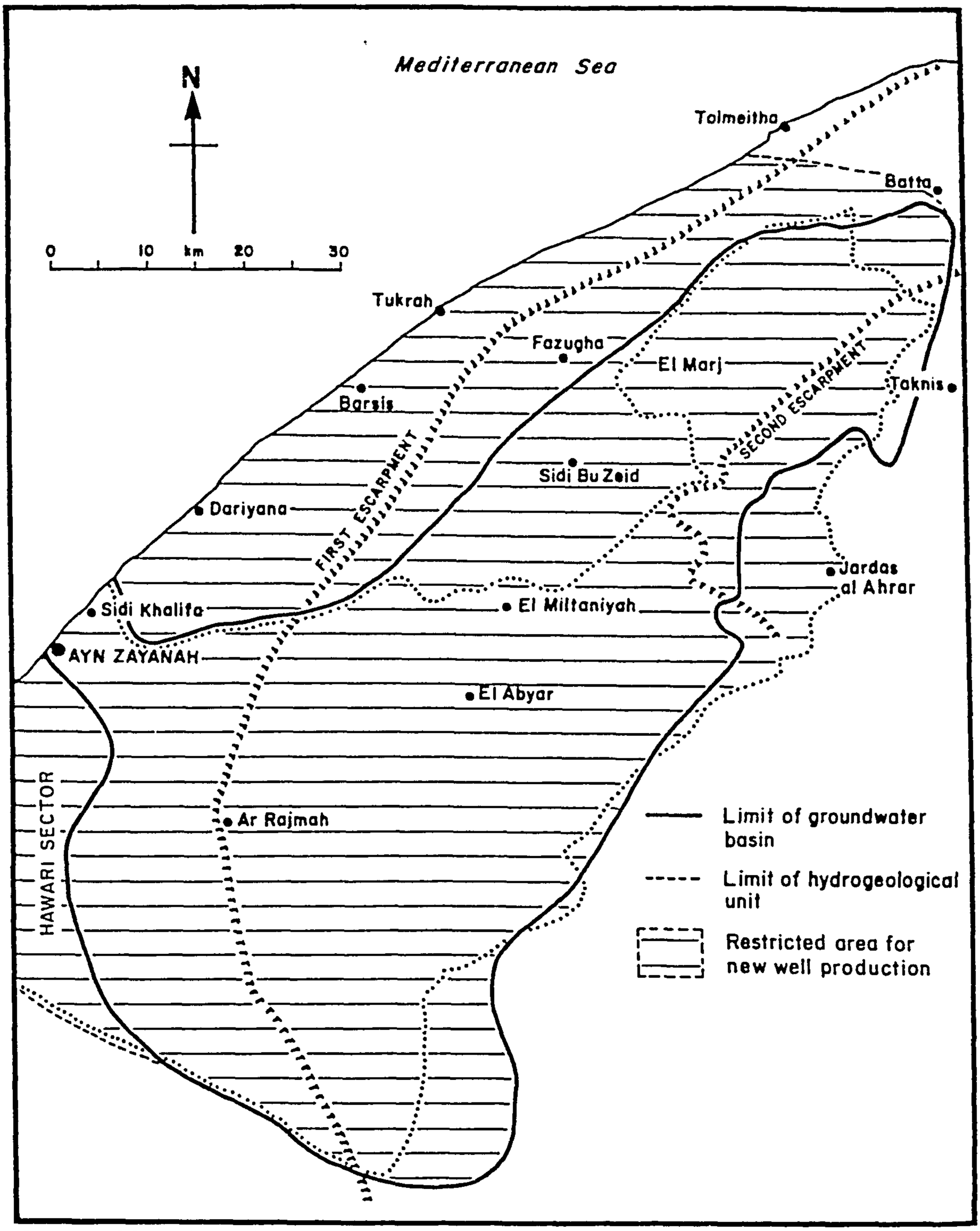
(1) Introducing appropriate modification in cropping patterns.

(2) The development of irrigation methods such as drip irrigation and sub-surface irrigation which can reduce water consumption to 40 percent (Stander, undated).

(3) Education in the efficient use of water, e.g. application of required quantities of water only at the most suitable times of irrigation.

(4) Development of scientific cultural practices e.g. mulching and

Fig.4·16 RESTRICTED AREA FOR DRILLING OF NEW PRODUCTION WELLS



Source : SDWR (1984)

technology such as anti-transpirate and use of plastic covers.

(5) Location of new irrigated farms only in water surplus areas.

(6) Fiscal measures to encourage efficient use and hence to limit water consumption.

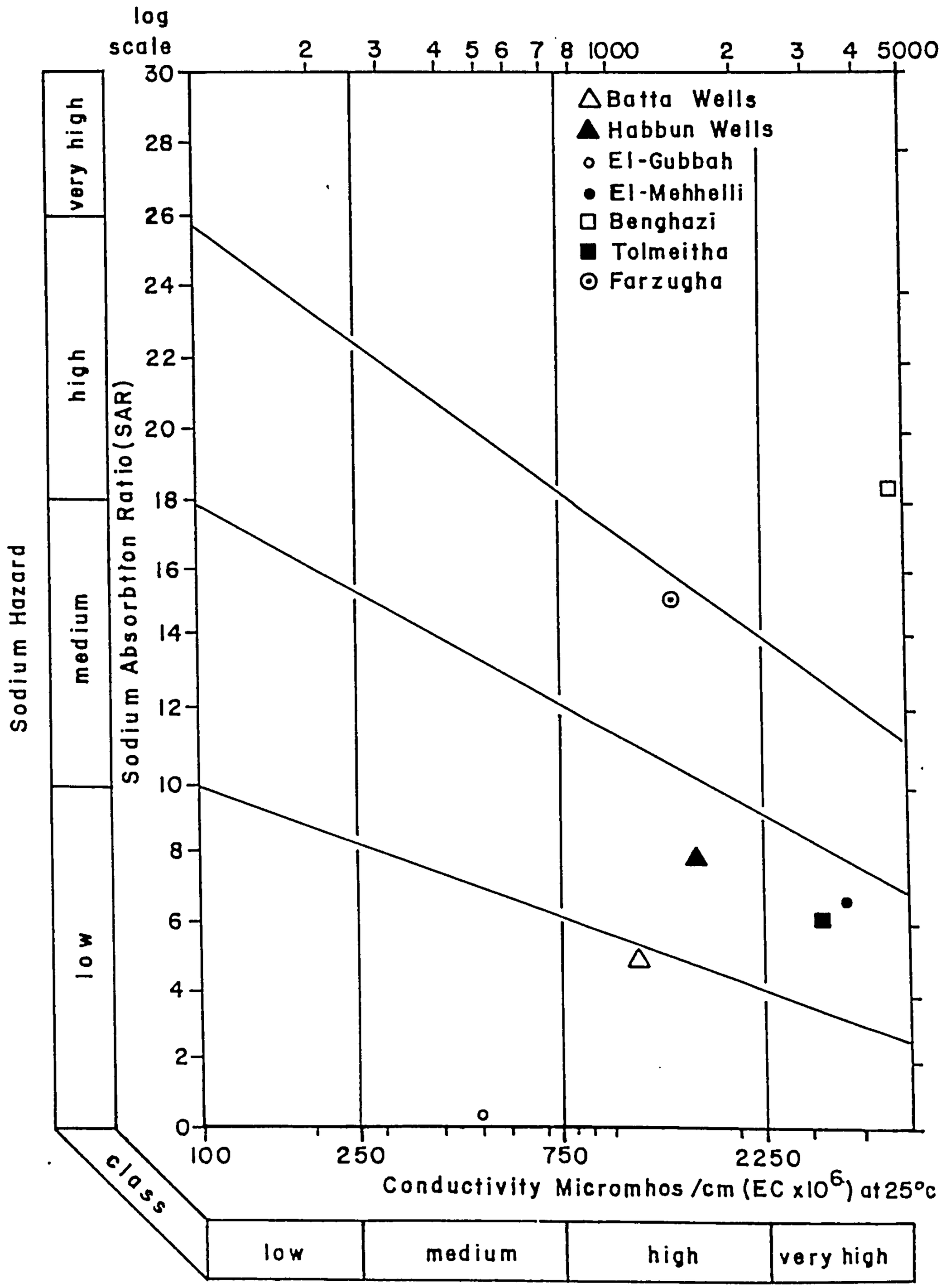
The cooperation of the farmer in these efforts to increase efficiency can be secured by giving guidance and information and even financial incentives. He must be induced to improve his system of irrigation, and thus save money and labour, also water.

The role of the Water Authority in this programme involves development of efficient irrigation methods, fostering their introduction by the farmers, granting loans and reducing market prices of water saving devices, education, pilot projects, the implementation of irrigation extension services, instruction of professional staff, demonstration or experimental farms, applied research and its full achievement.

CHEMISTRY OF UNDERGROUND WATER:

The regional picture throws light on good to fair quality of water underlying large areas of the Jebel El Akhdar. The main aquifer has local variations in the value of the total dissolved salts (TDS) which range from 300 to 1000 ppm (Newport and Hadder, 1963). The quality is better inland near the higher precipitation along the crestline. The quality deteriorates northward to the coast in accordance with decreasing hydraulic head, where it is highly influenced by sea water intrusion which differs according to the quantity of stored water pumped. Good quality water occurs in the area of Messah Bayda Oligocene aquifer and the north side of the Miocene aquifer (Fig. 4.1). A more

Fig. 4·17 CLASSIFICATION OF IRRIGATION WATERS



U.S. Salinity laboratory diagram

significant feature is a large amount of fair quality ground water beneath the coastal corridor, some of which is moderately over highly mineralized.

East of Dernah there is an increasing concentration of dissolved solids inland along the direction of flow from the underground water reservoir. This supports a view that no significant current recharge is occurring over this immediate area (Wright, 1977).

There is a wide range in water quality measured by TDS values in the El Fatayah area of 650 ppm increasing eastwards to 2000 ppm and reaching 5000 ppm in the coastal springs (Doxiadis Association, 1978a). The range of ion concentration, the water quality and its uses is tabulated in Appendix 6. The water for irrigation is dependent on several factors which include the nature of the soil and the proposed crops. In certain circumstances water with more than 1000 mg/l total dissolved solids may be used successfully (Boyke, 1968).

A useful classification is based on a plot of salinity and exchangeable sodium (Fig. 4.17 and Table 4.6) see (Wilcox and Durum, 1967). Therefore, saline water requires salt tolerant plants and well drained soil. Sub-soil drainage is inadequate in the clay soil of the El Marj plain area. There is good drainage at some localities in the coast region near areas of sand dunes in Benghazi plain and in different places as far east as Dernah.

The sodium absorption ratio (SAR) values given in Figure 4.17 show variation according to the location of the water resources. In the middle of Jebel El Akhdar at Messah and El Hania and eastern springs, the SAR value is below 10. The value of SAR ranges between 0.62 at El Gubbah to 8.32 at El Habbun. The wells on the El Marj plain and El

Fatayah area are found in this range, which is good for irrigation of their ferrosiallitic soils.

In areas, such as Benghazi, Farzougha and others with values of SAR ranging between 10 and 18, this type of water is of moderate suitability for irrigation and is preferable for the permeable coarse textured

Table 4.6: Classification of Water Quality Based on SAR:

Class	S.A.R.	Sodium Content	Usage
1	0.10	low	Can be used for all soils
2	10-18	medium	Preferably used for coarse textured soils of good permeability
3	18-26	high	Can produce harmful effects: good soil management is required
4	26-100	very high	Not satisfactory for irrigation purposes

Source: El Chandour, and Atta (1983) Distribution of sodium and potassium in the ground water of the Nile Delta region (Egypt), Catena; 10:180.

soils. The water quality changes dramatically at Farzougha, adjacent to the west of El Marj plain, where the SAR increases to 17.89, but is still under 18 SAR and therefore suitable for irrigation. In areas of SAR value ranging between 18 and 26 water is unsuitable for irrigation and special management is essential.

In the coastal area, particulary at Benghazi, the range of SAR increases to 19.15 which can produce harmful effects and in some places reaches 36.16 with a very high sodium content (more than 45.20 mg/l). Good soil management is essential but as a general rule this is unsuitable for irrigation.

As a general conclusion water with high exchangeable sodium should not be used on fine textured, non calcareous soil with high cation exchange capacity. Replacement of Ca and Mg by Na will reduce permeability and harden the soil (Wright and Edmunds, 1972) which will add a negative characteristic to agricultural land use in this type of soil. The effect of high salinity and alkali hazards (see Percira, 1973) has begun to appear at some farms, particularly experimental farms in El Marj plain, and the effect of chemical fertilizer requires considerable emphasis since most of the soil in the main agriculture areas is ferrosiallitic soil with distinctively inadquate drainage.

Special remedies using different methods are required which take a long time and increase costs of production. It is probable that a larger area was lost to cultivation for long periods due to salinity then was gained by new irrigation schemes.

CISTERNS:

The system of old Roman dug wells which were partially re-employed by the inhabitants are still used, particularly inland, because of the scarceness of natural water points. Several old rainfed cisterns recently collapsed whilst others had not been cleared for long periods. These need to be developed and used for livestock supply, particularly in the hinterland of the region in the dry season, where a large number

of cisterns were found on the second escarpment, especially south of Tacnis. On the coastal plain the aquifer is near to the surface and so the cisterns are few. The scarcity of wells made the construction of more cisterns essential, with capacities of up to several thousand cubic metres. The most important cistern in the western Jebel was that supplying the Roman Aqueduct in Tolmeitha with a capacity of 6,500 cubic metres which has become very well known (Leuenberger, 1965).

The ancient small cisterns are usually 4 x 3 metres in size and 5 metres deep, and mostly for public utilisation, but on the Ente farms each house has a cistern which collects the runoff from the roof, which is for the private use of the owner of the farm. The same situation applies to new farms in El Marj plain especially, and on all the new farms in the Jebel in general. These cisterns furnish the needs of human and livestock consumption in dry seasons where cisterns are widely employed for surface storage.

CONCLUSION:

Conservation of major water resources, particularly ground water, raise problems, mainly those of scale and time. This applies to socio economic aspects as well as hydrogeological (Wright, 1977).

Mechanised agricultural development is planned in some localities in the Jebel El Akhdar. Instead of the traditional process of flooding, sprinkler irrigation or preferably drip or sub-soil irrigation may be more suitable methods and must be combined with an adequate drainage system. A 40 percent improvement of water use is possible and hence will increase the agricultural yield per unit of water.

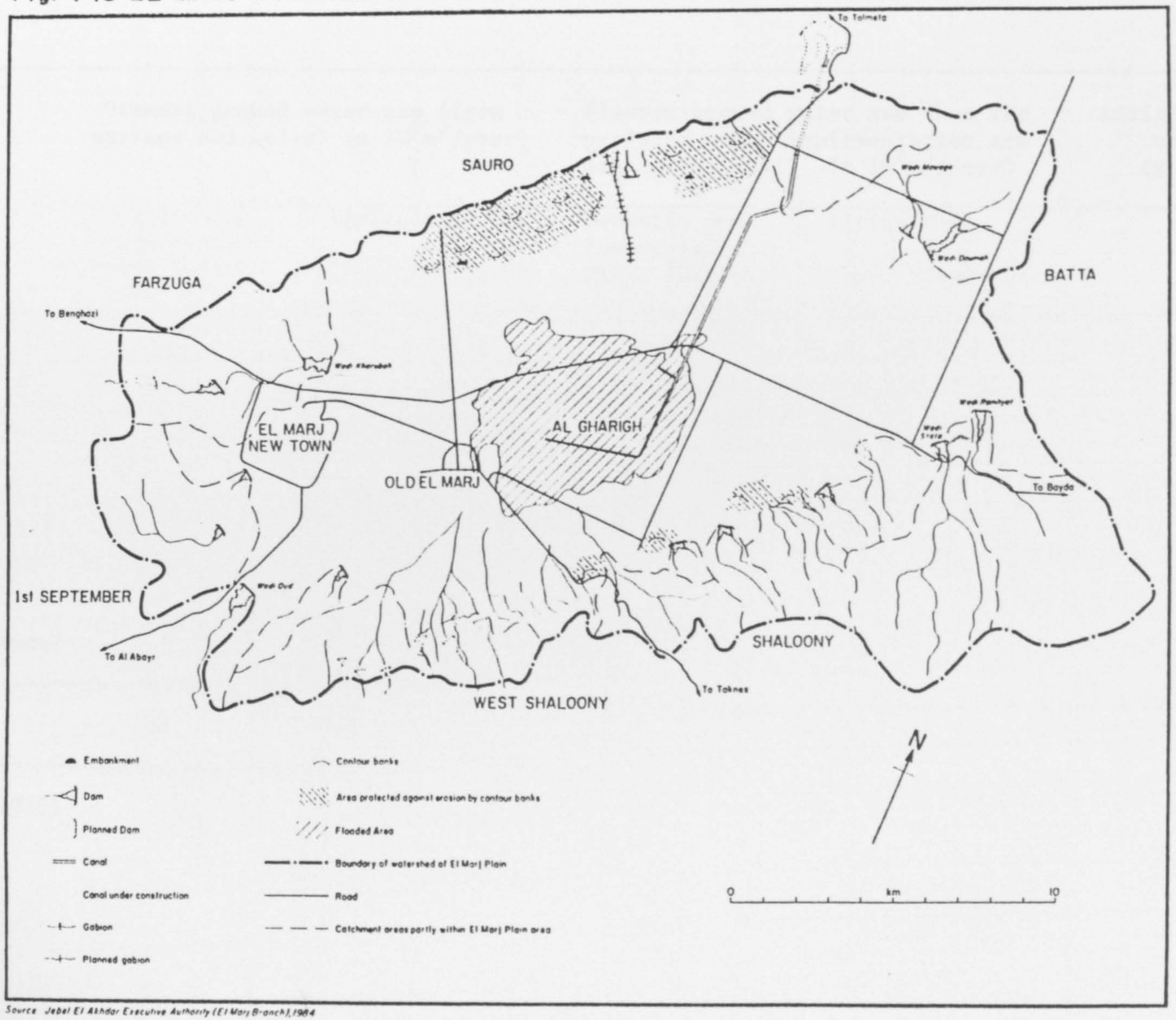
Examples of hydro-agricultural development differ in different

areas. Old farms using natural springs and seepage, and occasional floods and infiltration to the soil, all may contribute to some small irrigation water, although the valleys owe their origin and continuing existence to ground water. The main wadis are distinguished as foci of hydrology conservation in the whole of the Jebel by construction of dams and ditches at different localities to maximise utilisation of surface water. Typical are Wadi Dernah and Wadi El Qattarah south of Benghazi, and the water project of El Garigh (Fig. 4.18).

Adequate development and use of water resources will not be achieved unless proper legislation, administration, research and technological innovation, instruction and extension services are provided. A step in this direction is the law passed in the seventies to constrain the digging of wells and their uses, to protect the decline of the regional water table and the utilisation of surface water in different ways.

A great deal of improved efficiency is essential for the development, maintenance and utilisation of water resources in order to use even small and unstable springs in the region and maintain such small areas of irrigation agriculture as that of Ayn Marrah and Dernah Wadi. Ground water discharge and use in Jebel El Akhdar can no longer sustain the ever increasing water extraction rate (Table 4.7), some alternative development strategies are essential. Improvement in management of rainfed agriculture use might be sustained with favourable output, so that in the future water will not limit the development of the Libyan economy. By better water use and total waste-water re-use, all domestic demands will be met and still allow increased production levels.

Fig. 4·18 EL MARJ CATCHMENT AREA DEVELOPMENT



Source Jebel El Akhdar Executive Authority (El Marj Branch), 1984

Table 4.7: Ground Water Discharge and Use in El Jebel El Akhdar:

Area	Present ground water use (from springs and wells) (x $10^6 m^3$/year)			Planned ground water use when the projects under implementation are are operational (x $10^6 m^3$/year)			Additional extraction under study (x $10^6 m^3$/year)
	Domestic and Industrial Water Supply	Agriculture Private	Agriculture Projects	Domestic and Industrial Water Supply	Agriculture Private	Agriculture Projects	
Benghazi Plain El Marj / El Abyar area	53	57	2	53	57	25	
El Bayyadah, El Bayda El Gubbah	23	4	0.6	23	4	?	
Dernah Bomba, Tobruk	14	3.5	0.1	14	3.5	11	
Southern flank of Jebel	0.5	0	0.1	0.5	0	38	23
South coastal area, Ajdabiya, Sulul El Khdav	2	12	0.2	2	12	-	
Total	92	76.5	3	92	76.5	74	100 (?)

Source: Pallas (1980)

CHAPTER FIVE

SOIL

INTRODUCTION

This section is concerned with a general description of the soil characteristics of the detailed study area and a characterisation of these soil units with comments on their agronomic properties. It is especially concerned with investigating the soil maps which have been published recently by Russian consultants Selkhozpromexport in (1978).

A review of the relevant literature shows it to be intensive though diffuse over the last 20 years, as a result of the endeavour of many international and foreign organisations working on behalf of the Jebel El-Akhdar Executive Authority. Consequently a flood of official reports and papers on the agricultural, forestry and natural resources of the region have appeared. Certainly in the field of soils and agriculture, published work would seem to indicate the need for integration and correlation. The present study attempts an overall appreciation of the soils and their related problems in a very limited but vital region. Thus it concentrates on illustrating the role of soils in agricultural systems and landuse patterns, particularly in the main agricultural regions where landuse is in a state of change.

FACTORS OF SOIL FORMATION

Climate The climate of the Jebel El Akhdar, like much of the Mediterranean bioclimatic region, has two distinctive features: a concentration of rainfall variability and reliability during the cool

winter season, and a very marked summer drought between June to October with dry-laden air descending from the desert land to the north. By contrast, the short rainy season is between October and February in the region of the semi- arid coast area, which produces the subdivision of the Mediterranean bioclimate discussed in the climate section.

Generally, climate is reflected in the soils of the region, although some of the soils have been leached so that they no longer contain free carbonate in the solum (Hurbout, 1964).

Geology The following geological formations are of importance for the soils and their development. The whole of the region is underlain by rocks of Secondary, Tertiary and Quaternary ages. They are separated into physiographic units by their extension in each component. However, all the exposed rocks of the area are sedimentary and are mainly marine limestone. The oldest are of the Cretaceous and the youngest are marine deposits of the Pleistocene, of Eocene age with subsidiary Miocene.

The variation of parent material gives variety to the soil pattern. The lithological character of the different geological strata exert a strong influence on the nature of the soil. The hard, pure limestone, gives rise to a ferro-siallitic red sort (Terra Rossa - red soil of Mediterranean groups). Soft chalky limestone is associated with Grey Rendzina soils (Reifenborg, 1938) and brown limestone or marl with very clay vertic soils on the second terrace of the plateau, and stony soils on hill top sites (Yaalon, 1963). The lower plateau is made up mainly of older Eocene, hard limestone, and is karstified.

Generally, the massifs of limestones are deeply eroded and subsequently its influence is noticed on the clay soils of the region

which originate mainly from the weathering processes and decomposition of the parent rock material.

Topography and Geomorphology The nature and distribution of soils is closely related to the vegetation and both reflect changes in topographic position and gradient. Most of the soil properties vary in a marked sequence along the terraces.

Soil profiles in depressions and the footslopes are very deep in the El-Marj basin, mostly as a result of colluvial accumulation, but partly related to increased weathering at these positions. Over the summit areas profiles are generally thin, and the shallowest sites are found at steeply sloping eroded locations on the maximum slope sections, such as in the Ayn Marrah area and the high area of the Jebel.

The nature of the topography plays a dominant role in controlling the pattern and character of the drainage system, the associated soil moisture regime and the soil depth which is found in terraces of Ayn Marrah, Wadi Dernah and the lowest part of El Marj plain area.

Hydrology and Drainage Soil water relationships are fundamental to soil development and to its potential utilisation in the area. Aspects which are considered important are the nature of the water input soil permeability and slope (Bradley, 1983).

Most water in the region comes from either rain or from ground water reservoir. Further water from wells or springs occurs at the top of some wadis where irrigated farms are found on the terraces of Ayn Marrah and Wadi Dernah. At El-Garigh in the lowest part of El-Marj plain, a lake is formed during the winter by high precipitation and in the spring is replenished by flood waters deriving from drainage of

precipitation in the second escarpment.

From the drainage divide, the region falls gently southwards towards the desert and the general relief is hilly with more or less gentle slopes. The main tributaries originate at the edge of the upper bench and the wadis in the upper terrace run directly in a northern direction with some of them flowing onto the second escarpment. However, most of them belong to the second terrace, forming a very short valley on the first bench, such as the importance of Wadi El Kalij tributaries which have deposited colluvial soil in the El Fatayah area. Generally, the wadi beds are deep with steeply sloping sides, steep wadi flow depends on precipitation. The most important soils for agriculture are the calcareous brown soils and the rendzina soils which are widespread in eastern parts of the second terrace of the Jebel El Akhdar. Most of these soils do not present any problem of permeability, because permeability ranges between 25 to 35cm per hour due to the organic content of the soil. Ferrosiallitic soils, however, which cover most of the area under consideration, are less permeable, about 15cm per hour for the typical colluvial ferrosiallitic red soils and less than 9.6cm per hour for the same types with a calcareous horizon in depth (G.E.F.L.I., 1972b), because the surface tends to seal under the impact of rain, due to its weak structure. Consequently, a larger proportion of the rainfall on these soils is lost through evaporation and occasional surface runoff. In addition, these soils tend to crack, which causes loss of soil moisture if no surface mulch is maintained through shallow cultivation (Leuenberger, 1965).

Structure features of Brown Rendzina soils found at high elevations and in high precipitation areas of the Jebel are much more stable due to

high clay and humus content. Consequently infiltration is high enough to prevent runoff and erosion under the prevailing climate. The slope angle is also associated with the soils of the region, such as in the sample study area where soil can be defined by reference to its slopes which are very shallow to flat leading to internally drained depressions. This is combined with the highest clay content and lowest permeability with a period of inundation at depth, as in the El-Garigh zone, and are hence likely to have a more humid soil climate than shedding and freely draining sites on slope crests and slope flanks. This reflects itself in the formation in the damper area of hydrated iron oxides, and here brown soils of terra fusca type (Atkinson, 1969).

Other factors Time is important in soil formation and pedologists have considered terra rossa as a paleosol, therefore it is a relict form which indicates development under climatic and environmental conditions of a previous period (see Kubien, 1953). Although some types of soils are continually receiving new materials by alluvial or colluvial deposition, they are in a constant state of development. These may indeed by very young, particularly the alluvium in wadi beds which today is thin to nil, with many exposures of bed rock in the channel. Some thin soils covering the plain south and east of Benghazi plain appear to be soil sediment that dates from a recent time period (Hansen, 1975).

Biological activity and the practice of fallowing, often for long periods, leads to marked improvement in the agricultural value of soils.

CLASSIFICATION AND DISTRIBUTION OF SOILS

Soil types and nomenclature

The soil description in this section depends on the review of

different typology studies which have been analysed in terms of soil planning development.

However, much of the confusion in the literature concerning types of soil developed over limestone is derived from the large number of different terms used to describe them, terms often having different meanings and connotations (Atkinson, 1969).

The nomenclature used is given in (Table 5.1) together with approximate FAO, USSR, OSTROM and USA equivalents. This is not intended as a formal classification system, but as a means of identifying the natural soil types of the country (Libya). Thus, the systematic list of soils of the region compiled by Soviet specialists is based on the principles of genetic soil science, taking into account the agricultural demand.

In this context, the soils are classified and described according to the basis of the international system as used by OSTROM (The Overseas Scientific and Technical Organisation at Paris), which were inventoried by G.E.F.L.I. during its prospecting (Table 5.1). In the description of soil type, reference is made by OSTROM to equivalents in other major classification schemes (to avoid confrontation with a lot of unsettled problems of nomenclature). This is because in different sources the same soils of the country are given different names. These differences reflect not only a distinction in terminology but the variety of the approaches to soil classification and determination of soil unit in such classification.

For example, the group of ferrosiallitic red soils corresponds in the compiled list with the same Soviet classification and the

Table 5.1: Asystematic classification of the OSTROM and other systems of classification

Soil groups of OSTROM	Soil units of FAO (UNESCO)	Soil order and sub-order (USA-7th approximation)= USDA soil taxonomy	Soil types of the systematic list of USSR for Libyan soils
Ferrosiallitic	None	Rhoduxeralfs	Red ferrosiallitic
Non lessives	Combisols	Xerochrepts	Siallitic cinnamon
Vertisols	Vertisols	Vertisols	Dark compact
Rendzinas	Rendzinas	Rendolls	Rendzinas
Yermosols	Yermosols	Yermosols	Reddish brown arid
Subarid brown	Yermosols	Aridisols	Brown arid
Alluvial deposits	Fluvisols	Fluvents	Alluvial
Lithosols	Lithosols	Lithic sub-groups	Lithosols
Desert pans	Crusts	Colciorthids gypsierthids	Crusts
Sols salina	Solonchake	Solorthic	Solonchaks

Rhodoxeralfs of the USA, but is not to be found in the FAO classification. Generally, the soil types of the region reflect the conditions of their formation and the agronomical properties of soils in a more detailed way, as compared to other classification are widely used in the world for the practice of soil survey and mapping, see Young (1976); D'hoore (1968). In whatever conditions the soil distribution of the area under specific consideration will emphasise the sub-group in order to gain a general concept of soil agronomy.

Table 5.2:

Soil Classification of Sample Detailed Study Area

Classes	Sub-classes	Groups	Sub-Group
Iron Sequixide soils	Ferrosiallitic		Ferrosiallitic red soils Ferrosiallitic brown soils Thick colluvial and alluvial
Calcimangnesion	Calcareous	Rendzinas soils Calcareous brown soils	Rendzinas form soils Calcareous brown soils Vertic brown soils

G.E.F.L.I. (1972b)

Table 5.2 indicates different types of soil which place a particular consideration on the characteristics related to agricultural assessment.

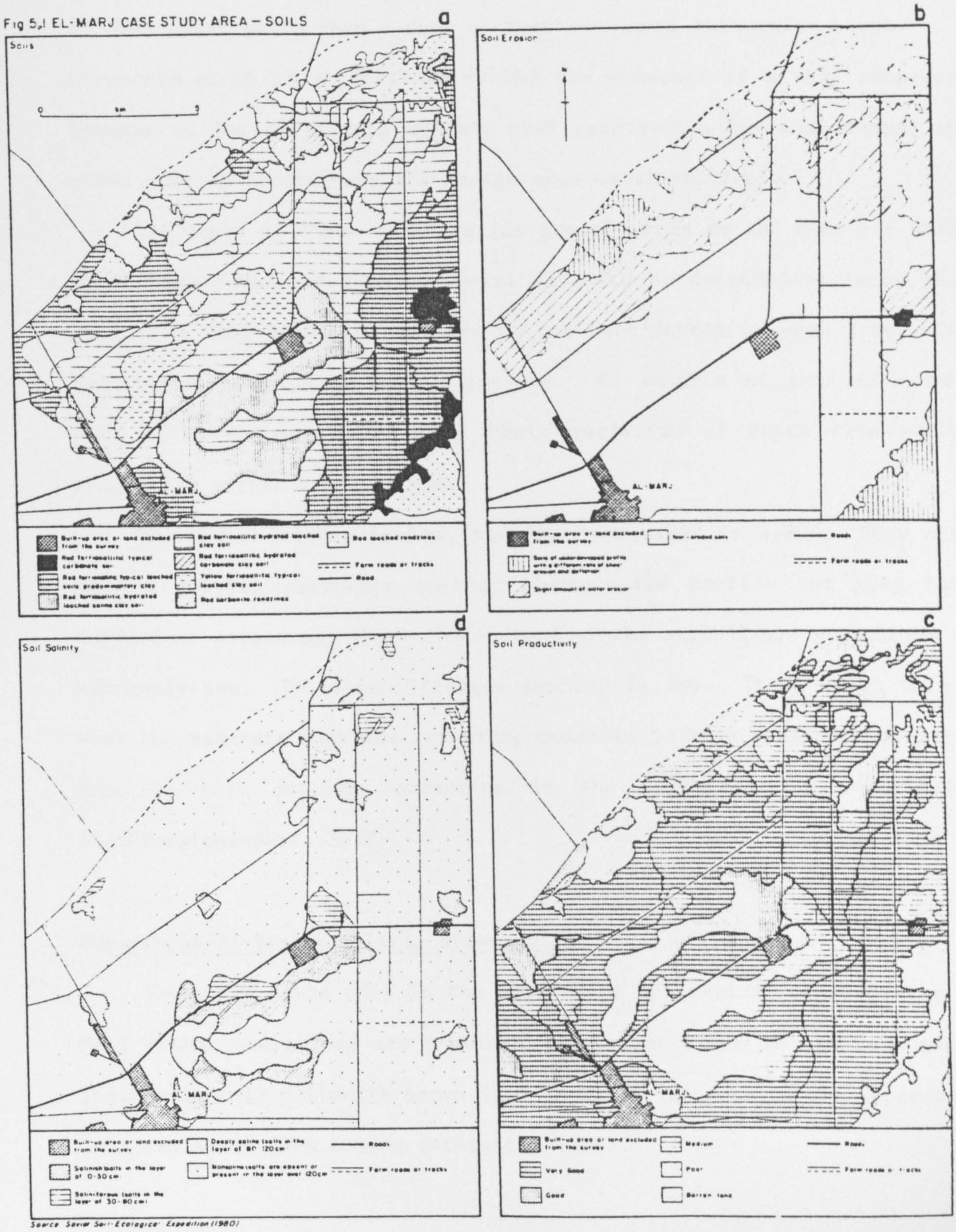
Sub-groups of Red Ferrosiallitic soils

These soils are widely distributed throughout the El Marj and the El Fatayah areas (Fig. 5.1a and 5.2a respectively), and are by far the most widespread soil groups at different levels of topographical features

on the Jebel El Akhdar plateau generally. The soils of this group are typical of Terra Rossa soils or Mediterranean soils, which are rich in individualised iron or manganese sequioxides (Atkinson, 1969), which give them a very light reddish colour (2.5 YR - 5 YR) and (10 YR) for the ferrosiallitic brown soils (G.E.F.L.I., 1972b).

The analytical data for this sub-group reveal several interesting features. They have a heavy texture, with average clay contents, and silt contents vary, whilst sand contents are low.

Fig 5.1 EL-MARJ CASE STUDY AREA – SOILS



Source Soviet Soil-Ecological Expedition (1980)

The ferrosiallitic red soils are characterised by their red colour (2.5 YR-4YR) and moreover often range from pink to brown, while their absorbing complex is saturated with calcium. Their texture is clay loam or clay which gives them a more or less vertic or subangular block structure which is slightly hard, and the presence of a very compacted horizon at low depth acts against root penetration for some crops, and slows down water drainage (El Garigh area water holding).

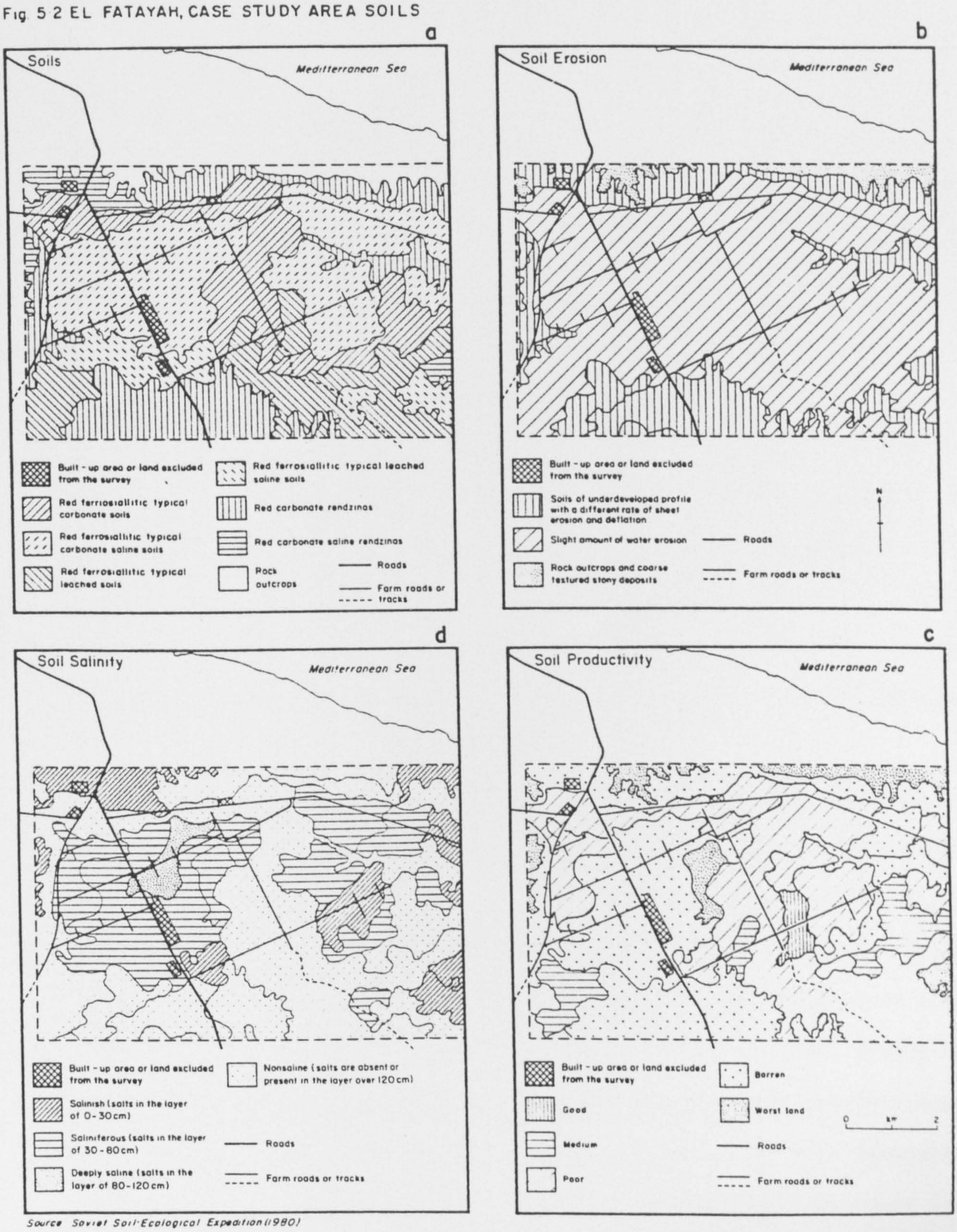
The depth of these soils varies greatly from 1m and over for soils which have developed from colluvial deposits in depressions (more than 90m in El Marj basin) or valleys to ten centimetres or even less, with associated outcrops of hard limestone. An example of this is north-west of El Fatayah area where their variation of depth also varies frequently within a single plot.

The humus content is low, varying from 0.90% to 2.20%. They also have a varying carbonate content through the profile but they have sufficient potassium, where the content of the assimilable phosphorus is extremely low. The total Nitrogen content is low. These soils have a weak and moderate alkaline reaction, moderate to high cation absorbing capacity with calcium dominating in the exchange base composition (Selkhozpromexport, 1978).

Sub-groups of ferrosiallitic brown soils

These are found only in the north-east and central parts of the El Marj plain, where they are combined with other types in the farm plot. Their colour is yellowish brown (7.5 YR to 10 YR), due to the process of dehydration of iron oxides (Atkinson, 1969).

Fig. 5.2 EL FATAYAH, CASE STUDY AREA SOILS



Source Soviet Soil-Ecological Expedition (1980)

These soils have chemical characteristics similar to those of red soils, but are generally thinner, have less extension and differ in their poor physical properties, particularly their moderately slow internal drainage (Atkinson, 1969). These soils exhibit a number of large cracks, and mulches are confined in view of their limited agricultural potentiality (Buru, 1964). Most of these soils are therefore suitable for cereal crops and one of the reasons for the variation of yields on different farm plots is local soil differentiation.

Deep colluvial or alluvial soils

The characteristics of these soils are similar to those of red and brown soils. Nevertheless, these soils, enriched with fine elements of silt, appear to be less permeable in general. Their texture is not homogeneous, and lamination is observed in different sections. In the young soils no profile development has taken place, because of the lack of maintenance of the anti-erosion structure, thus the upper horizon has often disappeared.

These soils are made up of recent colluvium at the foot of the slopes and local depressions on the lower part of the El-Marj basin. They occur in narrow bands in the upper section of the wadi floor or terrace as in Ayn-Marrah area and the mouth of wadi Dernah. Their profile forms are varied, but they are generally deep soils often over-lying slope deposits. The upper horizon is invariably brown though the sub-surface horizons can range from yellowish brown to reddish brown. The texture becomes heavier with depth and the soil more indurated, particularly in Ayn Marrah where a partial infiltration of water from

Ayn Marrah spring forms a stretch of water 1-2 metres deep which makes the sub-soil almost water logged and hydromorphic in character. Their texture is silty clay loam. They contain lime and are moderately permeable and their colour is dark grey, due to the presence of deoxidised iron (G.E.F.L.I., 1972b).

The analytical data for wadi soils show quite wide variations in mechanical and chemical characteristics with clay contents varying from 38% to 62%, silt content from 30 to 55% and sand from 6 to 12%. There is a marked increase in clay content with depth, which has an effect on the saturation percentages. These are generally high and influence the amount of irrigation per hectare.

CEC is high due to clay contents and pH values range from 6.6 to 7.8 in the upper horizon, increasing downwards to 8.0. They are the only acid soils in the watershed (Selkhozpromexport, 1978). The available nutrients are high. They show several interesting features; phosphate contents are high, whilst great differences seem possible in potash contents which related to illite forms and montmorillonite clay to increase a total cation exchange capacity and peculiarities of their water regime. Moreover some distinctive features are noticed when dry such as :

i) Fairly wide vertical cracks.

ii) Coarse prismatic or angular blocky structure.

iii) Slicken sides on some places of the structural units, and some of them have a self-mulching surface, others a crusty one which delimits root depth (Hurbort, 1964).

However, brown and red soils are often mixed to give complex soils a fairly high potentiality. The presence of water at certain periods of

the year, in conjunction with poor filtration and with the very considerable inflows, plays an important role, especially in the lowest part in the El Marj basin, which give it a specially high agricultural potential.

The other type of soil in the area, is a calcareous soils which are classified into calci-magnesium soils and divided into sub-classes of carbonated soils, including the following groups :

Sub-group of Rendzinas

These soils have formed on the mountain slopes and north of the Jebel El Akhdar, and often contain a chalk substratum which is favourable to water retention in depth. They are also well structured and fairly rich in organic matter. They tend to be pebbly in places with very rapid permeability.

These soils are relatively unimportant in the sample area, occurring only in the south-east of the El Marj plain and on the edge of the first escarpment which surrounds the north and north-west of El Marj basin (Figure 5.1a), whilst in the El Fatayah area they occur as a tongue in north-east farming (Fig.5.2a).

Their profiles are generally shallow clearly granular and often include limestone pebbles. In their natural state, these soils show some erosion including rill erosion. Despite their granular texture they can retain moisture and this is beneficial to crops with roots in the sub-soil. These soils are widespread in the humid bioclimate zone (Leuenberger, 1965), similar to the highest part of north-east of Jebel El Akhdar (Labrag and El Gubbah areas). These are good soils for growing forests and fruit trees which are the main products for that

area.

Rendzinas soils show many analytical characteristics, the content of clay materials is relatively high and there is little variation in depth. Similarly the loam contents are among the highest recorded. The carbonate is high and nitrogen is medium which may be compensated by fertiliser. pH varies from slight to moderate alkaline. Available nutrients are lacking, particularly available phosphorus. This can be effectively added with fertiliser (Selkhozpromexport, 1978).

Sub-group of calcareous brown soils

These are calcic carbonated soils having a structural horizon rich in organic matter and generally thicker than rendzinas. Permeability is very high. Their texture is loamy-clay and they are often very strong. In addition, the depth of these soils is fairly regular.

Their distribution is mainly along the coastal belt. Along the edge of the first escarpment they are not very thick, are very pebbly and constitute an intermediate stage with the rendzinas (G.E.F.L.I., 1972b).

Sub-group of vertic calcareous brown soils

These soils are restricted areally and are found only in the eastern part of the Jebel El Akhdar. They develop on marls and marly limestones, and are related to specific topographical features, ie. flat surfaces or slight slopes.

They are distinctive by their high clay contents, poor structure and compactness, which is reflected in poor internal drainage, and low permeability.

From these particular characteristics, it is apparent that these

soils are difficult to work and need tilling, taking into account their wet condition (El Maddah, 1972; Young, 1976). Generally, the carbonate content in the soils is high and they are very rich in available potassium and deficient in available phosphorus. The soils have medium alkaline content and are distinguished by a high CEC in the upper horizon and a lower CEC further down.

From the point of view of cultivating crops, trace elements in these soils are sufficiently supplied by available nutrient, but their contents change considerably further down (Selkozpromexport, 1979).

MECHANICAL AND CHEMICAL ANALYSIS

Some physical and chemical properties of the soils of Jebel El Akhdar region have already been analysed by Chanduri and others (1979) and for general observation of soil types about 32 surface soil samples 0-20cm depth were collected from Jebel El Akhdar area.

Table 5.3 indicates the soil fraction percentage and the texture classification for all soil samples and the main character can be noted

TABLE 5.3 : Soil Mechanical Analysis

Variables	Range %	Mean %	% of 32 soil sample	Texture class
Sand	0.10 - 27.4	13.6		
Silt	25.0 - 47.4	39.1	44	Silty clay
Clay	34.2 - 68.6	47.4	34	Clay
			12.5	Silty clay loam
			9.4	Clay loam

Source : Chanduvi, F., Rasheed, M.A. & Fayd, O. (1979), Trace element of soils of Jebel El Akhdar region, Tripoli, Table 1:6.

that out of 32 soil samples, by using the criteria of family classes, 44% of the samples were classified at silt clay, 34% clay, 12.5% were silty clay loam and 9.4% were clay loam. Soils of the Jebel El Akhdar

TABLE 5.4 : Range and mean of soil chemical analysis

Variables	Range	Mean
pH	7.04 - 8.26	7.81
$CaCo_3$	0.00 - 42.47	8.38
Organic matter %	0.74 - 8.25	2.25
Na meg.100 of soil	0.31 - 5.57	0.87
K meg.100 of soil	0.82 - 7.30	2.37
Ca + Mg	1.39 - 3.68	2.59
Cation Exchange capacity	14.78 - 50.44	32.37
Available phosphorous p.p.m.	0.50 - 10.00	1.74

Source : Chanduvi, F., Rasheed, M.A. & Fayd, O. (1979), Trace element of soils of Jebel El Akhdar region, Tripoli, Table 2:8.

area range from moderately heavy to heavy and include most other intermediate classes. The frequency distribution of the texture component is present in Table 5.3.

From the mechanical and chemical analysis point of view Table 5.4 shows the mechanical anaysis of soils to be an excellent index of many properties which indicate a gradient in these soils. In those with a low proportion of sand, through those where silt and clay become more important the increase in clay and silt is evident in all the samples of the area, with commensurate increase in exchange capacity and total base. However, compared to coarser textured soil from areas near the coast or from soil in parts of Western Libya, this will correspond with lower CEC, which indicates the poor quality of those regions,

revealed in poor crop performance (Willimott, 1960).

Table 5.4 also shows the extreme variability of phosphorous and Nitrogen. Its level throughout the Jebel El Akhdar area is low and varied to a significant extent so they are cleared by analysis sample results of sample soil in the region, showing that more than 95% of samples had less than 3 ppm. of phosphorus and this indicates that P is under the critical level of 5 ppm. as suggested by Oslen (1958) for calcareous soils (Rasheed and Chanduvi, 1979).

Obviously Nitrogen and phosphorus fertilisation could play a dominant role in establishing good productive agriculture in the area, whilst K, Ca and Mg levels were all adequate.

CEC meg./100 gr. of soil is related to soil textures. From an analysis of the mechanical point of view, the CEC is relatively high and ranges from 20.00 to 50.44 meg./100 g. of soil. Due to the increase, the clay type would be dominated by montmorillonite, illite and kaolinite, which varies from 200 to 800, 100 to 120 and 5 to 20 m^2/g respectively (see Brady, (1974). Such a clay composition would offer little in the way of structural stability. Furthermore, data from various studies on structural stability suggests a near structureless soil with little or no resistance to the collapse of peds (Atkinson, 1969).

As a general rule, the sum of CEC is large in comparison to the other soils from other parts of Libya. In addition, in the upper humidified horizon, the total is larger than in the lower ones. As a whole, exchangeable calcium constitutes the major part of the exchange capacity.

From the foregoing discussion it is apparent that the surface

layers of the soil in the region suffer from high bulk density and low permeability, particularly the ferrosiallitic soils. They will affect the drainage system and root development, moreover, and the surface cap is likely to restrict infiltration of rain water where slopes of even the lowest magnitude are found to have surface run-off, either by sheet flow or via gully erosion which will lead to the loss of rain water.

The soils are moderately and sometimes slightly alkaline. Their pH values vary from 7.00 to 8.26 with a mean value 7.81. pH increases downwards in all soils due to the presence of limestone.

The main characteristics of these soils are relatively high Ca and alkaline pH levels, and a high exchange capacity per unit weight of clay. All suggest that this type of soil has developed from decomposition of rock material primarily through the influence of climate in situ Reifenberg, (1938), although some places receive their material through alluvial or colluvial deposition such as the El Marj basin and often in small valley areas where there is evidence of vertisolic process.

Their sub-group corresponds to argilaceous calcareous brown soils, in which the sub-soil exhibits vertic characteristics polyhedred to prismatic, presumably with swelling clays having a high exchange capacity. This carbonate soil is characterised by its high clay content, its poor structure and its compactness which is reflected in poor internal drainage and the permeability rate is low (k - 0.9) (G.E.F.L.I., 1978).

These soils are difficult to work owing to their compactness in the dry state and their plasticity in the wet season. Consequently this land is difficult to improve and must be tilled taking into account its

wet condition.

Furthermore, information about the fertility status of Libyan soil is needed, particularly concentrating on the available micro-nutrient status. Zn, Cu, Fe, Mn, Co, Mo and B of the area under consideration have already been reported by Chanduvi and others, (1979) which is the basis for the discussion of results of the trace element status of soil of the Jebel El Akhdar region. The evidence is that 3% of the samples were found below the critical level for zinc and 28% were deficient in molybdenum, although most of the soils have an adequate supply of available Co, Zn, Mn, Co, B and Mo for plant growth.

EROSION HAZARDS

After having reviewed the region's soils in the foregoing discussion special attention must be paid to soil erosion the major part of the sample study area.

It is clear that after a rainy season with normal precipitation, traces of erosion on the land hardly remain visible. However, it is certain that erosion occurs roughly where there is a permeability lower than 4cm per h. which is represented by ferrosiallitic red and brown soils. These are found almost solely in the El Marj plain and the El Fatayah plateau. Therefore erosion is much more marked, especially when the slope is steeper than 5% and when it is long, for example, along sloping terraces in the Ayn Marrah depression.

Erosion losses are excessive because of the way in which the soil is used in Jebel El Akhdar and the farming techniques employed can only bring about an increase in erosion. To start with, cereal crops which have been grown on a large scale for a considerable time without

employing either organic or chemical fertiliser now exercising crop rotation are particularly erosive and do not afford the soil protection which would be expected from production. On the other hand, the rangeland and forest formation act as an erosion control, unless it is overgrazed.

Sheet erosion by water involves the even removal of a thin soil layer cover of a large extension of land and is probably the least conspicuous of the major types of erosion (Fig.5.1b and 5.2b), but it has a particularly damaging effect and is undoubtedly the most significant type of erosion in the sample detailed study area. Susceptibility to sheet erosion depends on a number of related factors, including topographic features, the climatic environment and the character of the soil. Human interference in the landscape, such as land management for agricultural purposes can be constructive or destructive. Therefore, the farming techniques employed, like the preparation of the soil by means of tractors or overly powerful farm machinery (i.e. > 75 pH) makes the soil sensitive to erosion. Further a moistured sub-soil creates a self-mulching block. On the other hand, ploughing is most often carried out in the direction of the slope and used to stir the soil without turning it over, leaving a surface which is much less sensitive to erosion, than with the new methods of turning the soil over. In addition, after the harvest, the sheep are concentrated mainly in the stubble fields until the first rains begin and the straw is entirely consumed, often eaten down to the roots. The soil is intensely trampled. Its upper layer thus becomes fine dust which is very sensitive to erosion.

A large area of the surrounding El Marj basin is covered by natural

plant formation of average density so that more than 70% of area is protected against soil and water losses, Fournier (1972). However, a dense growth of grass may be almost as efficient, but if this is over-grazed rapidly erosion increases. Therefore, the increase in land cultivation after clearing and the area protected by forest or scrub formation is diminishing regularly, thus aiding erosion.

A comparison of two aerial photographs of the El Fatayah and El Marj area, for example, taken respectively in 1964 and 1979, is an indication of this aspect. In 1964, the cultivated area covered roughly 30 to 50 per cent of the total, while in 1979 the percentage of cultivation increased to about 80 to 90 per cent.

Gully erosion and mass movement are less widespread in the area, but evidence of their importance becomes more visible in the Wadi Ayn Marrah, where steep valleyside slopes occur and mass movement in slides and slumping are common.

The fine material eroded from the slopes is deposited in the valley bottom to form wadi soils. These tend to have high silt contents and low organic and mineral nutrient content which act to increase erodibility (Morgan,1979), and on the whole spoil rather than improve valley land. The fine collouvial material, so valuable for plant growth, is carried away in suspension during the flood periods.

Wind erosion tends to be restricted to low level areas with low rainfall and scanty vegetation, ie. Benghazi plain. Generally, the Jebel El Akhdar reduces the violence of the strong dry winds. Although wind erosion seems less effective than water erosion, in the southern part of El Marj basin strong winds go through the bottom of the El Marj area after harvest, carrying dust clouds and also raising up the fine

dust created on the surface by the trampling of the livestock which feed on the straw. In addition, certain earlier winds in March and April have a definite depressive effect on cereal crops, especially as the crops are poor-growing owing to limited or irregular rainfall. These should be protected by windbreaks which would reduce the harmful action of these winds and create a micro climate more suitable to the crop.

Broadly speaking, soil conservation seems to be significant in the area under consideration, particularly in the El Marj area which differs from the El Fatayah area, having less erosion (Figs. 5.1b and 5.2b). In fact water availability is the limiting factor in agricultural productivity and the condition of the soil minimises the erosive effects of raindrops, run-off and wind. It is emphasised that rain water should be conserved and must be fully utilised for cultivation. These aims, however, can be achieved by the construction of reclamation dams in locations where the beds are most clearly defined and the sites most favourable for conservation measures to be employed. In a sample detailed study area, preference is always given to agronomic treatments, although for some areas of the Jebel El Akhdar region emphasis on conservation of soil should be applied by mechanical measures, accompanied by agronomic treatments.

The Use of Fertilizers

From the foregoing discussion it can be seen that the soils of the region are mostly clayey and contain relatively more organic matter than soils of the north western region of Libya (Roy, 1974). As the soil of the areas under discussion are poor in plant nutrients except for potassium, it is necessary to employ fertiliser as required by the

crops, using a method of application which is most suitable to the plant.

The most practical way of achieving and maintaining a fertile soil is to apply organic matter which may be added as green manures, straw or as a manure which has already undergone a high degree of fermentation. Thus most of the farmers use animal manure which has a good effect on both dry and irrigated farming and is also easily obtained. This counterbalances the deficiency of organic humus, which represents less than 2% or between 0.29% to 1.79%, as organic matter content, and its percentage decreases under the surface layer of the soil. It can be observed that of adding one of these three kinds of material beneficially affects not only the structure of the soil, but also the solubilisation of the phosphate and of the trace elements such as boron. Wallace (1951) concludes that boron deficiency may occur when soils are low in organic matter. Further organic manure has a rather different effect in dry soil; it may seriously affect the E.U.R. of the movement of water in the sub-soil. However, slow-acting, long-lasting fertilisers are to be preferred because of the deficiency of water supply (Reifenberg, 1938).

In arid, or semi-arid regions, similar to the areas under consideration, it is necessary that chemical fertiliser be applied to neutralise a number of factors contributing to the decline in yields. Paramount among them are the falling levels of phosphorus and nitrogen under a system of frequent cropping, often involving successive annual crops (Donald, 1974).

These deficiencies are met by the adoption of the following which gives an accelerated release of nitrate nitrogen from soil organic

matter and by the use of superphosphate, which corrects the deficiency of phosphorus as will be clear in the forthcoming discussion.

The nitrogen level throughout the soil of the sample area is low and varies to a significant extent ranging between 1.0 to 29.6 ppm. Obviously nitrogen fertilizer could play a dominant role in establishing a good productive agriculture in the area, particularly in irrigated farming and also in the case of legumes and pulse crops to act on fixing nitrogen in the soil, but nitrogen should be avoided in dry farming, which may lead to increase in crop growth. This will cause drying and lodging. The rate of fertilizer application is linked with the amount of water available. As an example, if 60 kg. of nutrients (NPK) are used per hectare as the maximum level in a good irrigation such as in the Ayn Marrah area, this level should be decreased to 30 kg. per hectare as the minimum level for rainfed farms (Roy, 1974).

Dry farming usually does not require mineral fertilizer when the land is recently cultivated. However, to increase production of continuously used land, application of fertilizer would be quite useful. As a consequence of these practices, yield rose strongly during recent years, which is proved by data on the assessment of soil fertility and fertilizer use in dry farming in the El Marj plain during the two seasons 1975/76 and 1977/78.

Phosphorus fertilizer (Ca - superphosphate 8.3%, 19% P_2O) was applied to wheat at 4 rates ranging from 0 to 120 kg/ha. during the 1975/76 season at El Marj (rainfed). In another rainfed season, 77/78, at El Marj 3 rates (15 to 45 kg/ha.) were applied. That application was done in two ways: (a) broadcast by hand, then mixing with soil surface; and (b) localised placement along with seeds in rows 5cm deep in soil

(Amer, et.al. 1979).

Applying the second method gave pronouncedly higher yields, particularly at the rate of 15-60 kg/ha., but at the very high rates of 120 kg/ha., the reverse occurred and broadcast gave more yield over localised application; but band application of fertiliser of phosphorus may give greater yield over broadcast particularly with the clay soil (Reifenberg, 1938). Banding, therefore, has been found in various parts of the world, to be more effective than broadcast in the same high P fixing soil, are usually those of fine clayey texture (Amer, et.al. 1979). If present in large quantitities, it is able to maintain enough phosphorus in solution to meet the need of growing crops. It is also essential that these fertilisers should always be ploughed under at the time of sowing or before it (Roy, 1974). Thus it is an effective value-cost ratio and is being used more and more by farmers.

Relating to the rate of application of different fertiliser materials to crops some standard recommendations are essential for guidance to local farmers in order to gain maximum yield and good economic return by:

(1) Selection of crops and varieties most adapted to low moisture conditions such as cereal crops.

(2) Soil management for maximum water conservation and method of seeding to allow optimum utilisation of available moisture.

Finally, apart from carefully planned fertiliser application, the essential condition which should be taken into consideration under dry farming condition is better crop performance.

As nearly all soils of the area are calcareous and have high pH (7.30-8.0), chemical fertiliser, when added, should have an acidic or

neutral component which is reduced in its acidity by adding lime. Thus ammonium sulphate, ammonium nitrate and superphosphate are preferable. Fertiliser like sodium nitrate and calcium should never be applied to the soil of Jebel El Akhdar (Hurbot, 1964). Moreover, the continual use of mineral fertilisers without organic manures may lead to structural deterioration of the soil and increased erodibility. Therefore farmers should take care in using chemical fertiliser alone, and they have to know the appropriate utilisation of chemical fertiliser in the long run.

GENERAL ASSESSMENT OF AGRICULTURAL VALUE

Figures 5.1d and 5.2d deal with agricultural potential as indicated by a soil type and soil analytical data, a number of characteristic properties of the soil can be discussed, and a brief statement made of their effect on agricultural land use.

From the point of view of the physical properties of the soils, they are clayey, and are also generally slightly calcareous or silico-calcareous, poor in humus, sometimes reddish. Shifting cultivation of cereal is practised on most of the soil types in the region. Rock soils predominate with a thin crust of brick red soils, such as terra rossa of the Miocene impermeable, particularly in the coastal plain of the region. This is indicated by chemical dissolution even on rather small size masses. Such chemical weathering could be intense only if there is a humid sub-soil, rich in humus which gives off carbonic acid. Therefore, most of these soils are subjected to dry farming by winter cereals, and form highly productive land in the area.

Furthermore data from Buru 1965 survey on structural stability suggests a near structureless soil with little or no resistance to the

collapse of peds. Thus, it is apparent that the surface layers of the terra rossa suffer from high bulk density and low porosity and these soils can pose problems for root development. Moreover, the surface cap is likely to restrict infiltration of rain water.

However, we have already pointed out that in many cases the main type of soil, ferrosiallitic soils, are underlain by a pan which forms an impenetrable barrier to the roots and restricts the movement of water in the soil.

Undoubtedly, a high percentage of the rainfall in the area does not penetrate very deeply on account of the impermeable layer and is lost by high evaporation in the summer and this limits the success of tree growth which when started are unable to send roots to a sufficient depth to utilise the moisture above the hardpan. Thus, non-irrigated land needs a special practice in relation to the choice of tilling dates as a function of the wetness of the soil. It must be ploughed as deeply as possible and in the meantime if possible be dressed with organic matter, which compensates for the deficiency of nutrients for plant food, improves the cohesiveness of the soil, increases its water capacity and promotes a stable aggregate structure (Morgan, 1979).

These soils allow the cultivation of fruit trees such as peaches, apricot, prunes and plums, whose rooting is not very deep; less than 0.6m (G.E.F.L.I., 1978). It is possible to use plants with powerful rooting such as vines, which are all suitable to areas free of high percentage of $CaCo_2$, and dissoluable salts found in the El Marj plain and El Fatayah plateaus. Whilst, vegetables and the market garden generally have been cultivated preferably with irrigation in the area having a permeable sub-soil. In addition the area of brown calcareous

soils are specially suited for cereal crops and fruit trees, which show the best yield when the sub-soil is chalk, owing to high water retention.

From the point of view of chemical analysis, the improving agents aim at providing a chemical balance in the soil, so that the pH of the soil varies from 7.04 to 8.26 degrees in the region. In acid or alkaline soils the crop varieties might be suitably selected to preclude unfavourable productivity so that it is essential to match crops with soil type. Also increased alkalinity under the surface soil would affect the growth roots of trees.

In general, the soils of the agricultural land of the region give an appearance of being more fertile than they actually are. Nevertheless, there is little humus, although most soils are heavy, with high CEC, which is related to type of clay. They also crack badly when they begin to dry, which effects the growth of the plant, and loss of soil moisture. Thus, the texture of soils is relatively good from the agricultural point of view, and farm management would be able to support quite intensive landuse, to some extent different from one farm to another. Good farm management would depend a great deal on the skill and zeal of the farmer.

Furthermore, El Marj and El Fatayah areas are high value soils which are favoured for cereal production and this would appear to result from the general level of nutrient which is reasonably good for plant growth under dry farming. However, the deficiency of some elements could be corrected by adding chemical fertilisers.

At localities on the coastal plain and valley bottom or its terrace heavy alluvial soils are found which contain much silt due to the

colluvial origin of their material. Due to this and its topography its water status is variable and unpredictable. For example, at El Garigh in the lowest part of El Marj plain some crops prefer poorly-drained soil and the disadvantage in potential deficits is in soil moisture.

In all but in the finest-textured soils of El Garigh where infiltration is particularly poor, average rainfall will permit slow, but steady infiltration and provide what moisture is necessary for plants, while at the same time offering good drainage. Conversely, the terraces of Ayn Marrah and Wadi Dernah form the cultivation land, consisting of somewhat underdeveloped colluvial soil more than a metre deep. The easily utilisable reserve EUR and partial infiltration of water from Ayn Marrah spring has formed a stretch of water as just mentioned, which provides moisture to the sub-soil almost constantly. This is very important in water management to limit the irrigation amount for annual and vegetable crops needing water.

Consequently, it illustrates the intensive method of farming which is made possible by the exceptional quality of the soil. This fertile soil has built up over a long period of years, with the aid of large quantities of organic matter and combined with the water, it is the valley's essential asset.

Eventually, the agricultural assessment of the soil of the region must take into account the variation of bioclimate in the study area, where a semi-arid and sub-humid bioclimate allow the satisfactory development of Mediterranean dry farming. At the same time, in an agricultural area with arid, semi-arid bioclimate such as south of El Jebel El Akhdar, irrigation would make it possible to provide the water requirement of the crops.

Therefore, the most important soils in terms of local agriculture are formed in these regions because of their fertility for cereals and animal husbandry and appear the most suitable with reference to the scarcity of humus and Nitrogen and to the physical characteristics of the soils. In addition, irrigation would benefit not only fodder growing, but also crops suitable for crop rotation including pulses. It should be assumed that irrigation will take place whenever soil moisture stress is going beyond the limit a crop can tolerate without causing a yield reduction.

CHAPTER SIX

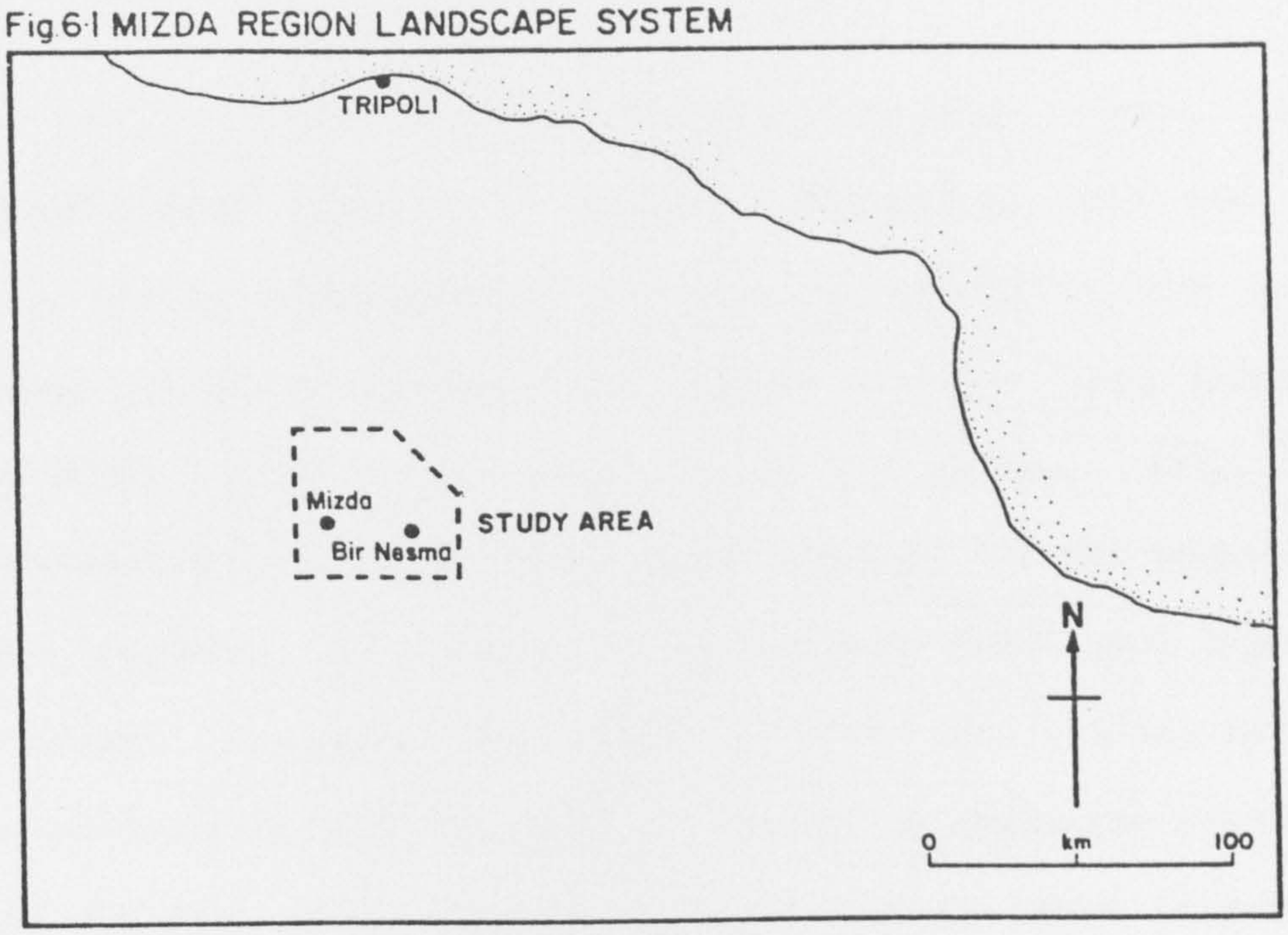
LANDSCAPE ANALYSIS

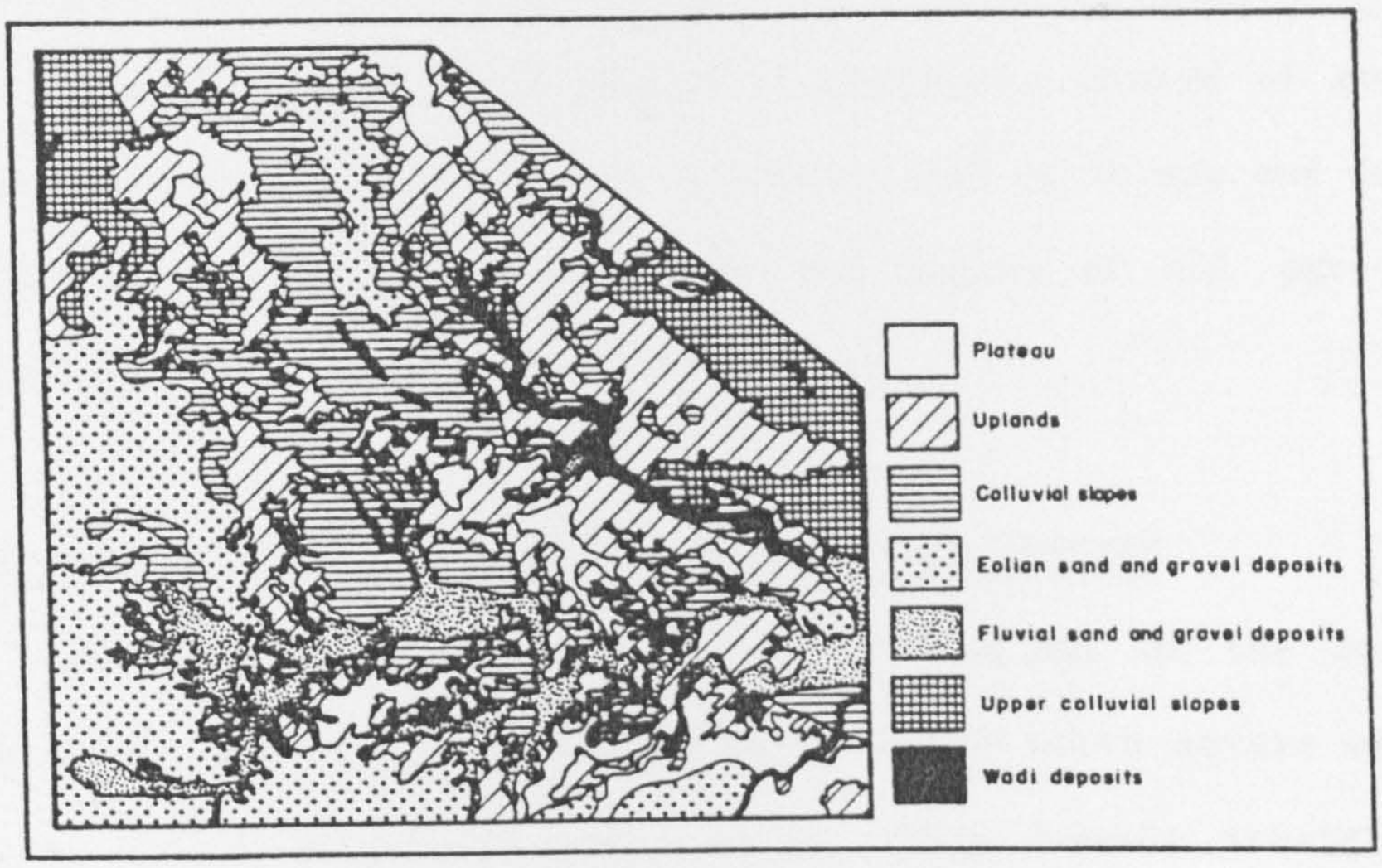
INTRODUCTION

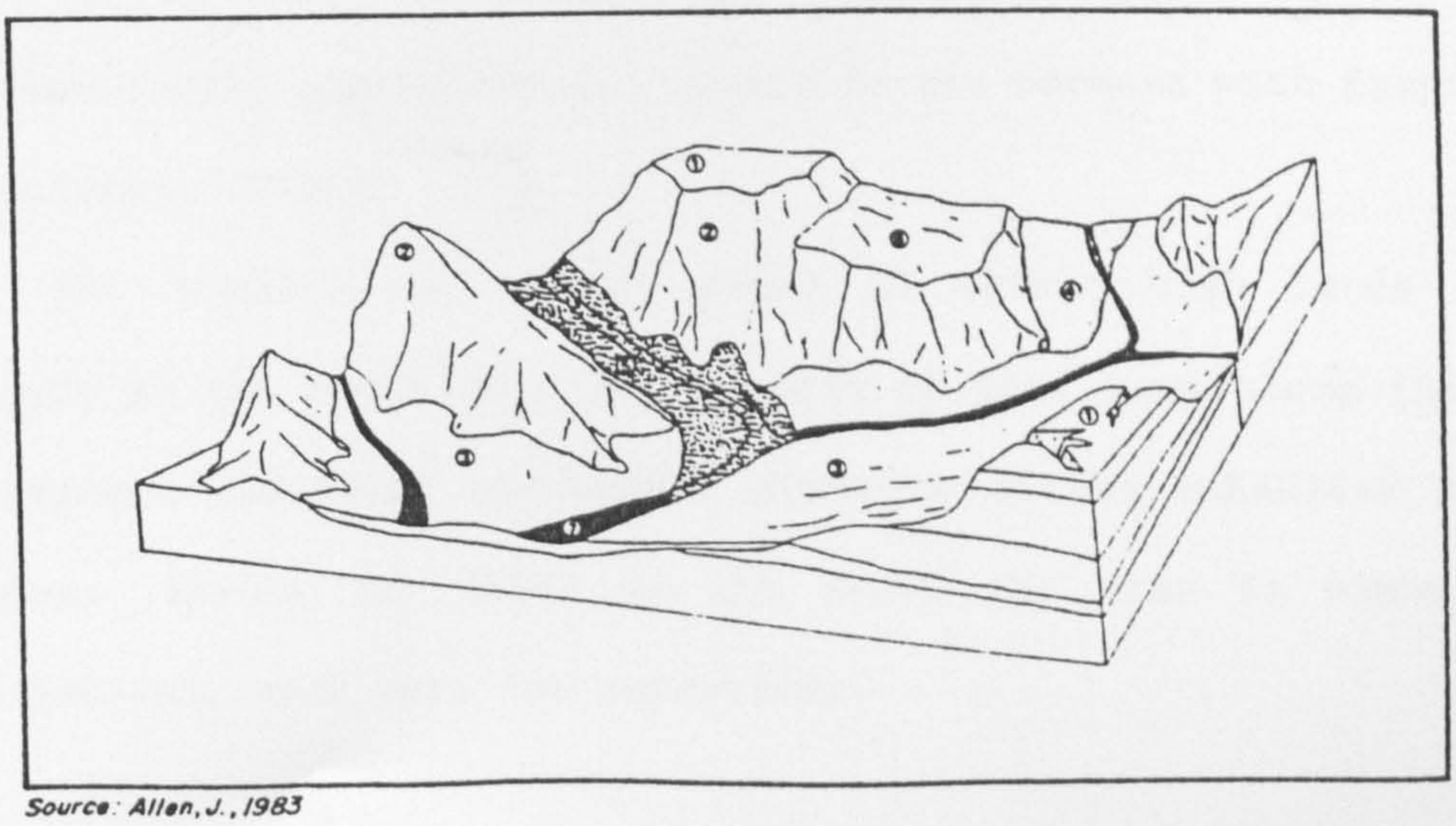
The term landscape is conventionally used to incorporate those features of the surface of the earth which try to give, as accurately as possible, a picture of all the phenomena and relationships which are of importance to the ecological development of plants, animals and men (Vink, 1982).

The approach used here is a form of landscape analysis in which the surveyed territory is divided into land systems, an approach used for many years by the Land Survey Division of the Australian CSIRO (Christian and Stewart, 1968). The concept was established at the stage of working method in the 1940's and 1950's (Christian and Stewart, 1953). Because of its relative youthfulness, the concept is in a state of evolution in its practical application. There is variation from one user to another, depending on the terrain analysis and the assumptions made during analysis (Dent and Young, 1981). However, the use of land system analysis has proved a significant method of approach in the appraisal of land resources in under-developed countries (Young, 1968a and b; 1969; Moss, 1969). An example of a land system method has since been employed by MEXE in the Masaka Land System, Uganda (see Ollier et.al., 1969). Other land system surveys have been carried out in the territory of Papua and New Guinea (Haantjens, 1965) and a Land Resource Study in Nigeria has been achieved by the Land Resources Division, Ministry of Overseas Development.

Fig.6·1 MIZDA REGION LANDSCAPE SYSTEM







Source: Allen, J., 1983

Land systems analysis involves mapping units, each having characteristic patterns of geology, topography, soil and vegetation, which can be distinguished in terms of potential land use. A land system can be sub-divided into simpler elements (land facets) such as the Mizda region's land facet Figure 6.1 (Allen, 1983), and can be incorporated into larger units (land regions) for the purpose of large-scale planning. An example is the northern flank land region of Jebel El Akhdar. Similarly, one or more adjacent land regions may constitute the province of Jebel El Akhdar. Several neighbouring provinces form a land division of the plateau of North Eastern Libya (Figure 6.2), and all divisions together make up the land zone of Cyrenaica.

In this context, the use of a systematic method of analysis has made possible the aims of this research, that is to map and describe the agricultural land use pattern in the region of all agro-ecological zones.

THE JEBEL EL AKHDAR LAND REGION AND ITS LAND SYSTEMS

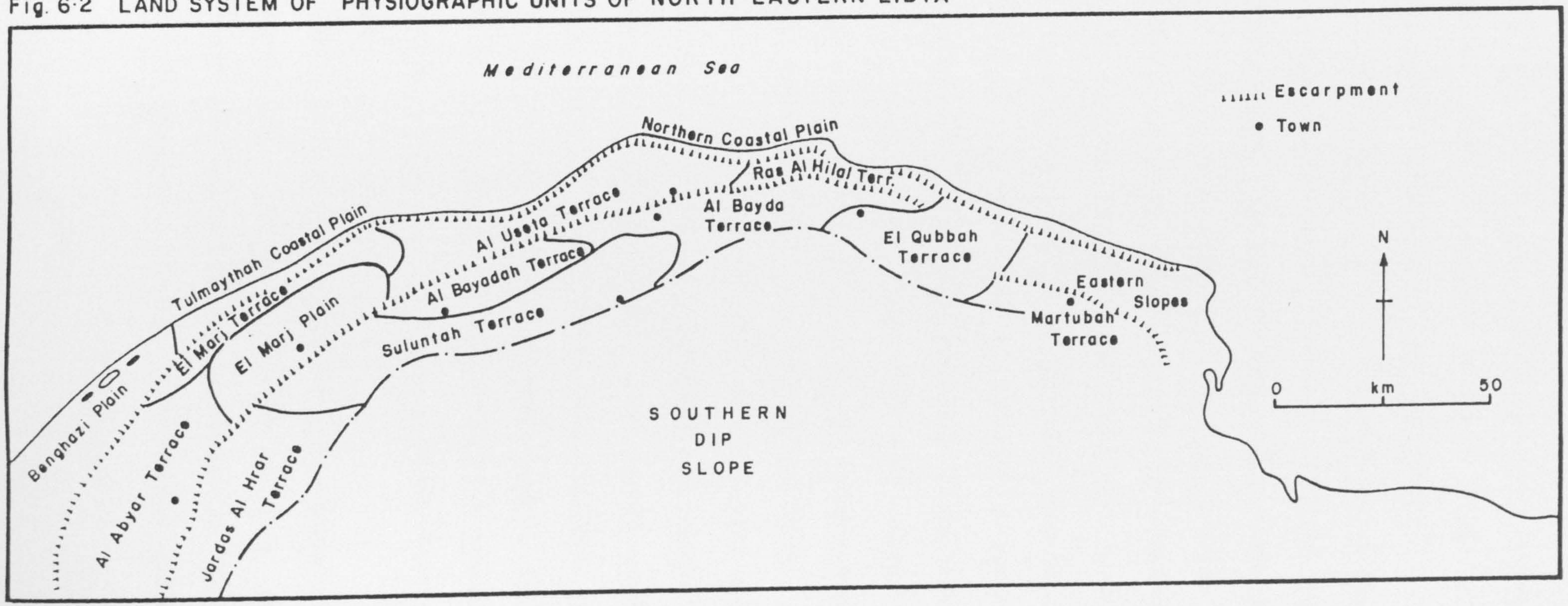
Of the total area of about 135,270 sq.km. of the north-eastern plateau of Libya, the inhabited part in the north covers about 11,000 sq.km. (about 8% of the total area). This densely inhabited zone is part of the Jebel El Akhdar high land and includes the littoral zone between Dernah and Tobruk and beyond to the borders with Egypt (Doxiadis Associates, 1978a).

The emphasis is on the Jebel El Akhdar high lands which rise sharply in the south of a narrow area of flat land along the coast and constitute the basic geomorphic elements of the inhabited part of the region. Beyond the Jebel to the south the area is almost flat and uninhabited, with very few exceptions.

Table 6.1: Land System Description of Northern Flank of the Jebel El Akhdar and Adjacent Area

Land System Division	Altitude m.a.s.l.	Mean Annual Rainfall/mm	Soil Parent Material	Land Forms	Vegetation and Land use	Soils
Benghazi Plain	0 - 20	200	Pliestocene	Flat to gentle slope to sea	Field crop cultivation orchards, bare ground	Lithosols, salonchalk alluvial fan and terra rossa
Tolmeitha Plain	0 - 20	220	Pliestocene	Flat, narrow to escarpment with increased gradient slopes	Fieldcrop cultivation, woodland, bare ground and Sebkha	Lithosols and salin salinchalk
West Dernah Plain	0 - 40	280	Pliestocene	A great dissent by gorges with great slopes	Field crop cultivation orchards, village gardens rough grassland and woodland	Lithosols, salin salinchalk and alluvial fans
Al Abyar Terrace	120	278	Pliestocene and middle Eocene	Flat to gentle slope to adjacent depression	Field crop cultivation grassland and forest land	Terra rossa, aluvium, reddish brown alluvial
El Marj Plain	280	380	Pliestocene and middle Eocene	Gentle slope toward lowest part of the plain	Field crop cultivation forest land on the plain fringe	Terra rossa, reddish brown alluvial
Batta	320	340	Pliestocene	Gently to moderate topographic		
El Ussetah	350	380	Lower Eocene	Physiographic unit forms varied topographic shape difficult to utilize	Scrubs and woodland plus grassland with shifting cultivation	Lithosols and brown med. soils
Ras El Hilal	450	330	Pliestocene and Miocene	Greatly influenced by network of wadis to form regional commerce plus topographic features	Scrubs and grazing (bee keeping)	Reddish brown alluvial and lithosols
El Gubbah	500-600	350	Miocene	Very gently undulating valley flood plain	Field crop cultivation grazing area and base ground	Rendzinas groups alluvial
Jarchs El Ahrar	550	300	Cretaccous	High altitude plateau moderate relief moderate slopes broad convexities	Dry farming, rough grassland, woodland and bare ground	Brown med. soils
Solontah	600	400	Oligocene and lower Miocene	Gently undulating terrace, low relief with numerous tributary gullies	Rainfed plantation (barley) rough grass land, scrubs and bare area	Brown med. soils and lithosols
El Bayyadah	430	310	Oligocene and middle Miocene	Deep main valleys with tributaries, valley floor, gently concave form	Scrubs or woodland, dry farms on small parcels particularly in valley bed.	Lithosols and alluvial deposits
Al Bayda	550	390	Oligocene and Miocene	Small valley bed concave undulating plateau with occasional small up hill features	Cultivated farms, wood-land rough grazing and bare ground	Rendzinas group lithosols
Martubah	150	200	Oligocene and middle Miocene	Crest broadly convex valley bed, small stream, V-shape	Cultivation crop field valley culture and bare ground as grazing land	Lithosols and alluvial deposits, and grey to greyish semi-desert soils

Fig. 6·2 LAND SYSTEM OF PHYSIOGRAPHIC UNITS OF NORTH-EASTERN LIBYA



The Jebel El Akhdar region was studied by choosing sample areas corresponding to land systems and obtaining sites within them to represent the area for detailed study by land facets.

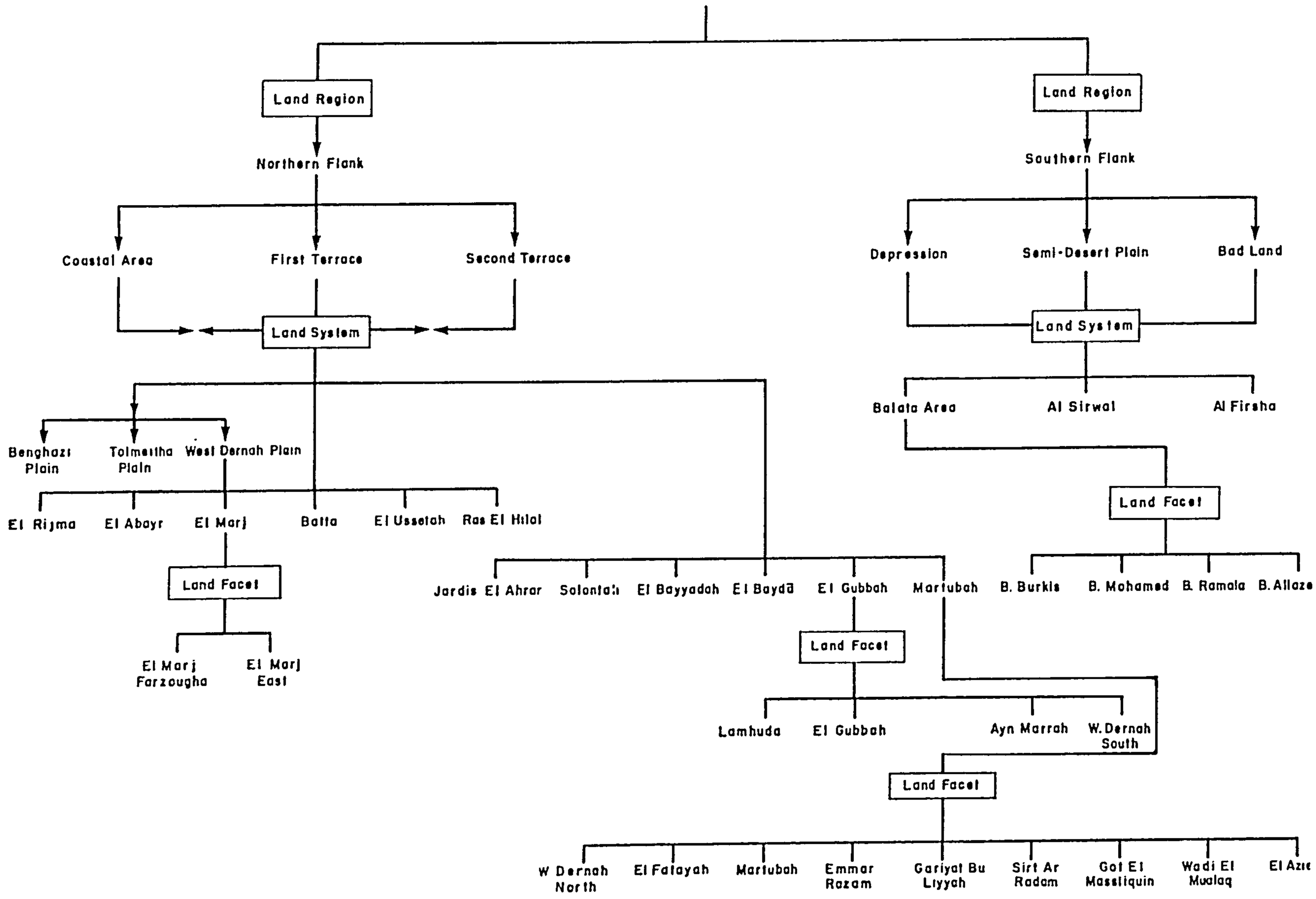
The land system approach is shown in Figure 6.3 and described in Table 6.1. Figure 6.3 gives the hierarchy of local classes for the Jebel El Akhdar region. In most instances each class at every level above that of the facet consists of several classes in the level immediately below. In a few instances, e.g. the Southern flanks land unit, the class contains only one land system due to the homogeneity. But in some cases land systems are divided into land facets with regard to their places in the hierarchy to illustrate a specific phenomenon which is related to the agricultural potential of the area.

These are local, rather than universal, definitions but they conform basically to the ideas expressed by workers elsewhere such as Stewart (1968); Haantjen (1965); Dent and Young (1981).

Land systems in the Jebel El Akhdar cover a more complex area than in north-western Libya which is a reflection of simpler lithologic and geographic patterns. Likewise, land facets in the northern flanks of the region occupy very large areas and elsewhere they might be considered a simpler unit, such as a land element. Also, the El Marj plain and El Fatayah plateau land system might be recognised by others as facets, whilst a region similar to the southern flank might be termed a land system.

It is stressed that, although the principal means of identification and delimitation are subjective or intuitive from general physical phenomena, their description is made objective by the use of clearly defined and class parameters, such as physiographic units (Fig. 6.2).

Fig. 6·3 LANDSCAPE DIAGRAM REPRESENTING LAND REGION AND LAND SYSTEM FOR JEBEL EL AKHDAR UNIT AND ADJACENT AREA



Of the several environmental variables and parameters used to identify land systems, topography or land form has proved to be the most consistent and reliable (Dent and Young, 1981). The geological and pedological factors can only be recognised by their relation to land form, while vegetation type differentiation has been indicated to be of limited value, due to the scattered distribution of unreliable precipitation and disturbance by man. In areas of intensive cultivation, land use can be highly sensitive to differences in land types of units, but is nevertheless insufficiently discriminating in this region of predominantly rainfed farming areas.

Overwhelmingly, the effect of altitude is apparent on climate, soil vegetation and land use in the high mountain ranges in different areas. It is for this reason that land form is so important, indicating areas of potential agricultural use as an agro-ecological zone.

In this context, the following points may be made with regard to land evaluation based on land form analysis, and its application in the area under consideration.

(1) Landforms divided into macrorelief (more than 50m height variations with its surrounding as El Marj plain), mesorelief (10 to 50m height difference such as El Fatayah area) and microrelief (less than 10m elevation variation) which is represented by the Ayn Marrah depression; are themselves important environmental factors for land use, including their influence on soil moisture conditions, and other physical environment hazards such as sheet erosion.

(2) Topographic features give a natural basis for water management similar to the traditional system of irrigation at Wadi Dernah and Ayn Marrah through channels or furrows. At the same time, modern systems of

irrigation in El Fatayah area are determined by land forms with the main reservoir for modern irrigation farming situated at the highest point of the area about 50m higher than the highest farm in the area, in order to permit irrigation by gravity and to save and reduce pumping stations which will affect cost benefit analysis.

The outstanding feature is the El Marj basin in the El Gharigh area, the lowest part of the El Marj plain, where water is collected during the rainy season to restrict its use to certain areas. For this reason, it has recently been reformed to drain the water to a sink hole in order to cultivate this area as an apple farm.

(3) Landforms, together with climate and parent materials, are basic factors of soil formation, and therefore determine to a large extent the nature of the soil, particularly in the El Marj plain and El Fatayah area. Landforms also give important indications of erosion and denudation where sheet erosion appears at both areas, whilst land slides occur on part of Ayn Marrah depression where it needs particular maintenance on soil development and soil degradation.

(4) The aforementioned have a direct impact on vegetation and land use. As regards the vegetation, it corresponds broadly to the main environments defined climatically, such as coastal vegetation, a forest or shrub highland vegetation and a steppe vegetation in the south of the Jebel.

In these different environments there is a corresponding flora, rich in species, and with a wide geographical diffusion (Mediterranean and semi desert species). Others are peculiar to Libya or only present in Cyrenaica (endemic species, sometimes only in the Jebel El Akhdar, e.g. Enesperchia, Linearifolia, Amarace Cyrenaica, etc. (Sandwich and Simpson, 1941; Johnson, 1973).

SPATIAL DISTRIBUTION OF AGRICULTURAL LANDUSE PATTERN IN JEBEL EL AKHDAR

The general distribution of agricultural landuse is shown in Figure 6.4 which indicates two types of landuse : agriculture and natural vegetation for grazing. However, a variety of agricultural types are located in the region, including irrigated and dry farming, orchards, vineyards and livestock breeding. The intensity, density and environmental situation of agricultural activities range considerably from place to place as follows :

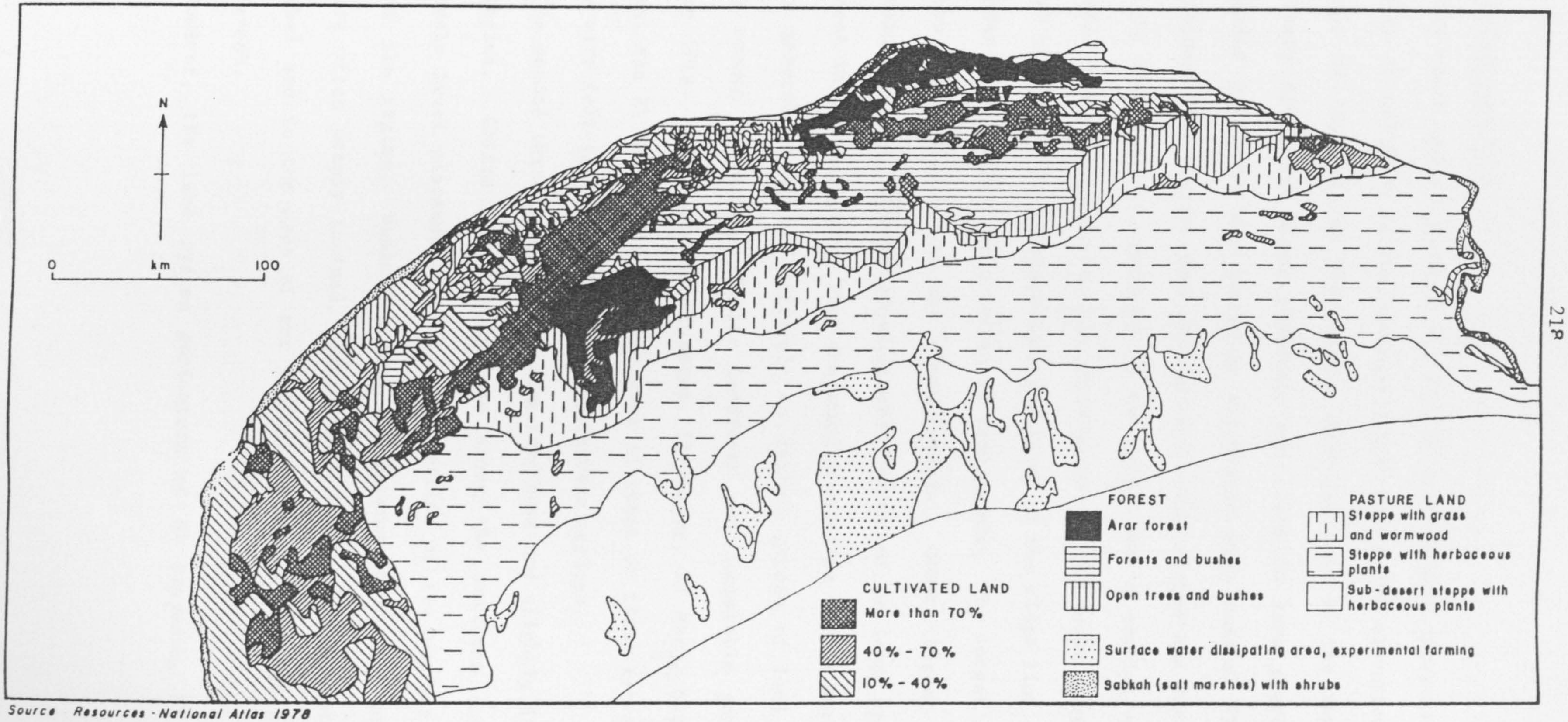
(A) Areas more than 70% cultivated, on the alluvial areas of the terrace bench surface.

(B) Areas where between 40-70% of land is cultivated located on the terrain marginal to the terrace escarpment areas and on the intergrades, north and northwest of the Jebel El Akhdar.

(C) Areas with between 10 and 40% of terrain cultivated in climatically marginal lands south and east of the Jebel where steppe land appears.

Furthermore, cropland of all kinds has been developed in those areas receiving adequate rain above 300mm each year. The majority of traditional dryland farms are to be found in the area receiving less than 250mm. Modern farming has followed the same pattern, but existing Arab gardens and scattered fruit trees already monopolise the best watered basins and valleys such as El Marj and Dernah areas. Traditional tribal cultivation is also found in the region extending into the south, where rainfall averages 150mm and less. At the same time the location and extent of traditional or modern irrigated gardens is mainly determined by the availability and ease of access to the groundwater.

Fig 6·4 GENERAL PATTERN OF LAND USE IN NORTH-EASTERN LIBYA



Source Resources - National Atlas 1978

LAND REGION ANALYSIS

The north eastern plateau of Libya is most readily characterised as a series of uplifted marine terraces which rise to an elevation of 880 m.a.s.l. at the peak of the Jebel. Most portions of the region are relatively flat, but slope gradients are steep in some places. The shallowest gradients are generally associated with coastal flats and depressions, the steeper ones with mountain-side slopes and wadis. The Jebel is comprised of terraces on the north and a complex of fans, badlands, semi-desert plains and depressions in the south forming the core of the area. The terrace surfaces north of the ridge line of Jebel El Akhdar are separated by a series of escarpments. The lowest of these terraces is identified as the coastal plain. Other, higher terrace surfaces, include several physiographic units of a land system to represent the land region. They are simpler entities than a land region and in general it is not difficult to delimit groups of land systems having common lithology, similar landforms and comparable geomorphic history (Fig. 6.2), such as El Rijma, El Abayer, El Marj, Battah, El Ussetah, Ras El Hilal. The predominance of these on first terraces and basins were felt to represent the first terrace regions.

The second terrace has contrasting landforms and slightly different lithologies. Cliffs occur in places along the northern coast and relatively level plateaus cover a large portion of the surface in the east of the region. Wadis traverse the escarpment between plateaus. They are often deeply incised, particularly in the central portion of the Jebel and in the east of the region. Examples are Wadi Naga and Wadi Dernah.

However, the land system perimeters of Al Bayyadah, El Bayda,

Labraq, El Qubbah and Martubah are located on the second terrace region, and the land system perimeters of Jardis El Ahrar and Suluntah are sited further south where the second plateau rises with a sharp relief which has a slight influence on the environment of this area. These physiographic land system units represent the land region of the second terrace.

It is sufficient to stress here, that while the physiographic unit of land system is a unique geographic area, the land region is not unique and may occur over widespread areas. This does not preclude the possibility that, for example, an area such as the north side slope of the first terrace can be the same as the second terrace region and height of the Jebel.

Haantjens (1965) has suggested the term "irregular pattern", where components occur haphazardly yet form a characteristic association to represent a land system. Therefore, the usefulness of land facets within a land system will be clear when applied to the area under specific consideration, in recognising the need for a multi-purpose land evaluation.

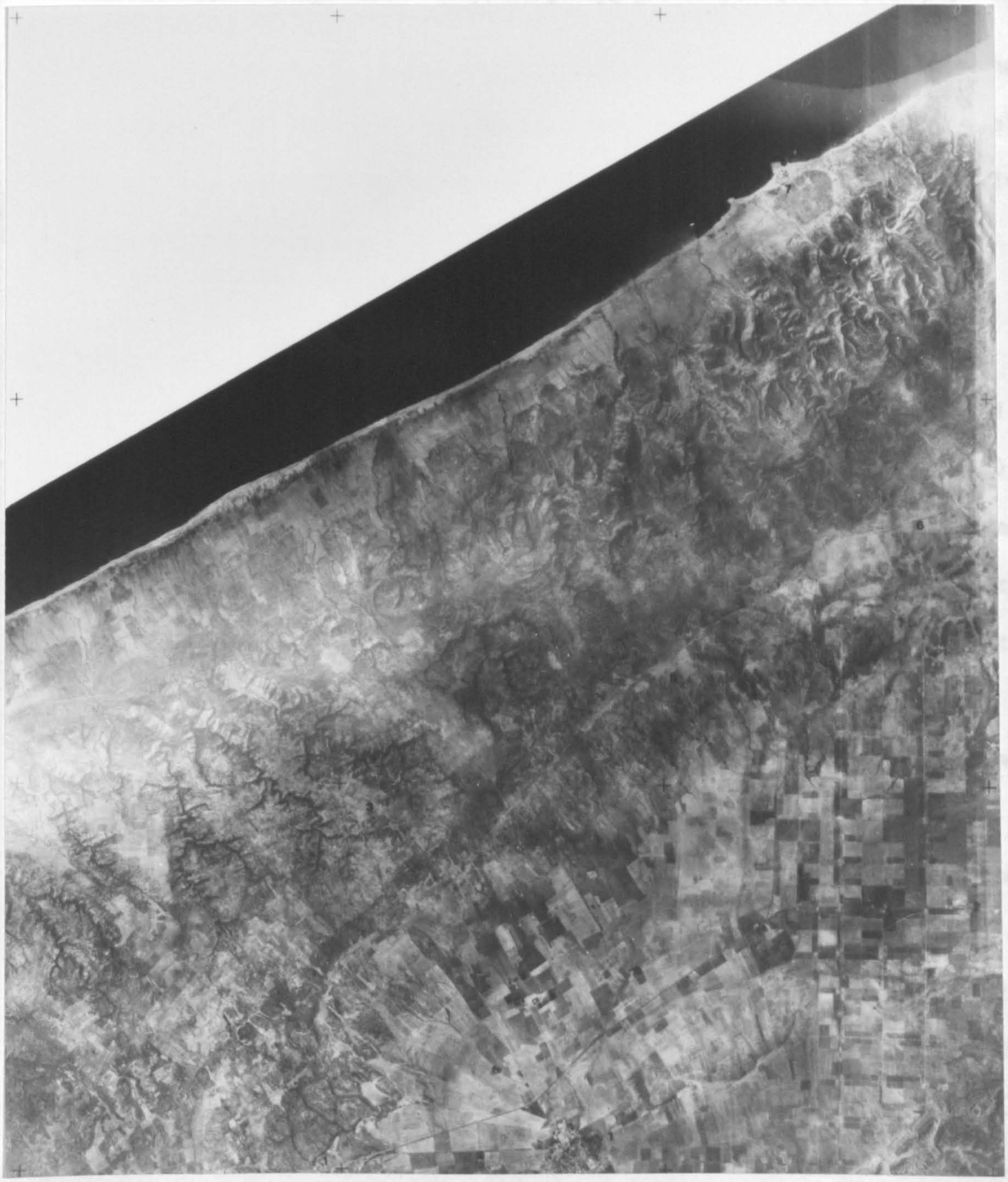
The land facet is the least satisfactory unit of those used in the sample area, as the El Marj plain land system consists of numbers of land facets which include El Marj east and El Marj Farzough west (see Plate 6.1).

The Martubah land system is sub-divided into several land facets, among them being the northern part of Wadi Dernah, El Fatayah plateau, Martubah, Emm ar Razam, Ghowt Al Massalliqun, Garyut Bu Liyyah, Sirt Ar Radam, Wadi El Mualaq and El Aziet units (see Plate 6.3). Likewise, land facets should therefore be considered in the hilly areas at least,

El Marj East

El Marj Farzougha

Plate 6.1 El Marj plain land facets



Source : Atlas Copco ABEM (1976) Semicontrolled photomosaic Jebel El Akhdar 1973-74 (Terratest AB)

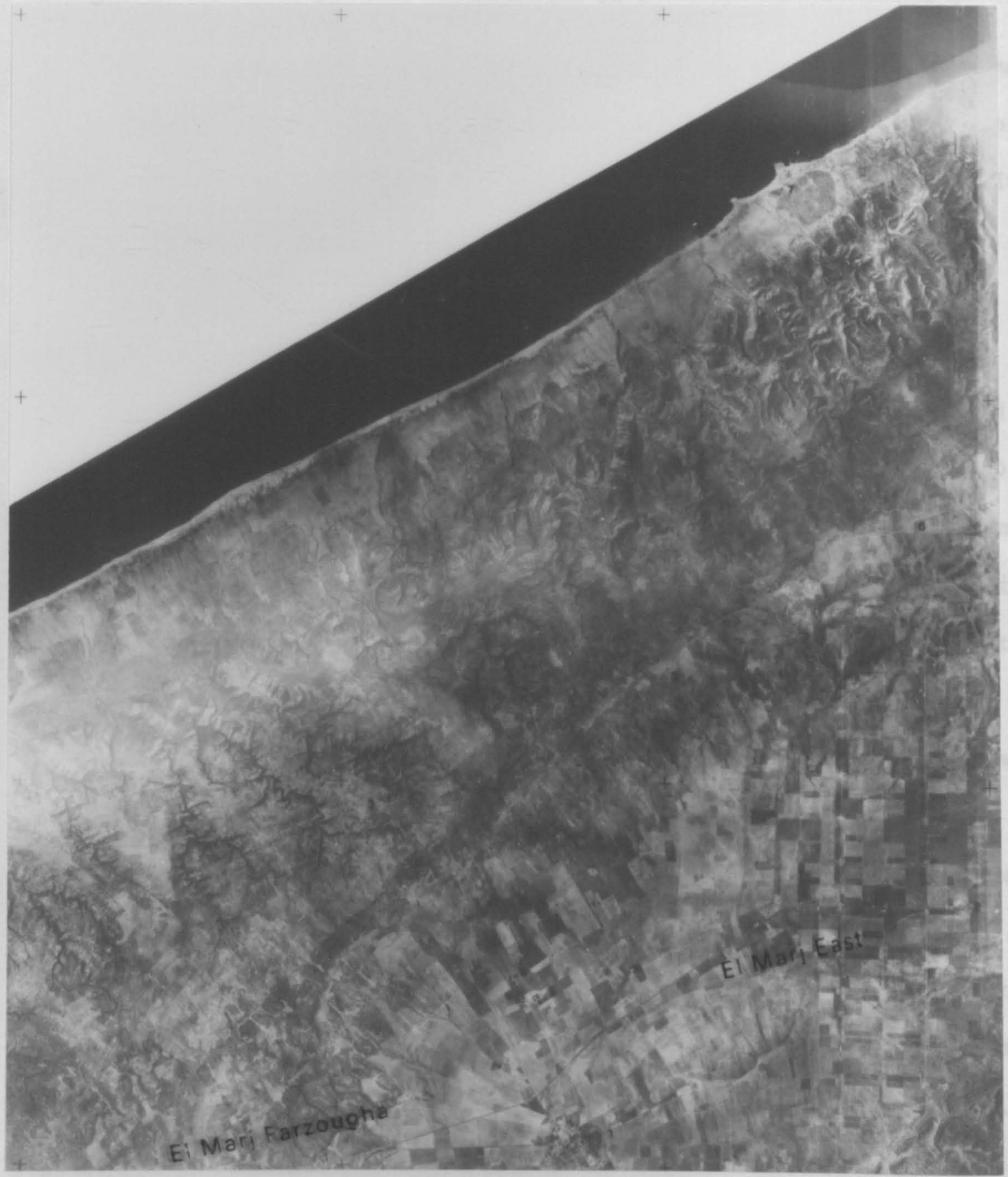


Plate 6.1 El Marj plain land facets

Source : Atlas Copco ABEM (1976) Semicontrolled photomosaic Jebel El Akhdar 1973-74 (Terratest AB)

as a first approximation of land system breakdown. This is particularly relevant in attempts to relate physical factors to facets where it is considered that sample area studies should be particularly helpful.

Finally, the land region for the southern flank of the Jebel has, as a distinctive feature, a general and different environment which could accommodate settled pastoral communities as this area receives less than 200mm rainfall.

EL MARJ PLAIN LAND SYSTEM

The El Marj plain land system extends over 36,000 ha. located on the first terrace land region and has an altitude varying from 270 to 340 m.a.s.l., with flat or gently undulating topography. The terraces with shallow and commonly infertile soils limit the range of crops that can be grown, as in the El Ussateh area (Central Jebel), where steep land is the major factor restricting agricultural development. In addition, erosion is constantly present, whether by gradual surface wash or by abrupt slope failures.

The El Marj plain is completely closed and has numerous large depressions and is drained through karstic features (see Figure 4.2). It is divided into two land facets from an agro-ecological point of view. El Marj east comprises 14,597 ha. of cultivated land (sample detailed study area). Likewise, El Marj Farzuagh has 14,952 ha. of cultivable land, located in the western part of El Marj plain and in the north western section of Farzougha area contiguous with this plain. Climatically and pedologically, this means that it is certainly the most favoured zone, and the environment is pre-eminently suited to agriculture, particularly under skilled management. The land is suitable for both arable and pastoral farming.

EL GUBBAH LAND SYSTEM

This area covers more than 30km on either side of the El Bayda to Dernah highway around the urban centre of El Gubbah. This area is slightly rolling and is divided into hills and domes with a large radius of curvature separated by very wide and shallow valleys.

The northern limit is the upper edge of the cliffs between the second and the first plateaus. Its physiographic units from El Gubbah land system which includes various land facets, among them being Ayn Marrah land facet (Plate 6.2). The El Gubbah land system has a large part of low average potential. This is located outside the main farming area which constitutes the most fertile part of this zone. To the south it declines in elevation from about 630 to 450 m.a.s.l. It is flat with low relief and is characterised by scanty rainfall and a vegetative cover with steppe-like features. Its economic utilisation is represented exclusively by transhumant stock raising.

The dominant ecological characteristics are the extreme rockiness of the environment and the irregularity of the relief. The pedological features are characterised by shallow soils and an unfavourable hydrological balance within them. This is due, in spite of the relatively high rainfall and atmospheric humidity, to the rapid run-off of the rain on the surface, given the steep slopes, and to the low-water holding capacity of the thin soils.

However, where these are flattened ridges between wide valleys an ecologically very significant environment appears, such as the Ayn Marrah land facet. So a strip of undulating terrace, of medium elevation (about 470 m.a.s.l.) with characteristic ecological juxtaposition of fairly thick brush wood on the ridges. The cultivated

Ayn Marrah

Plate 6. 2 Ayn Marrah land facets

Source : NASA, Aero exploration

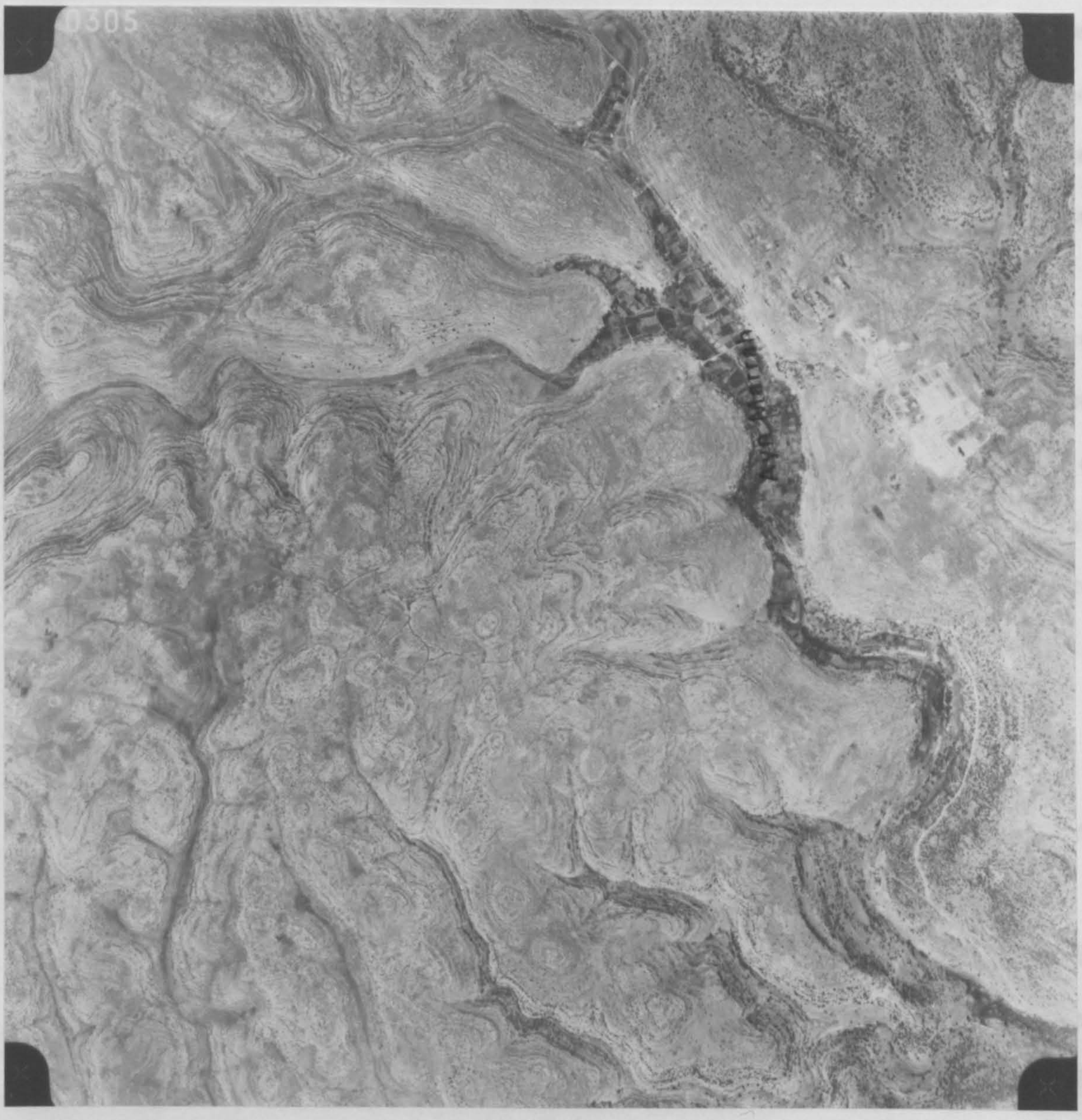


Plate 6. 2 Ayn Marrah land facets

Source : NASA, Aero exploration

lands occupy the valley and its terraces forming a pattern of traditional gardens extending about 43 ha (Plate 6.2 and Fig. 10.2), divided among 200 farm owners, with an average farm size of 0.22 ha.

Its current land utilisation is as an irrigated farming area used for vegetable crops and aboriculture, where the narrow valley (100-200m wide) lies between rocky limestone hills worn bare by erosion. The cultivated land consists of somewhat underdeveloped colluvial soil of a reddish colour and of a fine texture (siltly clay loam). It is alkaline and moderately patterned and permeable.

The exceptional quality of the soil indicates that intensive methods of farming are made possible and this is to all intents and purposes man-made, resulting from regular organic fertilising over a long period of years. In addition, the area is especially favourable, climatically and hydrologically for beans which are more successful here than in other areas.

MURTUBAH LAND SYSTEM

This area consists of different physiographic units at the eastern end of Jebel El Akhdar.

The eastern plateau is traversed by north-east flowing wadis of El Kalij and its tributaries. It shows outstanding landform features which greatly affect the soil mantle, particularly marked in the plateau of El Falayah area where small tributaries have laid down good loamy alluvia greatly prized by local tribesmen for the shifting cultivation of cereal. The wadi of El Mualag and its tributaries form the southern and north eastern parts of Martubah land system.

The second type of land is associated with the presence of calcrete

and is characterised by low rounded hillocks covered with thin stony soil. Calcrete landscapes are dominant in the western and north western parts of the area, particularly on the fringe of El Fatayah where the boundary of Wadi Dernah tributaries are located. In addition, the hummocks are of varying height up to 2m and parts of them are capped by scrub and Shibric (Poterium spinosm), Zahayra (Phomis moccosa) Sidre (Zizgphus lotus) etc. (see Johnson, 1973). The hummocks are most frequently along the north western of the area (see Plate 6.3).

The calcrete and hummock areas are of little value either to pastoralists or to cultivators due to their characteristically sparse vegetation and stony soils. At the same time wadis around hillocks of calcrete are separated by small and isolated patches of soils of moderate depth up to 50cms along wadi beds and in small basins where shifting cultivation of cereals is practised.

The main agricultural land is the El Fatayah land facet unit which is part of as flat plateau that overlooks Dernah town and is located at about 5kms from it. Before 1970, the area contained only one irrigated farm which was provided with water by a drilled well. Shifting cultivation was the main phenomenon of agricultural landuse in the remainder of the area. Nevertheless, the immediate importance of development in the El Fatayah land facet was essentially due to the introduction of settled farming. It is considered a pioneer model of farm settlement in an area that has been for a long time characterised by a high percentage of nomadic and semi nomadic inhabitants.

The utilisation of all possible ways of overcoming physical and human problems is needed for agricultural development in Libya in general and in the areas under consideration in particular, leading to

Wadi Dernah North

El Fatayah

Gariyat Bu Liyyah

Got El Massliquin

Martubah

Emmar Razam

Sirt Ar Radum

Wadi El Maulag

El Aziet

Plate 6. 3 Martubah land system

Source : Atlas Copco ABEM (1976) Semicontrolled photomosaic Jebel El Akhdar 1973-74 (Terratest AB)

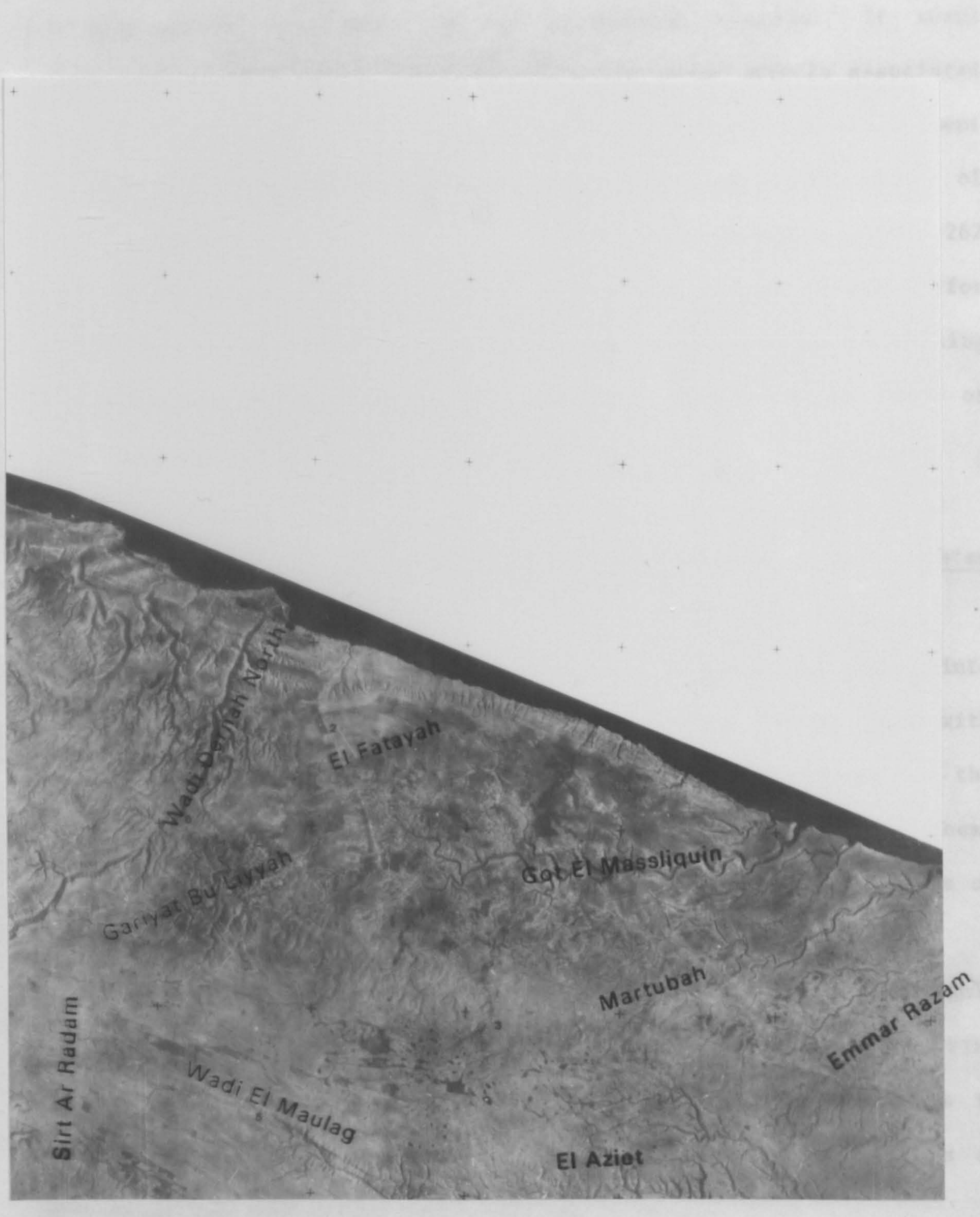


Plate 6. 3 Martubah land system

Source : Atlas Copco ABEM (1976) Semicontrolled photomosaic Jebel El Akhdar 1973-74 (Terratest AB)

the geographical importance of the El Fatayah plateau. It seems appropriate to focus most attention on the different aspects associated with the development of the main agricultural land and see replacement of shifting cultivation with semi-irrigated land. The area of agricultural activity is 1500 ha., 90% of which is divided into 262 farms of an average size of 5 ha. The area also has potential for agriculture to develop with multi-purpose projects aimed at controlling soil erosion and flood water, and irrigating hundreds of hectares of poorly exploited land.

The Determination of Agricultural Potential Through a Land System Approach

The agricultural potential of landscape is gradually coming into use for physical and geographical characteristics and relationships with activities of man over certain periods which are of importance for the development of plants, animals and men, to the extent that these attributes exert a significant influence on present and future uses of land by man (Beek, 1978; F.A.O., 1979).

Each of the areas included in this study displays a highly individual and widely varying landscape, because of its differing natural and topographical features, and also because of the uses to which the land and the resources have been put during the years or periods of habitation.

The purpose of this section is to deal with the landscape in the broadest sense to include that which is perceived, and land use activities which have both brought it about and will remain or change it in the future.

The region is favoured with many large blocks of land suitable for intensive agricultural development. Small areas occurring throughout the region are less fortunate in possessing sizeable areas with some ecological constraints to their development, such as the northern side-slopes of the first and second escarpment where steep land is the major factor limiting agricultural potential. In addition, soil erosion is constantly present, whether by gradual surface wash or by abrupt slope failure resulting in debris slides or landslides, particularly in incised valleys like Wadi El Kuf part of Wadi Dernah and the upper part of Wadi Nagha (Ayn Marrah, as a land facet unit). In some areas topographical features are not a limiting factor in agricultural potential. For example, shallow, commonly fertile soil may limit the range of crops that can be grown, as in the high plateau land region where a high proportion of farmers use their land for shifting cultivation of subsistence crops due to the physical limitation and the semi-nomadic the nature of the people. These elements restrict the activity to shifting cultivation, and development is concentrated mainly on grazing, cereals and tree crops.

Soils are key factors in all terrestrial ecosystems. It is therefore clear that any ecological land evaluation must pay a large amount of attention to the soils. In the Jebel El Akhdar region, in parts of El Marj and El Fatayah, areas occur where the soils show only minor variation between ferrosiallitic soils, calcareous brown soils and rendzinas form soils. Well developed thick colluvial and alluvial deposits predominate in El Marj basins and Ayn Marrah areas which, by sub-humid standards, are relatively fertile. Hence, there is a wide variety of nutritious food crops and also some crops such as cereals

that can be cultivated in the El Marj and El Fatayah area without irrigation, and with a fairly low risk of complete failure. Crop failure can also only be overcome by the use of fertiliser inputs and modern agricultural methods combined with a high standard of crop husbandry. In these areas, the different altitudes, the exposure with regard to insolation, and the influence of microclimate are much better differentiating characteristics and they can be shown indirectly in the agricultural potential of different land systems.

These and similar considerations have been found to be of particular importance in areas where, because of climate, the relevant crops are near their ecological limit of growth. Rainfall is the prime limiting factor in agricultural production, that is to say where potential evapotranspiration exceeds actual evapotranspiration, especially during hot months soil moisture supply is the critical factor controlling agricultural potential in the region, as indicated by the preceding discussion in Chapters III and IV.

An analysis of soil moisture regimes in the agriculture region is based on average rainfall and temperature conditions existing in different areas. The resulting information on the characteristics of soil moisture deficits was used as a guideline to evaluate crop potential in the various agricultural land systems. Soil moisture deficit, resulting from rainfall insufficient to meet the water requirement of the plants at all times, is the variation between actual and potential evapotranspiration according to Penman (see Chapter IV), wherever the following aspects have been obtained to delimit the agricultural potential of the area :

The Sub-humid area is represented by Shahat at 620 m.a.s.l., where

average amount and distribution of rainfall (total 565mm) are adequate to meet the winter crops such as cereals. In order to make the most efficient use of rainfall, deep rooting crops like grapes and orchards of apples, pears and almond are growing proving that these crops can be grown successfully where they are planted on deep soil at proper spacing.

In contrast, the average rainfall in the El Marj area (about 399mm) and less than Shahat, is sufficient to bring the soil profile up to field capacity to the end of February (see Figure 4.6 in Chapter IV). Marked ferrosiallitic soils of El Marj area hold less available moisture per unit depth of soil, which means that, in comparison with Shahat, less water is available in the root zone of wheat in the El Marj plain. Moreover, potential evapotranspiration rates are higher in El Marj due to a higher temperature than Shahat. The moisture supply becomes critical in El Marj plain but a rainfall of 350mm is still sufficient to satisfy the water requirement of winter crops provided it is properly distributed over the winter and spring months. On the other hand, the moisture supply is considered insufficient to produce grapes economically or any crops other than grains, unless it is exceptionally well distributed.

Based on the preceding discussion on climate conditions, the following conclusion can be drawn on the Fatayah land facet as a semi-arid area, where the more pronounced unfavourable rainfall condition is unsuitable for any other crops, not even wheat or barley, and severe losses in grain yields resulting from insufficient rainfall occur frequently. In addition, soil as a medium to store rain in the form of soil moisture should be taken into account as a basic factor determining

the agricultural value of the area, where it is shown by Figure 4.6 in the chapter on water resource. That indicates a soil moisture level capable only of supporting scrub and inferior pasture vegetation which are of low agricultural value. Thus the possibilities of agricultural development in these areas are dependent on the application of irrigated farms systems.

In the area of the El Gubbah land system, in the higher (400 m.a.s.l.) and colder region, with an average rainfall of about 350mm, it is possible to produce grapes, apples, pears and plums. Winter vegetables can also be grown unless the annual rainfall drops below average, although severe reduction of crop yields due to soil moisture deficiencies occur only infrequently in this area.

Although large irrigation schemes seem to be the normal type of development for the dry and semi-arid areas for years to come, it is equally clear that the major part of this area can never be irrigated, for hydrological reasons, because there has been a constant threat of water shortage in many areas as well as in western Libya (Allan, 1981). This must be balanced by information on unused agriculture land, which has in fact become a problem in this region. Some productive areas have been destroyed by the encroachment of salinity, water logging and silting up, i.e. El Gharigha as a direct result of heavy shower precipitation and intensive irrigation in some cases.

Thus, the introduction of a properly conducted irrigation farming system in areas previously barren or devoted only to dry farming can be extremely beneficial to such areas and can be of help in solving both human and economic problems with adjustment of environmental potential.

CONCLUSION

The method of analysis used in this chapter provides a framework for resource survey by delimiting the problems that may arise and providing a method of evaluating the constraints imposed by land on farming practices. With regard to land systems, the approach is helpful in giving particular consideration to the physical environment in terms of the resources it offers and the hazards involved. The main value to land use planners is that it assists in the selection and potential of a site for agricultural development by using imagery techniques, i.e. air~~hole~~photo or Satellite image. They provide a basis for an objective comparison in terms of the agricultural potential of a number of farming areas. Thus, the land system approach has been introduced as a classifactory technique. This system has highlighted the regional variation in the study area, and this approach could be repeated in other parts of the country and be a guide to the planner in the future.

On the other hand, the usefulness of using land facets as the smallest units of analysis could reveal the same environmental problems needing the same solutions in other parts of the country. For example, the Wadi Dernah development project is similar to the Wadi El Qattara development scheme in north east Libya and both have similarities with Wadi development schemes in north west Libya, i.e. Wadi El Megini and Wadi Kuam.

Certainly this technique of physical environmental analysis provides a base line for development planning. At the same time, natural resources surveys should not be regarded as isolated aspects of development planning, but the interaction of the physical environment aspects of rural life should be investigated in development planning, in order to assess the results of a change in one aspect.

CHAPTER SEVEN

HISTORICAL BACKGROUND ON AGRICULTURE IN THE REGION

CHRONOLOGY OF CHANGE:

During its long history Libya has been subjected to invasion after invasion. The prosperity of the country depended on the invader's outlook. Greek, Roman and early Arab periods were characterised by productivity and prosperity for Cyrenaica, due to the availability of virgin land and a largely self-sufficient nomadic Berber culture raised on a mixed economy combining herding and agriculture.

The main attraction for new settlers was the suitable physical environment particularly in the high land, where the Greek established the primary focus the new settlement at Cyrene (Shahat). From there settlements began to spread both east and west along the upper and lower terraces and much agricultural land was allocated to the sedentary population. The northern coastal districts represented no immediate threat to the nomad, therefore the commercial and agricultural prosperity of the region remained at a high level during this period before 330 B.C.

In the Roman period, the region was gradually incorporated into the Roman political system and this led to its subsequent reorganisation. During the Empire governmental authority was re-established and parallel trends throughout north Africa meant a huge expansion of agricultural settlement, with an increased agricultural population. The surviving ruins of farm houses and villages, and other constructions of sedentary agriculturalists show how expansion into the interior occurred during

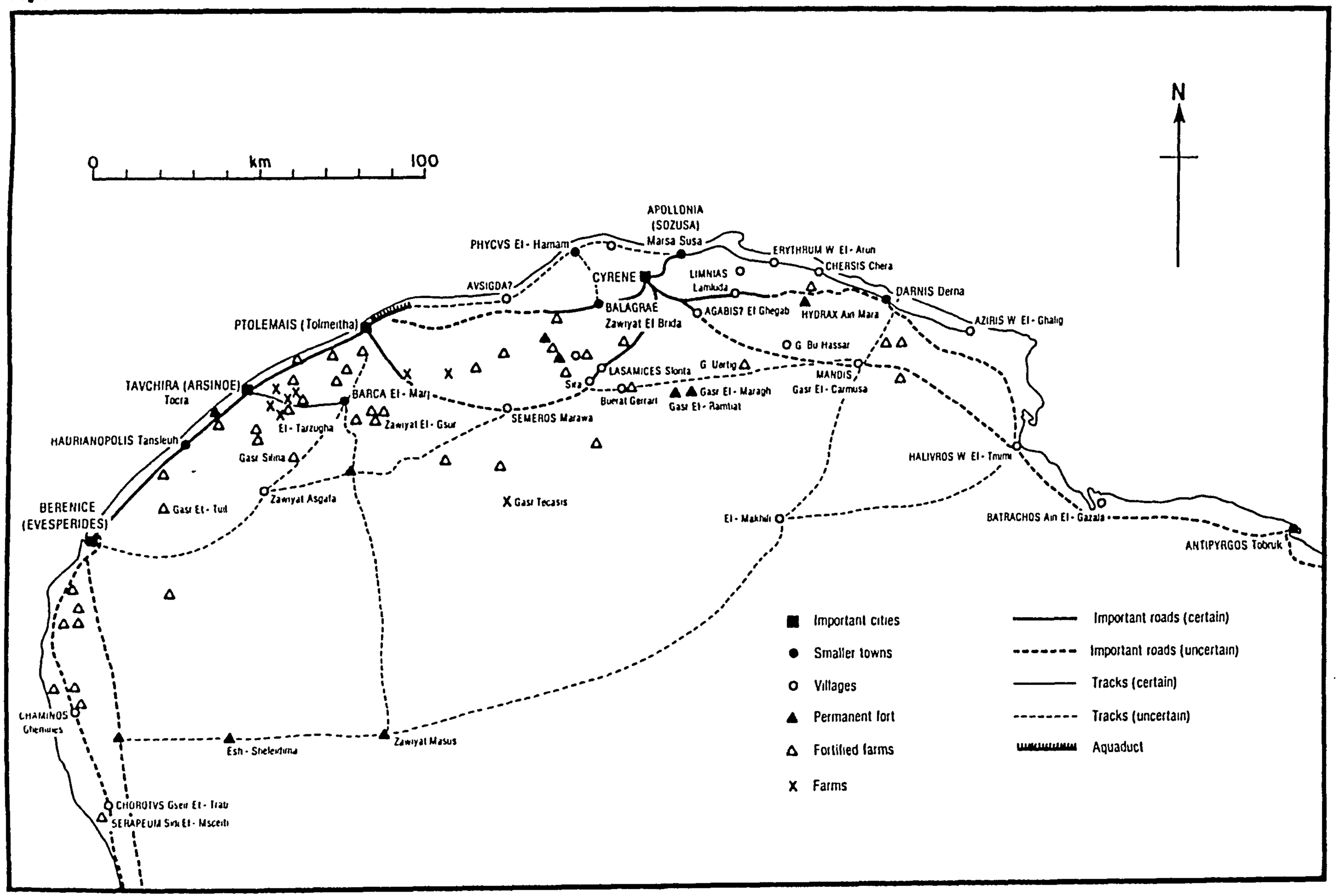
this period in order to reduce the military threat posed by nomadic tribes and to develop all potentially arable land.

Figure 7.1 shows the ancient Greek and Roman fortified farms on the Barca plain, and indicates intensive use of the agricultural resources. It is clear that most of the agricultural settlements at the beginning of the Imperial period were distributed on the coastal plain, the northern slopes of the Jebel and along the crest of the upper terrace in a pattern analagous to that of the fortified farms. As yet, sedentary agriculture had not spread down the southern slopes of the Jebel into the sub-humid and semi-arid land (Goodchild, 1952a).

From AD 390 onwards, the area of urban settlement (Pentapolis) was increasingly exposed to the incursions of the Austuriani, the tribes of the Gulf of Sirte from AD 395 to 413. They had a disruptive influence on the economic activity of the area, and the main settlements declined in size, vigour and population. They were exposed to destruction because the Jebel had become an area of small fortresses built to halt the nomadic invaders (Goodchild, 1952b). Another damaging factor, combined with human invasion, was a series of earthquakes occurring in AD 365, which furthered the destruction of the main settlements. As the power of the Romans declined, only the cities and forts remained, along with fortified houses interspersed with residential dwellings within the reduced urban area (Goodchild, 1968).

By the end of the Byzantine period, reconstruction and reclamation of farm houses had occurred and remains of churches throughout the upper terrace suggest that the quality of rural settled life continued to be prosperous at least until the Arab Conquest in AD 642, and cultivation of the land first farmed by the early Greek immigrants (Fig. 7.1) continued.

Fig.7·1 THE ROMAN CYRENAICA



Source : Goodchild. R. (1954)

The Arab Conquest:

In AD 642 the Arabs moved westward from Egypt to Cyrenaica where the Amir Ibn al-As was successful taking Barqa (El Marj) and settled there with his troops there as a base of operation. Within three years the Arab Conquest had been completed over the entire Jebel.

The importance of Cyrenaica in the beginning was its position on the main line of overland communication between Egypt and the Maghreb, through the steppe and desert regions avoiding the higher portion of Jebel El Akhdar and continuing to Tobruk, El Makhili Masus and Ajedabia, an important place with forts, markets, wells and cisterns. From there it led to Tarablus (Tripoli) and El Maghreb, which was secure from Byzantine naval raids. Other routes led east-west through the Jebel via Barqa El Marj with its position at the terminus of the postal route from Egypt. It is situated in the midst of a fertile plateau surrounded by mountains and protected from naval interference by its location. Barqa rapidly became the garrison centre for Islamic political and military control in Cyrenaica and most regional products were consumed locally or sold cheaply to travellers. A small trade was established through coastal settlements such as Tulmaith.

However, agricultural activities continued to play an important part even for the nomadic community and settled farming survived side by side with pastoral life for several centuries after the Arab invasion.

Migration of Bani Hilal and Bani Sulaym : Hilalian Invasion:

The most common view of historians is to blame the Hilalian invasion of AD 1050-52 for the disaster which ended sedentary life in Cyrenaica, and eventually demolished it. However, the process of decay

was drawn out over a century or more (Ibn Khaldon, 1958).

The nomadic tribes were able to expand their influence and territorial extent in Cyrenaica in the century following the Hilalian invasion. In El Bakri's day El-Edrisi recorded that tribally organised Arabs herding sheep and goats were present in the coastal plain near Tolmayth in the twelth century, and the high land of Jebel was a potential grazing region, a large portion of which was used successfully by Greek, Roman and Byzantine settlers. The nomadism was contagious and forced the sedentary population to practice the mixed agricultural-animal economy of the local Bedouin, making them relatively dependent on sedentary and urban products and converting the farmers into mere nomads (Goodchild, 1952a). Thereafter, the Arab-Berber sedentary population, both the rural farmers and the vast majority of the urban dwellers found themselves gradually being incorporated into the nomadic population, divided into units derived mainly from the tribal pattern of the Hilalian invaders.

By the time Leo Africanus settled in the region in the sixteenth century, the dominance of the nomadic lifestyle was complete in El Jebel El Akhdar and the region had returned to the same pattern of land use in vogue when the first group of Greek colonists came to Cyrene in 631 BC (Johnson, 1973).

The Turkish Period:

Following the Hilalian invasion local Muslim dynasties exercised varying degrees of control over Tripoli and Cyrenaica and Libya passed into the control of the Ottoman Empire (Turks) from the sixteenth to the nineteenth centuries.

The Bedouin were little affected by the Turkish authority, compared with the great influence the Turks had on the environs of the coastal towns such as Benghazi and Dernah whose populations were compelled to pay taxes from time to time. But the Turkish rule was interrupted when the Qaramanli family usurped the authority of Tripoli in 1811, and eventually exercised their control over Cyrenaica in the last decade of the nineteenth century. Between 1835 and 1858 the Turks regained control of Libya from the Qaramanlies by the construction of forts at El Marj (Barqa) and at Qaygab, which were designed to increase control over the Bedouin inhabitants of the interior and obtain taxes from them.

The Ottoman period was lacking in economic activity and social development except in the main settlements on the coast, and some military bases in the highlands such as El Marj (Dellan, 1975). Some efforts were made to develop agriculture as a means of implementing the Ottoman land codes and increasing the ability of the country to pay high taxes, because this was the main aim of Turkish authority. Therefore the land use and traditional agricultural way of life was left intact, but later, during the period of Italian colonisation, the emphasis was to exploit the productivity of the land by the settlement of Italian families, leaving Libyan tribes to look after themselves.

The Italian Period 1911-1938:

The Italians sought in Libya a "fourth shore" (Moore, 1940), and made the country a colony. In 1911 the Italians landed in Libya, the Turks withdrew inland and the Italians had completely conquered the country by 1930. Their main aim was to establish a strategic fort in north Africa and to develop economic activities in a promised land (Wright, 1982).

The impact of Italian colonisation on the use of land for agriculture began with a small scale experimental programme on state land grants, but gradually increased in intensity over the period. Italians controlled the agricultural zone in Tripolitania by 1923, and the Jebel El Akhdar in Cyrenaica by the end of the decade. In April 1913 the Italians occupied El Marj while the rest of the Jebel and the interior remained in the hands of the Libyans. The resistance ceased in 1932 with the death of Omar El Mukhtar, leader of the resistance.

The first phase of the Italian colonisation was the acquisition of land. In 1913 the Ufficio Fondiario (Land Registry Office) had been founded in Benghazi and in 1922 branches were set up in El Marj and Cyrene (Shahat). The office engaged itself in the acquisition of suitable lands for Italian colonisation (Table 7.1) (Quereshi, 1953). The following table shows the activity of the Ufficio Fondiario up to 1931.

Table 7.1: Land acquired by Ufficio Fondiario up to 1931 for Colonisation Purpose (in hectares):

Year	Land bought for colonisation	Land domanial by nature	Lands confiscated from rebels	Lands confiscated from Zawiyas
1922 - 1926	4,070	2,915	500	
1927 - 1929	39,371	4,762	5,300	
1929 - 1931	-	1,167	200	62,225
Total	43,441	8,844	6,000	62,225
Grand Total	120,511			

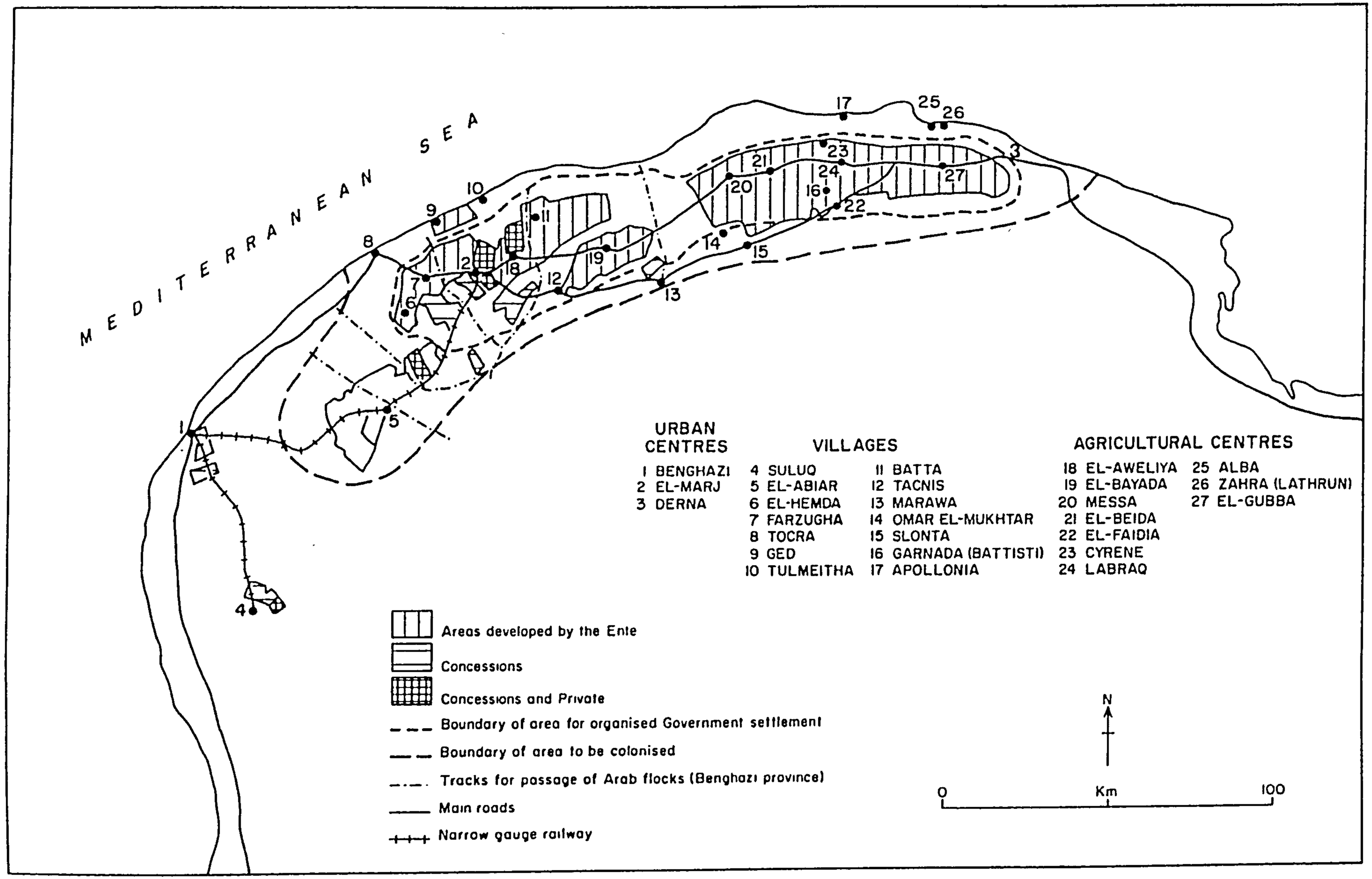
Source: Quereshi, A.I. (1953), System of Land Rights and Land Taxation in Cyrenaica U.N. in Libya, Tripoli, 41

The colonisation activities in the Jebel included the area between Farzough and El Abyar in the west, and Ayn Marrah (24 kms south west of Dernah) in the east. In addition to the coastal plain, a small area south of Benghazi and north of Soluq and a small plot west of the Dernah coast at Lathrun and Ras El Hilal were developed (Fig. 7.2). Early colonisation was by private enterprise and the final system of settlement was directed by events in the political and military history of the Italian Empire.

The disadvantage of a settlement scheme based on permanent state responsiblity was the difficulty of applying the system of agricultural classification used in Italy to Libya. Land management was classified in three forms: family managed and owned, particularly in irrigated areas; wage labour, paid either in money or with the product of the land; and share cropping on dry farming land, (Lombardi, 1982). However, the early settlement of Italian peasant families in Libya as a whole and the Jebel in particular, took place on contracts which varied in accordance with local circumstances. Nevertheless they contained regulations regarding the financial aid to be given by the Italian government because it was felt that the settlement of large numbers of peasant agricultural families on the cultivable land was the best way to establish an Italian presence in Libya in order to achieve the economic social and political goals of African colonisation (Fowler, 1982).

The Italian development plan for certain projects made life possible for Italian settlers, and was achieved during the first phase of the Italian occupation, 1913-1935. Expenditure was concentrated on schemes created to enhance the environment, so the country could attract colonists to settle in Libya. Therefore, roads, ports and public

Fig. 7·2 LAND SCHEDULED FOR AGRICULTURAL DEVELOPMENT BY THE ITALIAN ADMINISTRATION, STATE AGENCIES, COMPANIES AND PRIVATE IN EASTERN LIBYA



Source · Buru, M. (1964)

buildings had a high priority, in order to establish the infrastructure needed to bring the country into the 20th century (Fowler, 1982; Ghanem, 1982).

After Italy had extended its control over all of Libya, the second phase started with a huge concentration on agricultural development and land reclamation in order to obtain revenue from land, which was in fact the main target of the State (Segre, 1982). The Italian government had established agricultural development companies in the Italian colonies of Libya, primarily Tripolitania, by 1911. In 1932, it also set up the Cyrenaica Development Corporation, ENTE per la Colonizzatione della Cyrenaica (E.C.C.) and when its activities were extended to Tripolitania, it became ENTE per la Colonizzazione della Libia (E.C.L.)

The development of land in Cyrenaica was based on an assessment of its productivity by ENTE, which allocated land to Italian families. So each family received a plot of land which was regarded as sufficient to support it at a reasonable standard of living on the basis of a planned cropping pattern, a furnished house, and other equipment to develop the farm. Other requisites were supplied on credit.

ENTE had established major agricultural centres, Beda littoria (El Bayda), and Luigi di Doria (Labrag) in 1933, Luigi Rassa (Messah) and Giovanni Berta (El Gubbah) in 1934, and Maddalena (El Aweliya) in 1936. Up to 1937 colonisation was not as rapid as the Fascist regime had expected and so large scale immigration was encouraged. In 1938 about 20,000 colonists came to Libya and when this second wave of immigration arrived in Cyrenaica, the colonists settled on farms in El Marj and adjacent areas (Farzugha), Oberdan (Batta), D'Annuzio (El Bayada) and Batlisti. In 1939 the same number of colonists arrived, and most of

them occupied farms at Filzi (El Hemada), Sauro (El Gihad, 7 October) and Mameli (Ummer El Muktar), (Fig. 7.2) (Weir, 1943). The total number of settlers in Jebel El Akhdar was about 2,206 families made up of 15,014 colonists, occupying about 2,077 farmhouses (Weir, 1943; Fowler, 1982).

Table 7.2 indicates the number of colonists, families and farmhouses up to 1940 in the ENTE settlements, private land concessions and at the Instituti di Credito per il Labora all Estero (I.C.L.E.).

Table 7.2: Italian Agricultural Settlement in Jebel El Akhdar, 1940:

Type of Colonisation	Number of Farms	Colonist Population Families	Colonists
State Land Grants and private property	264	466	1,524
Colonisation companies (ENTE + I.C.L.E.)	1,813 (1,759 + 54)	1,740 (1,686 + 54)	13,490 (13,220 + 270)
Total for Cyrenaica	2,077	2,206	15,014
Total Libya	5,752	5,961	38,535

Source: Fowler (1982, The role of Private Estates and Development Companies in the Italian Agricultural Colonisation of Libya, Social and economic Development of Libya (eds) Joffe, E.G.H. and McLachlan K.S., Wisbech, Table 7.2 : 132.

The Italian development of agriculture in the region led to the development of some activities and industries based on agricultural products. These included wine making in El Bayda, and a number of food processing plants, mainly for macaroni and flour. Also a number of textile factories began producing local garments made from wool obtained from flocks in the region (Ghanem, 1982).

The colonisation company farms of 25, 30 and 50 hectares had a

cropping pattern based on the production of wheat and fodder in rotation with fallow land. There was also unused land totalling about one-third of total farm area, which was for the development of olive and almond groves (Allan, et al, 1973).

The size of ENTE farms varied from one place to another, depending on the different land potential of dry and humid areas. Some farms in the El Marj plain extended over an area of 25 ha, others were 37.5 or even 75 ha. the latter representing private agriculture concessions, especially to the west of the Bayda littoral and between the El Marj plain and Tacnis (Borgo Torelli) tract and its extension to the east of Jebel to follow the crest of the region. Even so in the El Marj plain and adjacent areas, the size of farms varied considerably from 16 to 40 ha and similar variance could be found in other settlements (Allan, et al, 1973). The smallest farms were found in Fiorita (El Atrun) and Alba (Ras Hilal) in the northern coastal plain west of Dernah where 32 farmhouses were built and provided with irrigation water drawn from springs in Wadi El Atrun and Wadi El Saqui respectively. Crop production was a combination of dry farming of cereals and irrigated production of vegetables and fruit. Farm size was less than 3 ha for each farm occupied by Arab families. The Italians demonstrated efforts towards local tribes as compensation for confiscating their lands (Evan Pritchard, 1973). This was achieved by encouragement to small farms of subsistence agriculture for local people.

During the era of Italian settlement in Cyrenaica, in the limited time available to the colonisation companies from the end of Bedouin guerrilla resistance to the beginning of the Second World War, some

718,764,315 lira were expended in both private and public agricultural projects. The public projects were significantly more expensive than their private counterparts, because of the many obstacles facing the early settlements, such as a shortage of finance on the part of the Italian government, which was eventually replaced by private companies (Fowler, 1982; Segre, 1982). In addition to the struggle with the indigenous population for their land, a feasiblity study was impossible in such a short period. Because of these obstacles, Italian colonisation had achieved little progress in the agricultural development of Cyrenaica which were for their own economic and strategic interests as indicated in Table 7.3.

By the end of 1940, 2077 farmhouses were constructed and 2,206 farm families settled on a total 143,580 hectares ceded to the ENTE from the public domain, of which 79,832 ha were cultivated, of which 10,000 ha were planted with 3,955,881 trees. About 75% of the colonised land was allocated for growing crops and the remaining proportion for plantation of trees, mainly olives and almonds.

The share of the El Marj plain in the development was about 13,000 ha. and 3,000 ha were at Sidi Mahuis at El Abyar. In addition half of the area which was developed by ENTE in the whole of Jebel was concentrated in El Marj, Bayda and Tacnis, where about 670 houses were built in the El Marj and adjacent area, 339 in Batta, 76 in El Bayadyah, 50 in Tolmeitha and 10 at Tacnis (Table 7.4, and Fig. 7.3).

With regard to the settlement programmes up to 1940, the emphasis was on inter cropping with grain. Other dry crops were planned at El Qubbah, Farzougha and Batta. Meanwhile at Ummer El Muktar only winter crops could be cultivated, but summer crops could be grown in certain

Table 7.3: Italian Agricultural Colonisation in Cyrenaica up to 1940:

Type of Colonisation	Land holdings		Land use			hectares
	Number	Total area ha	Total developed	Tree crops	Irrigated crops	Other
State land grants and private property	232	35,056.45	15,960	4,469.46		11,490.54
Private property colonisation companies	17	108,524.50	63,872	5,459.49		58,412.48
Total Cyrenaica	249	143,580.61	79,832	9,928.95		69,903.02
Total Libya	883	347,670.61	227,977.39	104,187.15	10,000	113,790.24

Source: Fowler, (1982), 'The role of Private Estates and Development Companies in the Italian Agricultural Colonisation of Libya, in Social and Economic Development of Libya (eds) Joffe E.G.H. & McLachlan K.S. Wisbech, Table 7.1, p.131.

areas based on irrigation from springs and wells such as at El Gubbah and El Garigha in El Marj plain in the first terrace of Jebel El Akhdar. In addition to the irrigation development of small plots on the coast such as at Ras El Hilal and Latrun, at the same time most of the spring areas, like Dernah, Ayn Marrah, Dabussia and Messah, were being used to feed small local water supply schemes, especially for human consumption, and livestock watering troughs, in much the same way during the Greco-Roman period. But in the western portion of the Jebel, as in the El Marj plan and adjacent areas, the main sources of water supply for ENTE farm settlements were the house cisterns (Majin), which were installed in each house to collect rain water. About 50% of the settlers had one or more Greco-Roman cisterns.

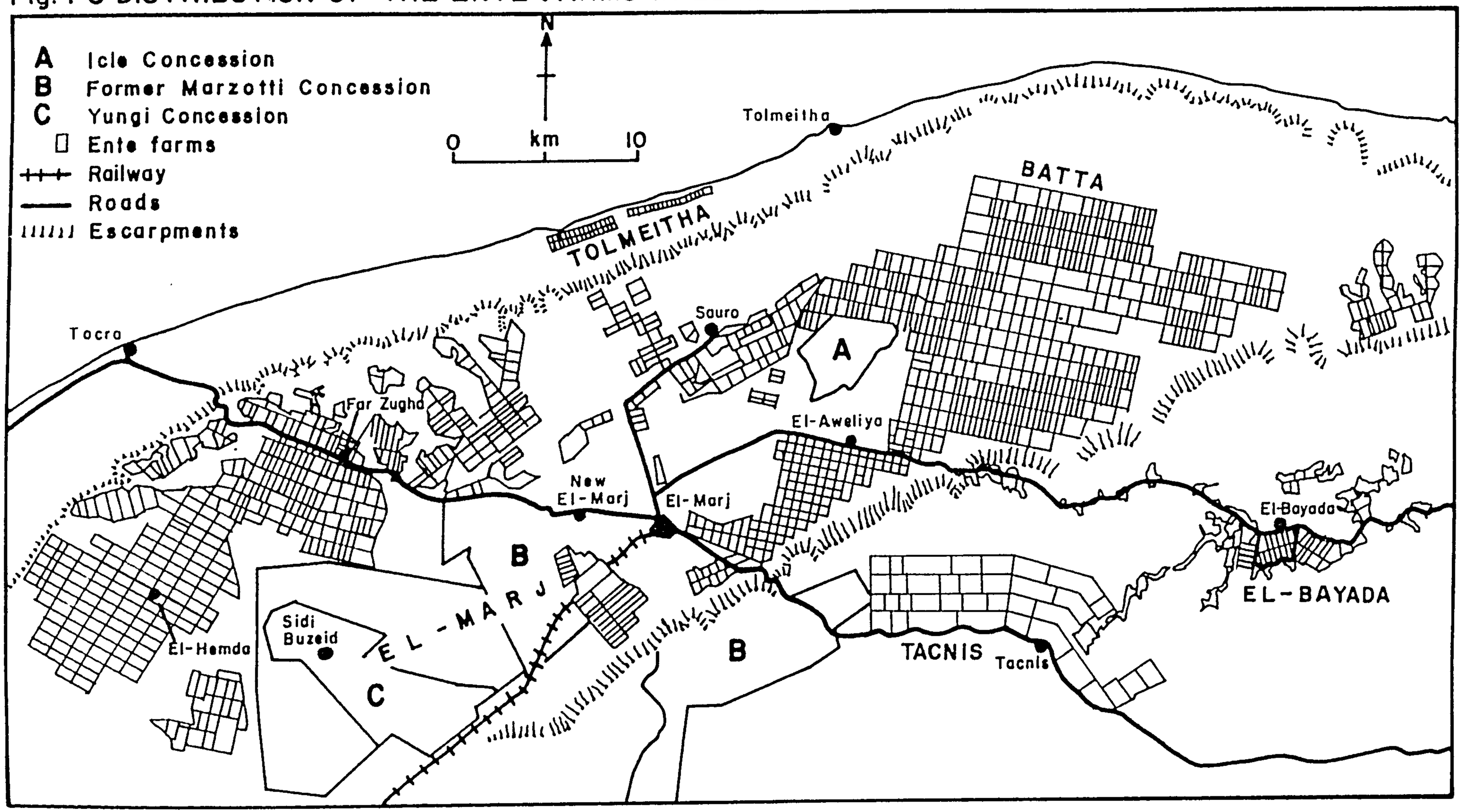
Table 7.4: ENTE Farms in Jebel El Akhdar Region 1958

Area	No. of ENTE farms	Total	Arable land average per farm
El Merj	624	10,433	16.7
Tolmeitha	387	5,534	14.3
Bayadyah	76	1,439	18.9
Tacnis	10	300	30.0
Messah	112	2,128	19.0
Bayda	161	3,519	21.9
Shahat	32	704	22.0
Omer El Maktar	70	1,266	18.1
Labraq	92	470	5.1
Gubbah	44	418	9.5
Ras El Hilal	32	117	3.7
Total	1,772	28,449	16.1

Source: I.B.R.D. (1960) The Economic Development Plan, Libya. John Hopkins Press, Baltimore.

A brief review of historical change in the north eastern region of Libya shows how influential the period of Italian rule was in changing

Fig. 7·3 DISTRIBUTION OF THE ENTE FARMS IN EL-MARJ PLAIN AND THE ADJACENT AREAS



Source: Buru M. (1964)

the agricultural landscape, from shifting cultivation to permanent cultivation of new land. The main features of agriculture, before the Turkish and Italian period, were predominantly grazing, with small orchards at oases and shifting cultivation of cereals. Settled farming started towards the end of the Turkish administration, which encouraged the new Italian occupation to develop agricultural production in the region. Therefore, the Italians laid out a general outline of land use patterns for the whole region, where ENTE state farms in Jebel followed a more or less standard pattern in which 25 ha dry farming plots were given over to vines (2 ha), almonds (4 ha), olives (5 ha) other fruit (0.25 ha), cereals (19.7 ha) and non-agricultural land (1 ha). (Allan et al, 1973). So, the general features of agricultural land use in the region during the Italian period can be summarised as follows:

(1) In the irrigated gardens, trees and vegetables were grown on a small scale by selected Arab farmers, generally in oases distributed along the coast such as Dernah, El Atrun and Ras El Hilal where the accessibility to water was easy. However, the situation of the Libyan did not improve as they had to rely on their own primitive farming methods coupled with a fear of confiscation.

(2) In the enclosed unirrigated domains particular kinds of trees were grown such as olives, together with cereals. This type of farm was found particularly in the El Marj plain and the crest of Jebel, at Sulunta and Tacnis, as well as in the eastern part of the second terrace at El-Qubbah (hill farms), and the bottom of the basins where winter floods aided culture in certain areas.

(3) The marginal land and the more rugged part of the upper terrace was not adaptable to Italian methods. The ENTE had planned for pastoral

activities in specific areas in the eastern portion of the Jebel at Tert, and a few agricultural plots were developed north of Jardis El Ahrar, and in the south of El Marj plain, but the scheme failed. (Johnson, 1973).

The aforementioned summarises the general activities of Italian agricultural colonisation in Jebel El Akhdar particularly, and in Cyrenaica generally, when it ended at the outbreak of the Second World War in 1940 which first of all postponed any further steps and finally led to the evacuation of all Italian colonists. At the beginning of the British rule, the Italian settlement schemes in Jebel were allocated to Libyan tribal people who claimed the land in the region. The tribesmen who occupied the former Italian farms had no knowledge of settled agriculture and most of them neglected the houses. Also the agricultural practices of the new settlers did not differ from their traditional methods of agriculture and most of the three million trees which had been planted were destroyed because of a psychological need to abolish colonial rule under which the tribal people had suffered the loss of their land and thousands of lives. There was an obvious conflict between the Bedouin use of land and settled agriculture and there was also the problem of land tenure, where tribal land had been confiscated by colonists from the tribes.

British Military Administration (BMA) 1943:

During the BMA period agriculture continued to form the backbone of the economy in Libya as a whole, and in Cyrenaica particularly. By 1943 the British Military Administration had begun to reinvigorate indigenous agriculture through the institution of a hill farming scheme at

El-Qubbah, where 65 farms were maintained under extensive crop management on the former Italian model. In addition there was a large scale mechanisation programme to increase cereal production in the El Marj plain which was considered part of the Middle East Supply Centre programme to provide food to the military forces in the Middle East. Further land was under contract cultivation by Arab farmers, but the performance of these schemes was inconsistent and failed to realise the targets of the BMA (Allan, 1981). However, with the encouragement given, land use regained the level prevailing before the Italian war, with a rapid build up of herds (Allan et al, 1973).

During this period the fluctuation of grain production changed the country from being a grain exporter in some years to being a grain importer at other times, which may have encouraged an expansion of pastoral activities during this period.

There were estimated to be about 3.5 million grape vines in Cyrenaica, with most of them used for wine production at the El Bayda factory. Furthermore, olive oil became an important agricultural product during the BMA and other trees which had been planted during the Italian occupation became productive during this period, but with less efficiency than usual because they were exposed to deterioration during the transformation period.

Therefore, the BMA had several obstacles to overcome during this period, and they did not give enough attention to the severe agricultural environment. Added to that the BMA had a large establishment in the Middle East region where they had a favourable environment for agricultural production. Further, the location of the country in the middle of North Africa made it an area of competition

between the USA, Italy, France and the UK, each of which extended its sovereignty over a part of the country.

Agriculture Since Independence, 1951:

In December, 1951, the new independent United Kingdom of Libya was established on a federal system, but in 1962 the whole country was unified into the Kingdom of Libya.

After the Italian evacuation, the Bedouin of Jebel El Akhdar returned to their land and occupied the former ENTE farms and houses. The property status of the ENTE farms was transferred to the Libyan government, and although the private concessions remained the property of their Italian proprietors, the Italians sold their farms as hope faded for any Italian resettlement.

The main aims of the strategic agricultural planning of the government in the 1951-1961 period, were to offer long term loans to Libyan nationals to purchase land from Italian settlers. This policy started with a credit scheme of lending up to 50% of the estimated sale price of the farm, but a year later it was modified to lend up to 100% of the value of a small farm (the value of which did not exceed one thousand pounds). This resulted in unreal land values and a decrease in production because the new owners were city dwellers seeking rural retreats rather than productive farms, which caused a deterioration in the position of agriculture in the Libyan economy (McLachlan, 1982).

The main crops produced were barley and wheat which depended on variable rainfall and this had a marked effect on the area cultivated and yield obtained from dry farming grain in Cyrenaica as shown in Table 7.5.

Table 7.5: Estimates of Barley and Wheat Production - Eastern Libya (metric ton and hectares)

Year	Barley		Wheat	
	Output (mt.)	Area (ha)	Output (mt.)	Area (ha)
1945	7,897	147,378	4,979	85,518
1955	18,200	112,840	10,700	-
1960	31,517	197,496	12,701	88,948
1965	34,164	105,660	43,718	129,419

Source: Allan, et al, (1973) Libyan Agricultural and Economic Development, London.

It is clear that wheat production increased dramatically compared to barley through the 1950s, and both area and output were greater than for barley due to the improvement of seeds and changing consumer demand both in rural and urban areas, which encouraged the change in cropping pattern in the area.

As mentioned before agriculture in eastern Libya declined somewhat after independence, and the standard of cultivation fell as a result of the dominance of common or tribal land occupied by nomadic and semi-nomadic people. Meanwhile sedentary agriculture was practised only on a very small scale by traditional methods, and most land was used for the grazing of animals, with associated shifting cultivation. Only the private farms developed by the Italians retained significant areas under modern farming systems. The Libyan farmers in western Libya were quick in adapting to the use of new farms which were more productive than in other areas due to the lower percentage of nomads and semi-nomads in western Libya in that period.

The second target of the government towards the agricultural sector in the same period was the encouragement of foreign aid agencies to fund and supervise development schemes. These were handled by a number of agencies for overseas aid, such as the Libyan Public Development and Stabilization Agency (LPDSA) which was set up in 1952, a mainly British

organisation; and a number of American agencies, such as the Libyan American Technical Assistance Service (LATAS), the Libyan American Joint Service (LAJS) and the Libyan American reconstruction Commission (LARC). They were created in 1955 to work on the completion of programmes of public utilisation and agricultural and natural resources development. Further, the USA and U.N. commissions have both supplied technical assistance to Libya on a wide scale through F.A.O., ILO, WHO and UNESCO (IBRD, 1960).

The activities of LPDSA have been allocated in Cyrenaica in different sectors, among them the development of the Zorda experimental farm in El Marj, providing Cyrenaica with barley. In addition this agency was responsible for flood damage in Cyrenaica in 1955/56. During the period of the foreign aid missions, there were few achievements in the agricultural sector, but at least no damage was done to the Libyan farmer. A real and significant change did occur, particularly in the economic conditions at that time (McLachlan, 1982). During this period all attempts to re-vitalise the stagnant production and to reinstate settled agriculture in Cyrenaica failed because of the common tribal land tenure system in spite of considerable support from international agencies.

Agriculture and the Impact of Oil 1962-1969:

After independence and the end of a long period of foreign domination the first exports of oil reduced reliance on financial aid. The year of 1961 thus signified an abrupt transformation and it was certain that controversies would arise over the allocation or apportionment of oil revenues. One real change was that there was

superimposition of an oil economy upon the traditional rural economy (El Mallakh, 1969). In addition, there was a widening gap between the rapidly growing modern urban settlements and the stagnation or slow evolution in rural economies, but in 1960 agriculture was the source of income for two thirds or more of the total population of Libya (IBRD, 1960; El Fathaly and Palmer, 1980).

The general character of agriculture in the Jebel El Akhdar during this period was the dominance of dry farming with a combination of flock raising, which was more or less influenced by the environment. Consequently, the average yield per hectare was low, at about 200 kg of grain. Furthermore, tribal tenure was also extremely widespread in the region, which was a great obstacle in developing and locating dry farming in this region. Under this system grazing areas were held in common and although a farmer might cultivate a specific plot for his private use, he might not mortgage it for credit.

The impact of tribal ownership had been severe in the Jebel El Akhdar with the result that the highland with agricultural potential for crop cultivation was instead for overgrazed. Thus the forage became depleted, little was invested in improving production, and afforestation and soil conservation were neglected, causing soil erosion and loss of fertility so that land had to be abandoned.

In addition to the problems of the physical environment, the agriculture sector was affected by labour supply constraints due to the inadequate knowledge of settled agriculture of most of the people who were semi-nomadic or nomadic. Also, the wage rate in agriculture was lower than in other sectors (Table 7.6) which pushed people to move to urban and industrial areas. In addition, the supply of farm labour was

reduced through farmers and members of their families preferring to engage in other forms of employment which created a group of part time farmers (Mabro, 1973). Moreover, crop sharing was also prevalent with the owner's share often being considerably greater than that of the tenant.

Consequently, annual income per capita of the agricultural population remained at a low figure of just over 25 Libyan pounds income

Table 7.6: Time Series of the Median of Agricultural Wages Paid; From the Accounts of a Farm Close to Tripoli: (180 ha. - approximately 40 permanent employees)

Year	Wage £ Libyan	Index
1953	0.135	100
54	0.140	103
55	0.140	107
56	0.145	111
57	0.150	126
58	0.170	133
59	0.180	185
60	0.250	222
61	0.300	222
62	0.300	222
63	0.300	296
64	0.400	370
65	0.800	444
66	0.600	481
67	0.650	572
68	0.800	

Source: Mabro, R.E. (1973) 'Employment and Wages Rates; in Libya Agriculture and Economic Development (eds) Allan, J.A. etal, London, 164.

per hectare of cultivated land, but income per hectare of agricultural land was less than 6 Libyan pounds (Farley, 1971), with the result that agricultural output was not attracting a large enough labour force from Libyan workers, who were replaced by alien farm labour particularly from Egypt, where they could be hired at lower wages. As mentioned before,

this is regarded as a negative impact of the non-agriculture sector which drew manpower away and caused production costs to rise, particularly after oil production started in 1961. By 1962 this had already accounted for an estimated 26 percent of the GDP which was about LD 169.2 million at current prices, displacing agriculture as the primary contributor which, prior to 1961 had contributed 25 to 30 percent of the GDP, and in 1962 was reduced to some 9.8 percent of the total and declined to 2.4 percent of the total GDP in 1968 (see Appendix 9) (Allan, 1981; Ministry of Planning, 1984), as will be discussed in Chapter9.

The growth rate of oil production and its revenue varied appreciably and in some years was spectacular as indicated by the rate of annual change during the period 1961-1969. This showed a contribution to the GDP of 75.7 percent out of a total GDP of about 750.3 million Libyan dinars. In 1970 production started to fall, the decline running at an annual average of 13.3 percent between 1969-1974 as a result of a government decision to limit oil production, and to develop other sectors in order to diversify the economy. This resulted in reducing its allocation in GDP to 66.4 percent in 1970 as indicated in Appendix 9.

The Libyan economic budget has largely reflected the allocation of oil revenue to the various plans, annual development and budgets. Accordingly, the first five-year plan was drawn up in 1963 and concentrated on infrastructural projects between 1963 and 1968 and extended to 1969 by increasing its funds to 625 million LD, about 1,700 million US$, while the actual spending amounted to 551 million LD. The second plan for 1968-1973 was started and cancelled in 1969. In those

plans agriculture had a minor share of 10.4 percent and 13 percent respectively from total funds.

The main aim in these plans for agriculture was directed towards preparing research and feasiblity studies on agricultural land, also to providing credit facilities with low and in some cases, interest free loans. As a result of these, the average annual rate of agricultural growth was 4.5 percent lagging behind the average annual growth in the economy of 28 percent. Despite the capital surplus situation agriculture therefore remained comparatively backward in comparison with other sectors (Farley, 1970).

The aim of agricultural development in the region was to increase investment and in order to reclaim the land particularly, aid was also given to absentee landlords to put their new farms into production, and foreign labourers began to enter agricultural employment, replacing Libyans. The government also made available in 1961, long term loans for the purchase of land (see Appendix 13).

In the Jebel El Akhdar the government began to establish agricultural settlement schemes on tribal land. This was based on the fact that since independence, there had been much concern about the settlement of nomads and semi-nomads, with the aim of raising their standard of living by improving the social services rendered to them.

The settlement programme of the Libyan government was started in 1963 in eastern Libya by Law No.44 on land settlement and a National Agricultural Settlement Authority (NASA) was established as an autonomous entity to develop plans, and execute settlement projects in the nomadic and semi-nomadic area, by re-development of ENTE farms and re-distribution of land to Libyan farmers under certain rules. The main

task of NASA was to take over the responsiblity for the development of all existing settlement schemes and establishment of new areas.

In Jebel El Akhdar the government decided to commence the reorganisation of its settlement projects with the assistance of the United Nations. A team of experts from F.A.O. began, in December 1962, to evaluate the whole situation in the region, and to suggest the main programme to be carried out by NASA.

In 1965 NASA decided to set in motion the gradual restoration of the farms of Jebel El Akhdar at El Marj. This needed the execution of work which was awarded to construction companies controlled by a consulting company assisting NASA in the reclamation of land, reconstruction of buildings, cisterns, terracing and planting of fruit trees and wind breaks. Selection of settlers and full social and technical assistance, including agricultural extension and the organisation of cooperatives were the main aims of the project, where in fact NASA was a watchdog committee over the execution of projects and coordination of plans.

The outstanding feature of planning was the basis of NASA's policy in dealing with the problem of resettlement and expansion of old schemes. The establishment of new settlement farms were being planned at Tobruk, Fatayah, Ras El Hilal, Butrabah and Gawarsha, constituting about 20,000 ha (El- Jawahry, 1965).

The procedures of NASA in the development of agriculture in the region gave trees to farmers free of charge to anyone applying for them, where NASA had started providing each farm with a number of fruit trees. However, this measure did not lead to positive results since only about 20% of all farmers asked for and were given trees. The main obstacle to

the development of tree cultivation was that the tree planting was either not, or only to an inadequate extent, followed by proper care and maintenance. This resulted in the deterioration of more than 80 percent of all trees planted, due to the failure to provide fencing and irrigation during the first two or three years (F.A.O., 1969).

The second task for NASA was to adjust farm size in ex ENTE farms, and the establishment of well defined farm boudaries with various sizes of farm, in order to create viable farmsteads by the establishment of large farms in the sttlement areas, under dry farming conditions. This would allow a better utilisation of farm machinery and guarantee a higher income for the settlers. Furthermore, NASA established conditional ownership rights which provided security and incentives for agricultural development, and in the meantime safeguarded the farmer against legal alienation of the land.

In addition to that, farming practices were improved taking into account the differences between the farming types. Land reclamation obtained little attention in the humid area, as most of the deep soils were already cultivated, particularly in the high part of the Jebel. Meanwhile, in some places in the region, where intensive cultivation was used, farms were trespassed by grazing animals and it was necessary to protect the vegetable units with barbed wire fences and concrete posts, concentrating on the irrigated area. Most dry farming settlements changed little in production patterns although the area under cultivation was enlarged through clearing the land of bushes which covered a large area of farm land (F.A.O., 1969).

However, it is also notable that despite a less hospitable agricultural environment in terms of natural physical availability of

resources, agricultural output grew slightly during this period, but not as was planned because agricultural development in the region (Cyrenaica) was faced with such problems as the traditional methods of tribal control. The small size of the agricultural operation in many cases was a result of fragmentation. There was a lack of extension services, the way of life of nomadic and semi-nomadic peoples was hard and they found it difficult to adapt to farming. In spite of that the scheme indicates that the pastoral Arab is capable of adapting himself to static agriculture where the farmers are supervised by the agricultural advisers. Moreover, the interesting phenomena during this period, as a result of growth of population, and increased income per capita were sudden increases in the demand for food and agricultural production.

Eventually, Libyan agriculture was left to stagnate at a low level and the consumer turned to the world market for the purchase of his daily food (El Fathaly and Palmer, 1980; Ghanem, 1985).

Post Revolution Change since 1969:

The Libyan revolution of 1969 changed the planning policies of the country, by creating certain notions of self reliance and self-sufficiency in food. It aimed to implement these policies by increasing its revenues from oil, and investing most of it in production schemes.

As mentioned before, the Jebel El Akhdar project was managed by the Authority of Jebel El-Akhdar which replaced the pre-1969 NASA. The Jebel Akhdar Authority starting in 1971 created about 2,000 farms, mainly practising dry framing and ranging in size from 20 to 80 hectares based on potential of the land, and also on the influence of an erratic

climate. As a result the acreage of agricultural land increased substantially. Moreover, according to a 1971 law, the government was able to acquire arable land, where it had been abandoned or confiscated if the owners were not farming it, and redistributed this land to landless farmers, or otherwise needy families. Some farms in the tribal areas in El Marj plain were created in this way as well as the new farms in El Fatayah area.

This project focussed both on developing new lands and introducing nomadic people to settled agriculture by reducing the effect of tribal ownership which had been revealed in pre-1969 studies and was considered the main constraint on development. In addition, the government allocated more funds for creating new agricultural settlement communities by setting up farms to provide a sufficiently high income potential to ensure an adequate livelihood for the farmer and his family.

Geographically, the overwhelming majority of the farmers practice dry farming and the farms are grouped in the more favourable environment of the northern slopes of Jebel El Akhdar and its adjacent areas, such as the El Marj plain where there are about 400 farms, and the El Fatayah area. Most farms have been allocated, and land use patterns have been laid down by the project authority in the first place, although change has taken place gradually as will be shown later.

Turning to private activities, entrepreneurs had an opportunity after the revolution to invest in agriculture due to increased demand for foodstuffs. Credits were easily come by and the government made subsidies available on almost every item used by farmers, such as the very high grain price subsidy (LD 150 per ton for wheat), to encourage

increases in production. In addition to modern irrigation farming which was practised in the El Marj plain instead of dry farming, a number of enterprising farmers took to animal raising and poultry farming, and part time farmers began to shift to full time farming, particularly after the intervention of the government in all private sectors (McLachlan, 1982). Consequently, this led to an increase of foreign manpower with farms being run by skilled managers, often from Egypt and Palestine, who brought with them knowledge of irrigated farming.

Thus, the physical landscape of old settlement sites had changed dramatically by 1980 and the essential infrastructure of new farms was well developed. This will be dealt with in the development section.

CONCLUSION:

The agrarian structure has remained highly differentiated throughout Libyan history, except in the case of the traditional peasants, and there has been increasing subdivision and fragmentation of holdings. The nomads and semi-nomads, particularly in Jebel El Akhdar, tended to aggravate tribal land ownership where there were absentee landowners. In addition, their way of life was mainly dependent on shifting cultivation and livestock raising.

The land development of the Italian colonists brought the first visible pressure on the utilisation of land. However, these reforms basically altered the system of land utilisation, by concentration on the establishment of family farming, as in the ENTE farms (Table 7.4; Fig. 7.3). These were an attempt at long run development which was largely subsidised by the Italian government in order to set up landless peasants from southern Italy on new land, known as the fourth shore.

The results were inconclusive, affecting a very few of the indigenous people who mostly occupied uncultivable land. They were pushed off some of the best farming land in the country and large numbers of their livestock were lost in the fighting which badly affected their economic situation, and stimulated them to migrate outside the country (Evans Pritchard, 1949). The most significant change affecting the landscape features came with the development of agriculture; that was done by creating new farming systems, complete with infrastructure, which facilitated the ability of new settlers to maximise the utilisation of land.

A colonisation policy of subsidies and price support played an important supportive role. However, it is equally important to note here that the colonisation policy at that stage was part of a Fascist strategy which can be described as "Capitalist settler colonialism", to create small family farms through colonisation companies, such as ECL (ENTE per la Dolonizazione della Libbia) ECC (ENTE per la Colonizzazione della Cyrenaica) INFPS (Instituto Nazionale Facisia per la previdenza Sociale) (Abdussalam, 1983).

The colonisation companies emphasised intensive settlement projects which provided 15,014 Italian colonists with farms in Cyrenaica, and a total area of 79,832 ha was developed by colonisation companies and private concessionaires. More than this figure was reached in the Tripoli region, due to the development of small scale dry farming in Cyrenaica, in contrast to large scale and vertical extension development approach, which emphasised the growth of the entire agricultural sector in the western region of the country, due to its favourable environmental conditions, and other strategic goals.

The development of agriculture after independence affected mainly private profitability, among other things the extent to which new and better inputs lead to positive change in the cropping pattern (e.g. multiple cropping). The level of crop yields increased slightly. At the same time, the traditional superiority enjoyed by small owner-operated farms was based on their intensive use of family labour and animal power.

In the Jebel El Akhdar region, emphasis was on the redevelopment of ENTE farms and this plan paid more attention to resettling the nomadic people through proposals produced by IBRD (International Bank for Reconstruction and Development) to NASA to achieve the plan. But NASA in fact did not realise the aims of the plan. In addition to that, the plan made an attempt to create a balanced economy between rural and urban areas, but it was far from attaining this target. This failure was attributed to the negative impact of oil production, which increased the gap between economic sectors in the country during this period.

The 1969 revolution brought many schemes of agricultural development in the country some of which have been briefly described but are as yet too recently established for valid judgements to be passed upon them. Where the earlier development projects had affected the farming pattern, such as ENTE farms in the El Marj plain, they have survived in their original form; indeed, it is ironical that some of the more recent schemes are in the same locality as those often of a different kind, which were abandoned earlier after the Italian colonists left the regions. During the Second World War, which had badly affected the settlements and after independence, particularly during the 1960s, the government made an effort through NASA to reinvigorate the ENTE farms in the region, but as mentioned, it did not achieve the target plan.

CHAPTER EIGHT

DESCRIPTION OF AGRICULTURE IN THE REGION

INTRODUCTION

The Jebel El Akhdar is similar to other regions in Libya in that agricultural land and settlement patterns are dependent on climatic conditions and availability of fertile land and water. The region has sever agricultural zones with district characteristics. These characteristics are used to delimit the land use pattern which is discussed in this section. Both traditional and modern agricultural methods exist side by side in the Jebel El Akhdar, as they do in other parts of Libya. This reflects the historical development of the country (Johnson, 1973).

As mentioned in Section VII, the traditional tribal system conducive to the nomadic way of life is the basis of the rural, social and economic structure. The main pursuits of pastoralism and shifting cultivation appear to have been practiced in the most marginal areas since they were first occupied. They have subsequently been replaced by a sedentary system, especially in the El Marj and El Fatayah areas. Sedentary farming provides higher yields per hectare which can encourage the rural population to participate in settled farming although there is often a lower output per man hour than in shifting cultivation, because of the lack of knowledge of the methods of sedentary agriculture (see Boserup, 1965).

On the other hand, the role of environment, population and economic growth in accounting for changes in shifting cultivation in time, and

space are clearly significant (F.A.O., 1957). These could be applied to certain areas of the Jebel El Akhdar which has a high agricultural potential. Moreover, the inevitable impact of oil revenue has led to an improvement of the social and economic situation of the country and increasing population pressure on arable land. Consequently, there has been an alteration in the life style of people generally. These and other factors make it possible to distinguish four types of agricultural systems within the region :

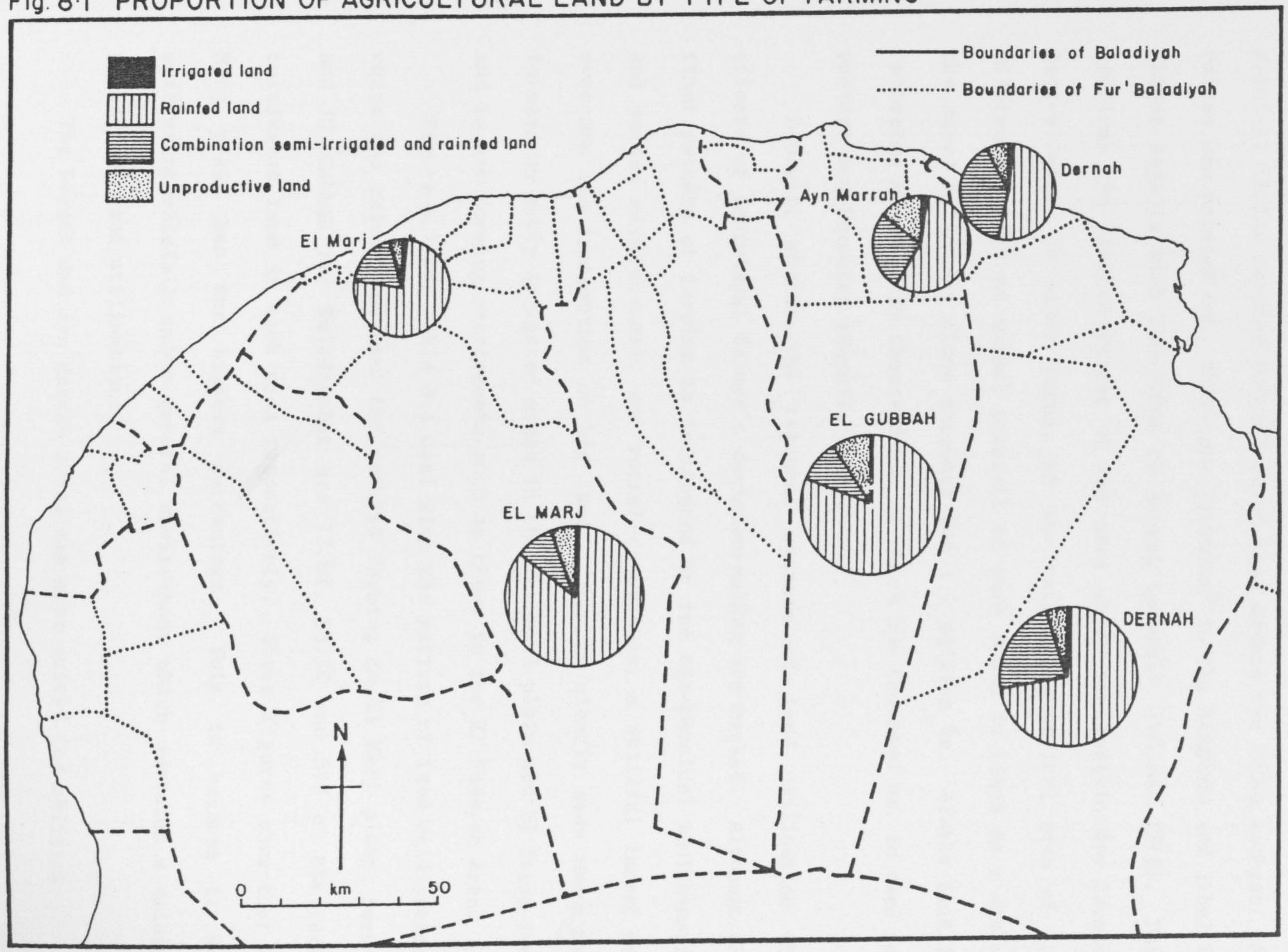
(1) The irrigated and partly irrigated type along the coast and in the wadis where water is readily available. Here, vegetables and fruits are the main produce under sedentary and semi-nomadic systems. Some land is individually owned, while other land is operated under a collective (tribal) system (Ministry of Planning and Development, 1966).

(2) The type that is dependent on local rainfall. Here cereals are the main crop, and in some places these are combined with fruit trees (grapes, pears and peaches). This type predominates in wadis and basins where winter flooding aids cultivation.

(3) The type that is partly irrigated and consists of modern, small to medium sized, private farms which are backed by government assistance. They make the main contribution to the region's production of vegetables, fruits and cereals.

(4) The type which consists of extensive livestock grazing. It is made up of two distinctive vegetation zones : the forest or scrub on the northern flanks of the Jebel El Akhdar and the steppe on the southern side. In addition, some shifting cultivation of wheat in the north, and barley in the south does occur. These cereals are used mainly as fodder. The latter so far is the most prevalent type of farming in the

Fig. 8·1 PROPORTION OF AGRICULTURAL LAND BY TYPE OF FARMING



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

whole region of Jebel El Akhdar. It is also the most precarious as it depends entirely on the availability and frequency of the precipitation, which itself is erratic and often deficient. The seasonal pattern of rainfall limits rainfed farming to an area within the 200mm isohyet. As Pallas has pointed out, there are 13,000km^2 in the Benghazi and Jebel El Akhdar regions with 250-300mm of annual rainfall (Pallas, 1978). This confirms the limited extent of the area which can sustain dry farming agriculture. In other words, of the total geographical area of 1.3 million ha. with an annual rainfall of over 300mm in Libya as a whole, the Jebel El Akhdar alone accounts for 1.2 million ha. Arable land is estimated at only 539 thousand ha. of which 334 thousand ha. is used for pasture and forestry (Bansil, 1978).

However, within the regional systems of land utilisation the effects of individual farmer's decision-making are marked. Although the final pattern of farming is influenced by the bio-physical environment, and varies with economic and social conditions, a skillful farmer may overcome the limitations on his land. This is clearly seen among new farmers on newly irrigated areas in the Benghazi plain and El Bayda area and in new farming settlements such as those in the El Fatayah area.

Figure 8.1 and Table 8.1 deal with the pattern of land utilisation, where the cultivated land for rainfed farming in El Marj plain, Dernah and El Gubbah Fur Baladiyahat are 77.6%, 53.3% and 59% of the total cultivated land in each area respectively. These figures show that El Marj plain has the highest percentage. This is because it has sufficient rainfall and a general environment which sustains a rainfed pattern of land utilisation.

The Dernah and Ayn Marrah areas are more suited for shifting

Table 8.1 Type of Farming:

Administrative Division	Irrigated holdings					Rainfed farming					Combination Semi-Irrigated and Rainfed								
	No.of holdings	Aver. farm size	Total Farm Area ha.	Cultivated land ha.	% of Total Farm Land	No.of holdings	Aver. farm size	Total Area ha.	Cultivated land ha.	% of Total Farm Land	No.of holdings	Aver. farm size ha.	Total Area ha.	Cultivated land Irrigated ha.	Cultivated land Rainfed ha.	% of Total Farm Land	Unproductive land ha.	% of Total Farm Land	Total Agriculture Land
El Marj Baladiyah	49	8.02	393	374	0.4	3,396	29.3	99,548	94,139	85.5	227	44.6	10,127	1,408	8,463	9.0	5,683	5.1	110,086
El Marj Fur Baladiya	20	12.65	253	244	1.0	588	30.7	18,093	17,870	77.6	69	60.5	4,177	668	3,383	17.5	858	3.8	23,024
Dernah Baladiyah	176	0.45	80	74	0.5	731	15.8	11,563	11,025	72.2	171	21.0	3,615	182	3,223	22.3	753	5.0	15,259
Dernah Fur'Baladiyah	167	0.37	62	57	0.9	139	25.9	3,609	3,316	53.3	94	27.0	2,555	84	2,307	38.4	461	7.4	6,227
El Gubbah Baladiyah	108	0.94	102	69	0.4	1,388	10.5	14,654	13,411	80.9	188	9.7	1,827	197	1,402	9.6	1,503	9.1	16,583
Ayn Marah Fur'Baladiyah	72	0.96	69	42	1.8	145	11.0	1,597	1,425	58.6	79	9.5	762	73	538	25.2	349	14.4	2,429

Source: Computed from: Secretariat of Planning (1979) Agricultural Census 1974, Jebel El Akhdar, Table No.6:14, Tripoli (in Arabic).
Secretariate of Planning (1979) Agricultural Census 1974, Dernah, Table 6:15, Tripoli (in Arabic).

cultivation and pasture than for static dry farming. This reflects the gradual decline of rainfall toward the eastern side of Jebel El Akhdar (see chapter III). Consequently there has been an increase in the number of semi-nomads in these two areas.

Agricultural holdings and their characteristics

The agricultural census in 1974 divided land holdings into two categories : holdings with land and holdings without land. There are 110,068 ha. of agricultural land in the El Marj region divided between the district of El Marj Baladiyah and the El Marj plain, which is called El Marj Fur Baladiyah in the agriculture census of 1974 (Table 8.1 and Fig.8.1). El Marj Fur Baladiyah has 20.9% of the agricultural land of El Marj Baladiyah, some 23,024 ha. It is owned by 677 holders, with an average number of one parcel per holding and an average size of 16.7 ha. This indicates a very low level of fragmentation of agricultural land at the regional level.

In the Dernah region, there are 15,259 ha. of agricultural land, of which 40.8% is within Dernah Fur Baladiyah. El Gubbah Baladiyah has about 16,583 ha. and 14.6% of the total is within Ayn Marrah Fur Baladiyah. Here the degree of fragmentation is greater than in other areas. This will be discussed later.

The pattern of farming shown in Table 8.1 indicates that 77.6% of the agricultural land in El Marj Fur Baladiyah is under dry farming. This is due to the favourable agro-climatic conditions which encourage the semi-nomadic practices of dry farming and pastoralism. The same percentage of dry farming occurs in Dernah and El Gubbah areas, but this percentage is less at a micro-regional scale for Dernah and Ayn Marrah Fur Baladiyah areas. The difference in farming practices is due to an

increase in irrigation which is related to availability of water and land development.

Irrigated land amounts to only 244 ha. (about 1%) of the total agricultural arable land in the El Marj plain. Partial irrigation or dry farming practices occur on 17.5% of the total agricultural land. The remaining 3.8% is unsuitable for cultivation.

Dernah and Ayn Marrah differ slightly in the percentage of dry farming, but they have less variance in the percentage of irrigated farms, which is estimated at 0.9% and 1.8% of the total agricultural land, respectively.

In Dernah there are many holdings in the City of Derna and on the terraces of the Dernah Valley. Several factors have influenced the amount of irrigated farming in the Dernah area. Among these are the accessibility of ground water and the general knowledge of the farmers about sedentary farming practices. In addition the periodic flooding of the Dernah Valley produces a fertile soil.

In Ayn Marrah there is only a small amount of irrigated land, despite the abundance of groundwater. The reason for this is physiographic limiting irrigated farms to the bed and terraces of Wadi Sarrah, one of the tributaries of Wadi El Nagha. The percentage of semi-irrigated farmland is 25.2% of the total cultivated land, which mainly occupies the high part of the Wadi El Nagha and its tributary. This percentage is increased in Dernah Fur Baladiyah to 28.4% of the total cultivated land as a result of the inclusion of the high plateau of El Fatayah and the west coast of Dernah. The percentage of unproductive land is 7.4% in Dernah and 14.4% of total agricultural area in Ayn Marrah. This land is used mainly as pasture. Table 8.1 shows

the predominance of dry farming in the region.

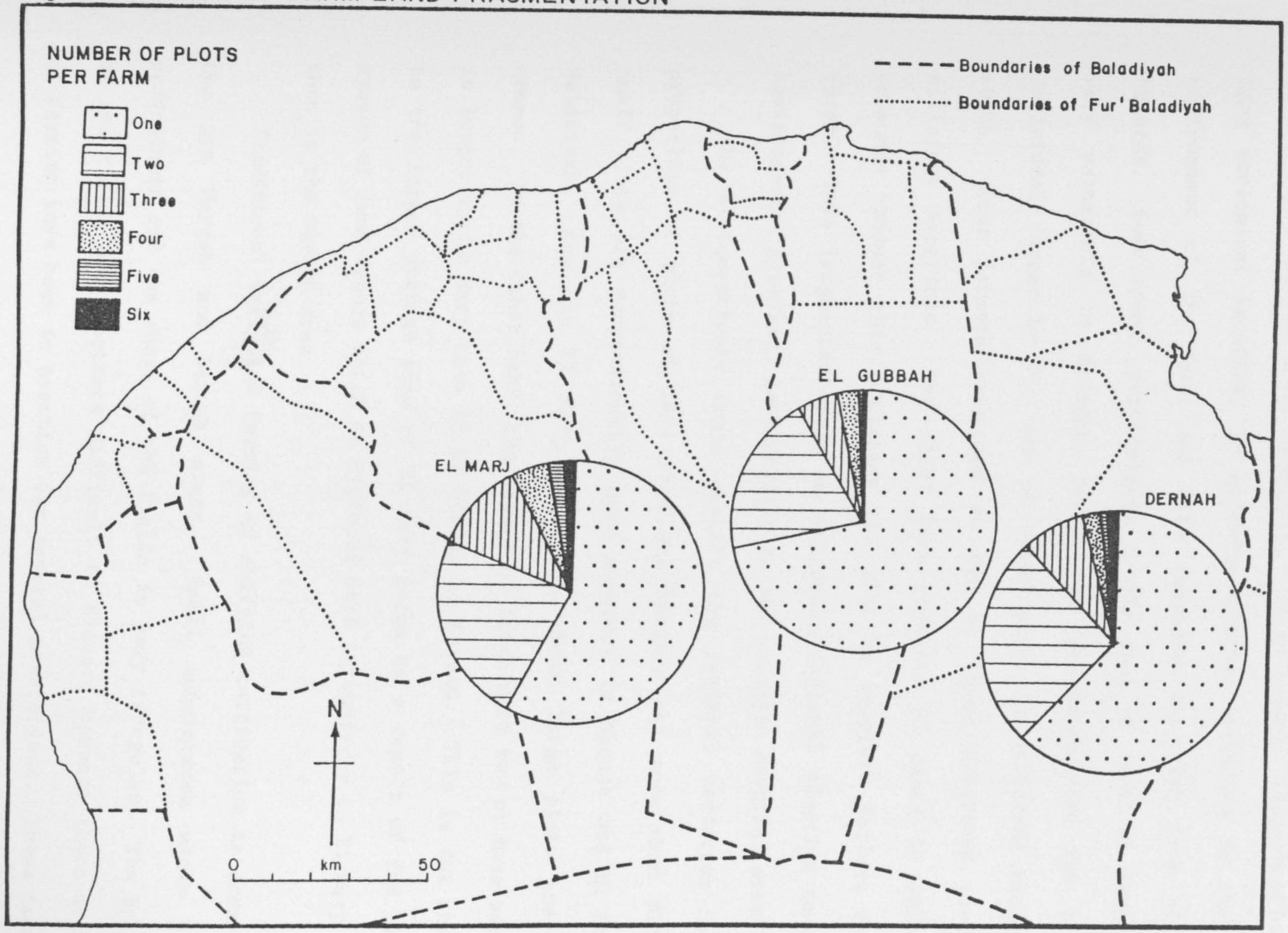
Farm size and fragmentation

Farm size varies throughout the Jebel El Akhdar. The average size is 19.5 ha. It is larger than this in El Marj and significantly smaller in El Gubbah and the Dernah areas. This is clearly shown by comparing (Appendices 7a, b and c and Fig.8.2), where farms of more than 100 ha. total 2% in El Marj Baladiyah, whereas there are none of this size in El Gubbah or Dernah.

The small mean size of farms is due to several factors. Firstly, Islamic inheritance laws require that property be divided equally among all heirs leads to fragmentation of holdings. Subdivision may also occur if a farmer rents his land to a tenant, as part of an economic process of letting land in small pieces in order to maximise income through tenancy or share cropping. Thirdly, farm size may be dictated by the physiography of a restricted valley, such as in the wadis of Ayn Marrah and Dernah where the main stream valleys make the continuity of farmed space difficult. In addition, policies of government land distribution may produce small farms as has occurred in the El Fatayah and South West Benghazi project area.

Farmland may be further subdivided within these small farms by what has been termed an "operational process" (Jones, 1982), where plots of land are separated by establishing a fence or ridge between plots or where a compact holding is cut up by roads or other items of infrastructure. In any event, fragmentation makes production costs higher and mechanisation of farms very difficult. This same problem has occurred in the Tripoli region and there the Libyan Government has given

Fig. 8·2 DEGREE OF FARM LAND FRAGMENTATION



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

a great deal of attention to the re-distribution of small farms, in order to preclude the problem of fragmentation and encourage a rational and economic use of land resources. Nevertheless, fragmentation may have ecological benefits, by allowing spatial variation in the micro environment of the farm and with reducing the risk from climatic hazards. Some areas, particularly to the east of Jebel El Akhdar are very vulnerable to drought, which can be compensated for by the individual farmer by the use of other plots in different ecological zones. Some farmers have and in two or three scattered plots in different locations. The ideal farm consists of plots in different ecozones because this minimises the risk of complete failure in dry years. Thus fragmentation is an extremely rational adoption to local environmental problems, particularly in the southern marginal areas.

The aforementioned could explain the regional variation in the proportion of plots of less than one hectare and more than 300 ha. Small plots are proportionally more numerous in Dernah and El Gubbah Baladiyah, than in El Marj Baladiyah, where large plots are more common. On the other hand, the number of farms with two or more parcels is larger in El Marj than in El Gubbah or Dernah. This is due chiefly to the larger average size of El Marj farms as a result of the tribal system of land tenure which is diffused more intensively in El Marj area than in the Dernah area.

Traditional irrigated farming or shifting cultivation is common in the Ayn Marrah and Dernah areas. Small subsistence micro farms predominate and the shape of the fields is very irregular. The borders of the fields are sometimes difficult to discern because these methods of farming have been in practice for several generations. These factors

Table 8.2: Farm Population Density

Administrative Division	Holding without land	Holding with land Numbers	Hectares	Population on farms with or without land Male	Female	Total from population	Density of population per ha	Density of farm per ha.
El Marj Baladiyah	335	3,672	110,068	14,076	14,364	28,480	0.25	7.7
El Marj Fur Baladiyah	110	677	23,024	3,043	3,134	6,177	0.25	9.1
Dernah Baladiyah	111	1,087	15,259	4,456	4,261	8,718	0.5	8.0
Derhah Fur Baladiyah	37	400	6,227	1,861	1,550	3,411	0.5	8.5
El Gubbah Baladiyah	448	1,684	16,583	7,360	7,144	14,504	0.8	8.6
Ayn Marrah Fur Baladiyah	56	296	2,429	1,256	1,178	2,434	1.0	8.2

Sources: Computed from: Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Table, 48:190 Tripoli (in Arabic).
Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Table 48:185 Tripoli (in Arabic).

make mechanised farming very difficult and create inefficient farming methods.

On the other hand the ecological variation in the land system of the Jebel El Akhdar indicates the lack of land consolidation in the region. Since the Italian colonisation the development programmes have concentrated on good quality land in specific humid areas such as El Marj and El Bayda region. As a result there appears to be less fragmentation in those areas.

Rural Population

Table 8.2 shows the total number of people on holdings with land and without land. It indicates the population density on farms and shows that there is not much difference between various parts of the region in terms of population density per hectare of farmland, there is a difference between the traditional irrigated areas and the dry farming areas. The population density is one person per hectare in the Ayn Marrah area, whereas in the El Marj area it is as low as 0.25 persons per hectare. The reason for this is the more intensive agricultural land use in El Marj.

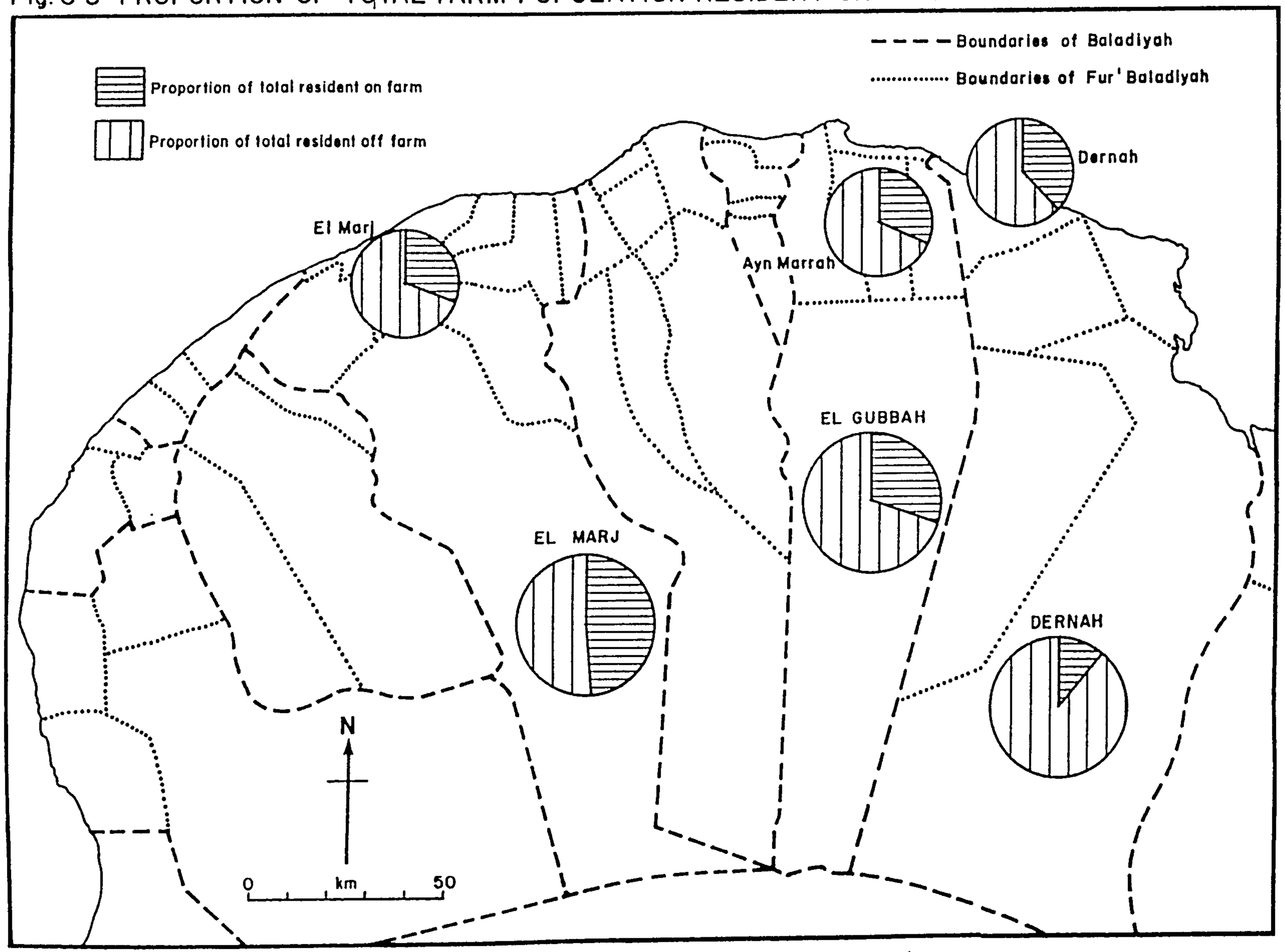
Table 8.3 and Figure 8.3 deal with resident and non-resident farmers. In the four areas of El Marj Plain, Dernah Fur Baladiyah, El Gubbah and Ayn Marrah, about one-third of the farmers live on their land. In El Marj Baladiyah the percentage is greater because of most of the farmers are semi-nomadic. On the other hand, in Dernah Baladiyah, only about 11% are resident. This is due to the many small, scattered parcels of land in this area, and, more importantly, to the fact that in 1972 a law No.4 was passed to prevent construction of new buildings on agricultural land. The percentage of non-resident farmers in the

Table 8.3 Farm Population Resident and Non-Resident on Farm

Administrative Division	Total farm Population	Resident on Farm				Non-resident Farmer			
		No. of holdings	Area ha.	Population	% of Total	No. of Holdings	Area ha.	Population	% of Total
El Marj Baladiyah	24,708	1,739	60,986	11,914	48.3	1,833	49,028	12,794	51.7
El Marj Fur Baladiyah	4,817	213	8,204	1,489	30.9	464	14,820	3,328	69.1
Dernah Baladiyah	10,639	159	2,024	1,165	11.0	919	12,557	9,474	89.0
Derhah Fur Baladiyah	2,925	150	2,576	1,111	37.9	250	3,651	1,814	62.1
El Gubbah Baladiyah	11,086	524	6,194	3,341	30.2	1,160	10,389	7,745	69.8
Ayn Marrah Fur Baladiyah	2,011	99	867	630	31.4	197	1,562	1,381	68.6

Source: Computed from: Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Table 49: 180-181: (in Arabic).
Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 49: 180-187: (in Arabic).

Fig. 8·3 PROPORTION OF TOTAL FARM POPULATION RESIDENT ON FARM AND OFF FARM



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

remaining area form two-thirds of the total farm population because of the small size of irrigated farms in both areas of Ayn Marrah and Dernah, and the nature of dry farms and shifting cultivation. Non-residence is, of course, detrimental to the efficient use of agricultural land since time and money must be spent in travel to and from the farm.

Agricultural Labour

In 1973 Within Libya about 23% of the workforce is employed in agricultural activities, but this proportion is much less at about 14% of the total workforce in Cyrenaica (Table 8.4). There was no increase in agricultural employment between 1964 and 1973. On the other hand, employment in the secondary and tertiary sectors increased considerably. In Cyrenaica, the proportion of the workforce in agriculture decreased from 26.3% in 1964 to 13.9% in 1973. This was due to migration to urban areas brought about partly by the oil boom which created an infrastructural imbalance. Various government schemes encouraged employment in the tertiary sectors within the cities, particularly in Dernah. This resulted in an excessive number of people working in the tertiary sectors at the expense of the agricultural and other primary sectors. In addition, several dry seasons helped to increase the migration from the land to the cities. Moreover, a delay in the implementation of the agricultural development scheme in the area encouraged migration from agriculture activities to other sectors.

In Ayn Marrah Fur Baladiyah 38.4 per cent of the total work-force is employed in the agricultural sector because of the predominance of traditional irrigated farming, and shifting cultivation combined with

Table 8.4: Agricultural Work Force:

Administrative Division	Total Area ha.	Land Occupied by Holdings ha.	Total Work Force	Agricultural Work Force	% of Agricultural Work Force as of total Work Force	Agricultural Workers/ha.
El Marj Baladiyah	1,000,000	110,068	12,929	4,228	32.7	.04
El Marj Fur Baladiyah		23,024	7,747	1,716	22.1	.07
Dernah Baladiyah	1,666,000	15,259	11,386	1,327	11.7	.08
Dernah Fur Baladiyah		6,227	10,014	869	8.6	.14
El Gubbah Baladiyah	455,000	16,583	5,395	1,512	28.0	.09
Ayn Marrah Fur Baladiyah		2,429	754	290	38.4	.21
Cyrenaica Region	13,909,500	497,868	148,983	20,732	13.9	.04
Libya	1,760,000,000	8,800,000	531,398	121,916	22.9	.01

Sources: Computed from:
(1) Secretariat of Planning (1977), The 1973 Census of Population, Jebel El Akhdar, Tripoli, Table 37: 81: (in Arabic).
(2) Secretariate of Planning (1977), The 1973 Census of Population, Dernah, Tripoli: Table 37: 81: (in Arabic).
(3) Doxiadias Associates (1979) Benghazi Region, Physical Development Plan, Existing Condition and Alternative Strategies, Report 1, Vol.1, Table 1.24:1.45
and
(4) Secretariat of Municipalities (1979) National Physical Prospective Plan 1981-2000, Tripoli, 36.

herding animals. On the other hand in El Gubbah Baladiyah only about 28% of the total workforce is in agriculture because of the availability of alternative employment. In the mid-sixties El Gubbah town grew because of its site on the highway between Dernah to Benghazi which led to the development of certain facilities for travellers, the growth of quarries, and a water pipeline scheme, transporting water from El Dabussiah to El Marj. These developments created job opportunities, attracting labour from the land.

Employment in agriculture is shown to differ considerably from one place to another, with the biggest difference in workers per hectare being between Ayn Marrah and El Marj (Table 8.4). The El Marj area is the principal agricultural region in north east Libya. As such, it might be expected to contain the highest proportion of agricultural workers. However, the 1973 census does not reflect this. This anomaly can be explained as follows: the old town of El Marj was destroyed by an earthquake in 1963 and the subsequent construction of El Marj New town absorbed a considerable amount of labour. The construction of the coastal highways also took place during this period. In addition, agricultural development schemes did not really get started until after 1970. In terms of the cultivated area as shown in Table 8.5, the El Marj farming area has about .27 of permanent adult workers per ten hectares of cultivated land and .36 of part-time adult workers per ten cultivated hectares while at Dernah Baladiyah and Fur Baladiyah the level is .50 and .46 permanent adult labourers per ten cultivated hectares, respectively. On the other hand, the intensity of adult part-time workers varies from .65 to .77 persons per ten cultivated hectares in the same areas respectively. Therefore, Dernah Baladiyah

Table 8.5: Density of Agricultural Workers per Cultivated Hectare:

Administrative Division / Type of Labour	El Marj Baladiyah	El Marj Fur Baladiyah	Dernah Baladiyah	Dernah Fur Baladiyah	El Gubbah Baladiyah	Ayn Marrah Fur Baladiyah
Cultivated land in ha.	84,224	19,814	14,449	5,735	14,423	2,063
Intensity of permanent workers per 10 ha.:						
Average density Male	0.24	0.17	0.39	0.39	0.66	0.88
" " Female	0.03	0.1	0.10	0.08	0.20	0.10
" " Adult	0.27	0.28	0.50	0.46	0.86	1.00
" " Children	0.02	0.07	0.03	0.01	0.06	0.03
Intensity of part time workers per 10 ha.:						
Average density Male	0.33	0.38	0.47	0.61	1.04	0.91
" " Female	0.03	0.04	0.18	0.16	0.76	1.02
" " Adult	0.36	0.43	0.65	0.77	1.8	1.94
" " Children	0.07	0.02	0.06	0.09	0.63	0.23
Intensity of total workforce per 10 ha.	0.73	0.72	1.20	1.30	3.40	3.2

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Table 43:149-50: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 43:145-146: (in Arabic)

and Fur Baladiyah have double the labour intensity of El Marj area due to differences in the type of farming in the two areas.

In El Gubbah Baladiyah and Ayn Marrah Fur Baladiyah the intensity of full-time and part-time farm workers is greater than in the other two areas (Table 8.5). The reason for these variations in labour intensity is the nature of the area as revealed in the agricultural economy, and the pattern of irrigated traditional farms existing in Ayn Marrah, which requires a high labour input, in order to optimise land use, (Boserup, 1965, 1981).

It can be seen from Table 8.5 that the region has three levels of labour intensity. In El Marj the level is less than one worker per 10 hectares while it is double this level at 1.20 and 1.30 per 10 hectares in Dernah and much higher at over 3 workers per 10 hectares in Ayn Marrah Fur Baladiyah and El Gubbah Baladiyah. The contribution of women and children in agriculture is still on a limited scale, except in Ayn Marrah and El Gubbah where it exceeds that of male adult workers, because the dominant crop pattern is one of irrigated vegetables in which labour demands can be met by female and child workers. Male farmers left Ayn Marrah and El Gubbah prior to 1969 because of the opportunities for construction work in El Bayda and Dernah. Labour shortage constrains rational land utilisation, particularly on irrigated farms. However, this shortage has been compensated for by foreign labour in the last decade.

Land Tenure

Historically, Libya had few large private estates with tenants or sharecroppers because of the nomadic nature of the rural population.

Sedentary agricultural practices were established by the end of the Ottoman period and this corresponded with new regulations for land tenure (international Review of Agricultural Economy, 1917).

The Turkish dominion cadaster applied in Libya. According to this the title to a property depends on the registration of a holding. The register is divided into two parts, the one for urban and the other for rural property. These consist of classes of property in land under the Ottoman laws as follows (Quereshi, 1953).

(1) Miri is for state properties.

(2) Wacuf is land belonging to religious foundations belonging to Zawiya.

(3) Matruk land is property held collectively by tribes and villages, for public utility and pasture land.

(4) Mulk is land belonging to individuals which is privately owned.

(5) Mawat land is bad land or unproductive land.

This classification is simply an adaptation to local conditions of the classification of properties in the Italian Civil code for 1885. Thus for the purpose of the Colonization schemes land in Cyrenaica was obtained by the Italian government, by purchases of individual's rights or by expropriation for public use under Royal Decree No.1044 of 2nd September 1912, and Royal Decree No.1235 of 20th August 1920, or, as in the case of the properties of "rebels" and of the Zawiya, by confiscation (see Table 7.1) (Quereshi, 1953).

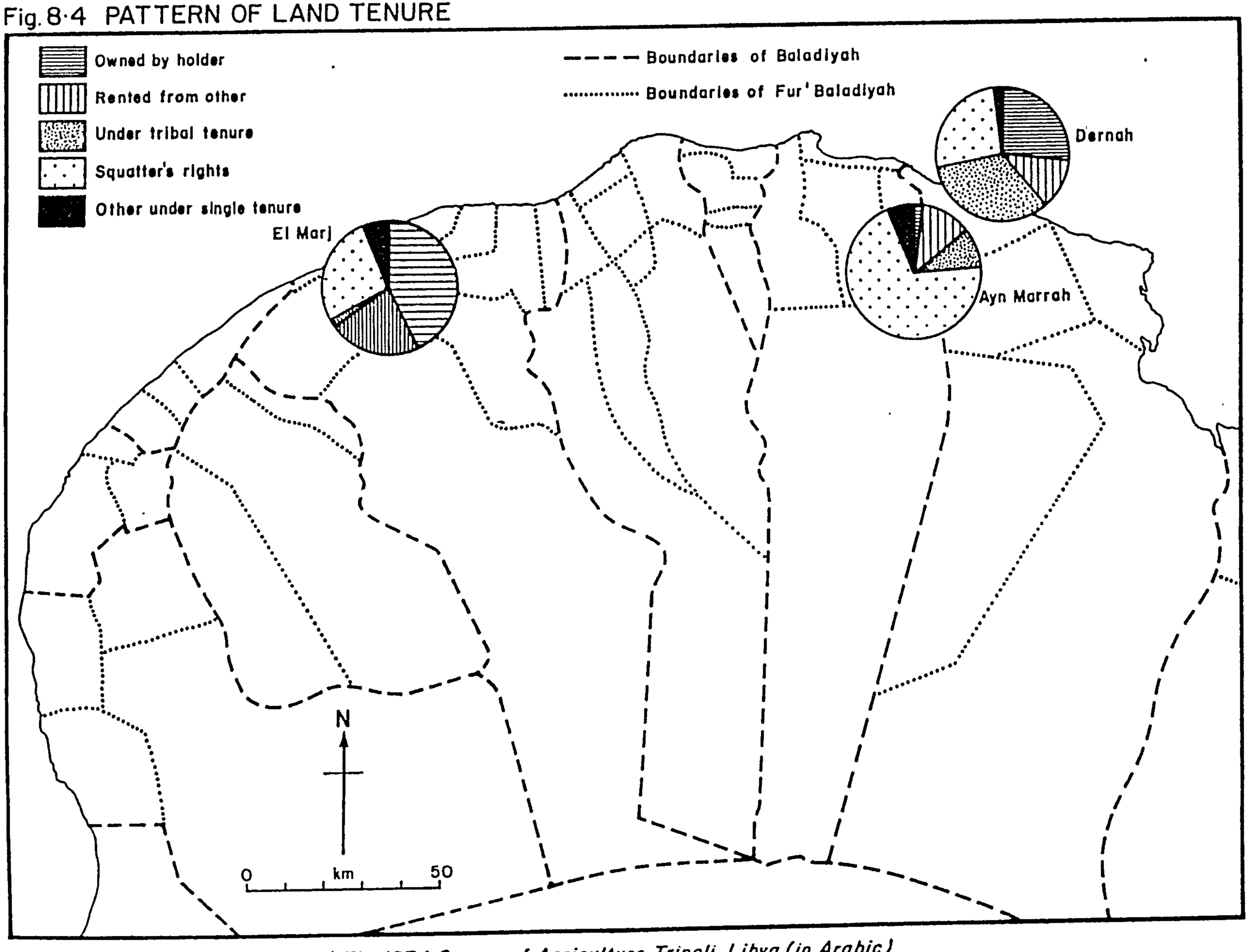
This system of land tenure has been the basis for the pattern of land ownership indicated in Table 8.6 and Figure 8.4 which is taken from

Table 8.6: Land Ownership:

Type of Ownership / Administrative Division	Total Holdings Number	Total Holdings Area ha	Land in Private Ownership	Rented Land For Fixed amount	Rented Land For Share of product	Land under tribal tenure	Land held under squatters rights	Other land under single tenure
El Marj Baladiyah	3,672	110,068	11,184	27,627	102	3,709	67,102	253
El Marj Fur Baladiyah	677	23,024	4,299	11,914	-	510	6,236	63
% of El Marj Baladiyah	18.4	21	38	43	-	13	9	25
% of El Marj Fur Baladiyah			18	51	-	2	27	3
Dernah Baladiyah	1,078	15,259	1,890	967	2	4,331	7,506	162
Dernah Fur Baladiyah	400	6,227	1,680	737	2	2,028	1,649	129
% of total Dernah Baladiyah	37	41	89	76	100	43	22	80
% of total Dernah Fur Baladiyah			27	12	4	32.5	26	2
El Gubbah Baladiyah	1,684	16,083	340	5,976	7	511	9,695	53
Ayn Marrah Fur Baldiyah	296	2,429	50	295	3	216	1,847	15
% of total El Gubbah Baladiyah	17.5	15	15	5	50	42	19	28
% of total Ayn Marrah Fur Baladiyah			.02	12	.201	9	76	.6

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Table 10:24: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 10:23: (in Arabic)

Fig. 8·4 PATTERN OF LAND TENURE



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

the agricultural census of 1974.

This data reveals that the three regions of El Marj, Dernah and El Gubbah have very different tenure patterns. The El Marj area had 3,672 holdings with agricultural land, of which 18.4% occurs in the El Marj plain where 677 landholders occupied 23,024 ha. Land rented for a fixed amount of money or sharecropped for a percentage of the crop accounted for 51% of the total agricultural land because of the large number of absentee landowners in the area; secondly, squatting involved 27% of the total agricultural land; thirdly, private holdings occupied 18% of the total, mainly concentrated in irrigated and semi-irrigated holdings which were exploited in the past by Italian colonists. Finally, tribal land formed only 2% of the total agricultural area. This is on the marginal land where shifting cultivation and animal herding are found.

On the other hand, in Dernah Fur Baladiyah, 32.5% of the land is common land and used mainly for dry farming. Private holdings took up about 27%. Most of this consists of irrigated farms in Dernah city. About 26% of land was squatted on and about 12% rented by sharecroppers. The remaining percentage of about 2.5% was under other single tenure.

In the Ayn Marrah area the various divisions of and tenure are different from those in Dernah, in particular there is a dominance of 76% of land held under squatter's rights due to inheritance. The second most important type is rented land with about 12% of the total which is mainly occupied by traditional irrigated gardens. Because most of the landowners have moved to an urban centre, either Dernah City or El Bayda City, the third percentage is tribal land accounting for 9% of the total holdings. Most of this is used for shifting cultivation outside the main irrigated farming area. The remaining percentage is about 3% which

is represented by farm dwellers on private property and other forms of land tenure.

The significance of land ownership can be related to the use of land. Most of the common land or tribal land is occupied by dry farming and grazing on the marginal land of the major agricultural farming area, while privately owned land is seen in the settled farms. In many cases, the economic process defines the pattern of land ownership and use, with rented land for share cropping seen on traditional irrigated farms, whilst rented land for a fixed amount of money is mostly found in El Marj plain, where semi-irrigated farms with permanent crops predominate. These latter are used by non-Libyan workers. This occupancy pattern may be reflected in the management of land because the main aim of non-Libyan workers is to obtain maximum output in a short period rather than to preserve soil flexibility and water resources. The agrarian reform has affected both the small peasant household and tribal ownership of land. This is due chiefly to the fact that the 1970's Land Reform and Law No.4 of 1971, used the mechanism of state agricultural policies in order to compensate for the deficit in the agricultural labour force. This was achieved by the establishment of district and arable land levels which led to a division of the tribal land and to a political and social re-integration of the landowning class into the framework of rural life. Subsequent to this land ownership became part of the co-operative society despite the partial social and political deprivation of the old landowning class, and the communal land system. The government has developed various types of agencies for securing the new system's reproduction.

Type and intensity of cultivation

Table 8.7 and Figure 8.5 illustrate the type and intensity of cultivation in the study areas. These data are based on the agricultural census of 1974. Table 8.1 shows that agricultural land makes up 96.2% of the total El Marj plain area, and unproductive land is only 3.8% of total arable land.

Intensive sedentary rainfed farming is dominant being found on 96.6% of the cultivated land. The area under temporary crops such as wheat, barley, fodder, legumes, etc. occupies about 80% of the cultivated land. These crops correspond with their environmental needs (see chapter III). Grasslands providing temporary grazing cover 11% of the total cultivated land, and temporary fallow land fills up about 4.2% of the cultivated land, which reflects agricultural rotation. This comprises about 1.1% ha. per holding and on some farms is less than one hectare. Finally, vegetables and flowers occupy some 2.5% of the total cultivated land, 95% of which are under irrigation.

The type of crops grown in the El Marj area is closely linked to the soil type. On the El Marj plain, cereals, legumes and root crops particularly are best suited to the irrigated areas (see Fig.8.5), but rainfed agriculture occupies 96.6% of land. Crop rotations are mainly practised in mixed cropping areas where there are trees and cereals or fodder. There are also small semi-irrigated areas with maize, melons, beans, tomatoes and a number of vegetables . The latter consist of various kinds of winter vegetables. Drought-resistant varieties of cereals, particularly wheat, barley and Medicago (as a fodder) have been introduced from other countries, such as Australia.

Crop breeding in general has been responsible for a considerable

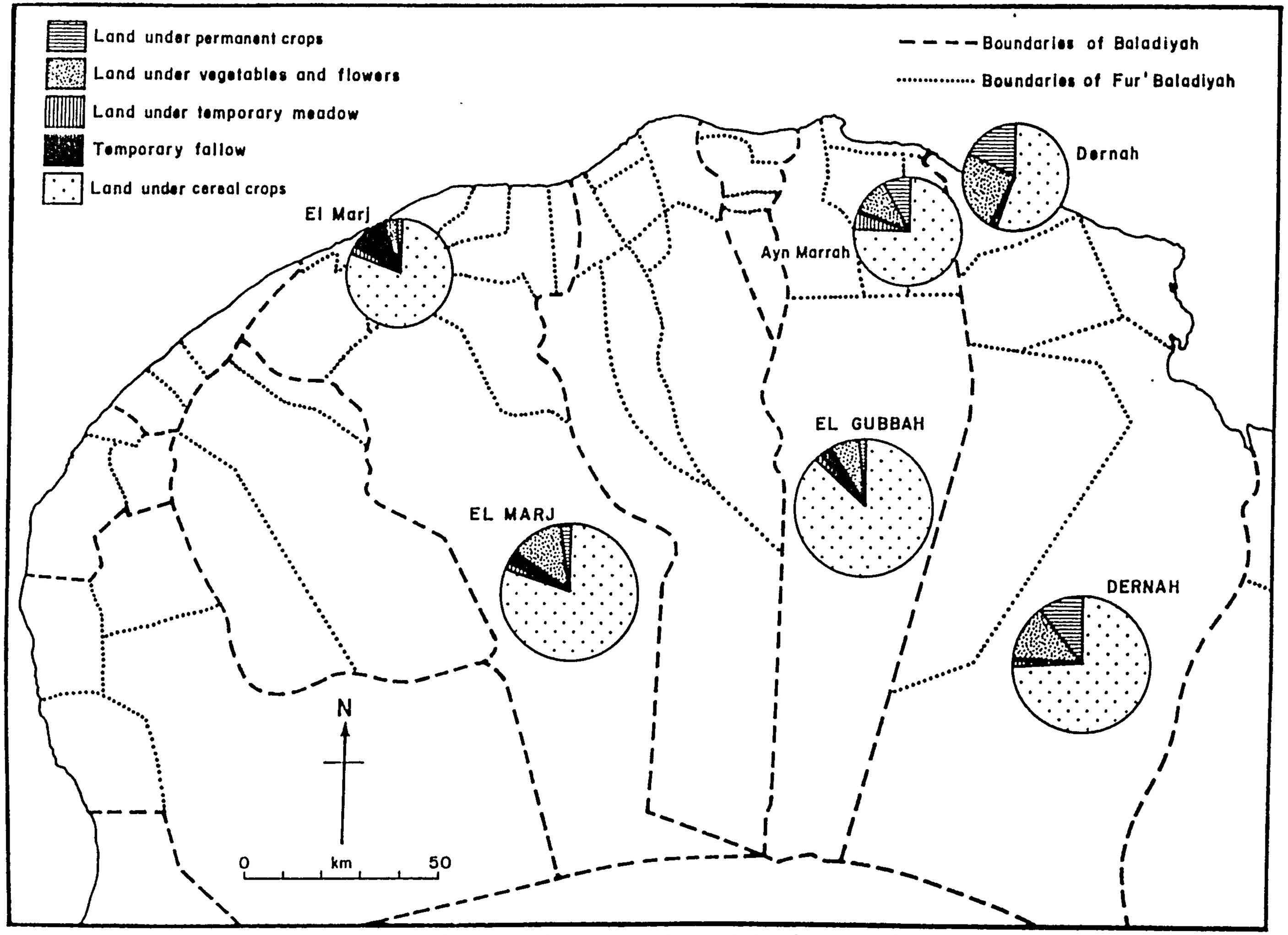
Table 8.7: Type and Intensity of Cultivation:

Administrative Division	No of Holding	Land under Current Cultivation Total ha.	Land under temporary crops i.e. cereal Total ha.	Land under temporary crops i.e. cereal % of total cultivated land	Land under vegetables and flowers Total ha.	Land under vegetables and flowers % of total cultivated land	Land under temporary meadow Total ha.	Land under temporary meadow % of total cultivated land	Land under temporary fallow Total ha.	Land under temporary fallow % of total cultivated land	Land under permanent crops Total ha.	Land under permanent crops % of total cultivated land
El Marj Baladiyah	3,649	84,224	67,729	80.4	1,169	1.4	2,528	3.0	10,898	13.0	1,899	2.2
El Marj Fur Baladiyah	669	19,814	16,002	80.7	497	2.5	2,165	11.0	823	4.2	324	1.6
Dernah Baladiyah	1,069	14,449	10,750	74.4	196	1.4	28	0.2	1,957	13.5	1,515	10.5
Dernah Fur Baladiyah	392	5,735	3,187	55.6	62	1.0	15	0.3	1,456	25,4	1,013	17.7
El Gubbah Baladiyah	1,654	14,423	12,909	87.1	197	1.3	390	3.0	1,017	6.9	2332	1.7
Ayn Marrah Fur Baladiyah	291	2,063	1,564	75.8	94	4.5	11	0.5	223	11.0	170	8.2

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Tables 15: 49-50: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 15:52: (in Arabic)

Note: This table includes only those holdings actually cultivated in 1974.

Fig. 8·5 AGRICULTURAL LAND USE



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

part of the increase in yields in the last decade. It has also helped to extend cultivation into areas which were too dry or had too short a growing season. It has accounted for 25% of the yield increase of cereals between 1950 and 1970 (J.A.A., 1978). Moreover, recent experiments with under rainfed production of cereals and legumes of different varieties revealed possibilities for further increases, for instance grain yields for some durum wheat varieties reached 6.0 to 6.5 tons/ha., for bread wheat grain yields of up to 6.0 tons/ha. were recorded, while for barley ceiling yields of 5.7 to 6.0 tons/ha. were gained. At the same time, the average yield per field was about 1 ton/ha., which is considerably lower than experimental yields (Khalifa., 1984). The yields obtained in the Faba Beans trial at El Marj averaged 1.8 tons/ha. with a maximum of about 2.2 tons/ha/. while the average yield obtained by farmers was 0.5 tons/ha. (Khalifa, 1984).

In the El Marj area, farmers' houses have been purposely located as close as possible to their farms in order to minimise travel time to and from the farm. Thus there is a concentration of housing on the southeast and northeast sides of the old El Marj Town. The advantage of this is that farm yard manure and crops can be easily carried back and forth.

The Ayn Marrah area covers over 2,063 ha. of cultivatable land, much of which is as yet largely undeveloped. Rainfed farming occupies 95.5% of the total agricultural land, while traditional irrigated farming practices take up the remaining 4.5%. A particular characteristic of the area is the highly fertile alluvial soils of the valley lowlands and the narrow terraces. These are used intensively as irrigated farms in wadi culture.

The principal crops of the Ayn Marrah area are vegetables. These cover 4.5% of the total cultivated land. This is a high proportion compared with the other sample areas. The temporary crops and fallow land occupy 86.8% of the total cultivated land, extending outside the major farming area. The remaining percentage is under permanent crops, about 8.7% of the total cultivated land. The irrigation areas, especially those in the upper parts of the valleys are similar throughout the region. They start in the front head of the springs water, and take in the narrow valley. The latter is usually set off by a steep ridge 2-4m high. The valley floor is level and usually between 50 and 109m wide, but can attain a width of 200m in the upper parts of the valley. A system of embankments and terraces has been constructed across the valley floors, dividing the land into individual plots. This system leaves a space several metres wide between the embankment and the slopes at the low section of the valley at Sersera. This is used intensively for irrigated tree farms (Plate 8.1). Thus small subsistence farms dominate the land within the valleys.

The Dernah area is in a less favourable environmental position than the other areas, being on the eastern side of the Jebel El Akhdar. Here shifting agriculture and rainfed cultivation dominate. In the Dernah Fur Baladiyah sub area, 55.6% of the total cultivated land is taken up by temporary crops. A further 25% is temporarily fallow and used for pasture. This occurs mainly in the southern part. The remainder is under vegetables and other permanent crops and this is found mostly in the market garden area near Dernah City. No doubt this picture has completely changed now in the Dernah area, particularly after the development of El Fatayah area, because some Dernah city farmers moved

Plate 8.1 Ayn Marrah traditional farming area

to the new farming area of Fatayah because of the urbanisation of some agricultural land.

The most common crops within the Jebel El Akhdar Region are wheat, barley, maize, legumes and melons. Potatoes, melons and some vegetables are grown in ridged plots and most of the vegetables are planted in basin fields, known as "Jadula", or on terraces. Crops are described locally as shatwe (winter) or sayfi (summer), depending upon when they are sown, but the same crop may be grown as sayfi and shatwi. Shatwi crops are sown in autumn and harvested in the following spring or early summer. As many as possible of the summer sayfi crops are grown to ripen before, or reach their period of maximum growth after the period of maximum transpiration, and water requirement and may be divided into three groups : (a) spring crops; sown and harvested before mid summer; (b) summer crops sown in spring or early summer and harvested in autumn, mainly being vegetables and fruit; (c) autumn crops; sown after mid-summer and harvested in autumn or early winter.

Individual crop patterns are influenced by variations in temperature between the coastal areas, such as Dernah, and the higher altitude inland areas such as El Marj and Ayn Marrah. The El Marj area has an advantage for spring and summer crops because they ripen earlier here than in the other areas. Market prices are higher for these crops from the El Marj area, in the early part of the season than for the same crops in the other areas. On the other hand, autumn and late summer crops in the El Marj plain are adversely affected by southern winds, known as "Gibli" whereas Dernah and Ayn Marrah are less affected by these winds because of their physiographic position.

Irrigated Land

Table 8.8 deals with the general pattern of land utilisation with regard to water resources. The cultivated areas are effectively determined by the amount and variability of annual rainfall. In the Jebel El Akhdar the rainy season occurs in the winter when the evapotranspiration is at its lowest. Consequently, in the wetter areas, there is a small water surplus during this part of the year. Thus in the El Marj and Dernah areas more than 90% of the total cultivated land is dry farmed. But in El Gubbah and Ayn Marrah dry farming decreases to about 80% of the total cultivated area.

On the other hand the irrigated area covers 4.7% of the total arable land and the unproductive area is 14.5% of the total agricultural land in Ayn Marrah. The same increase in irrigated land has been noticed in Dernah Fur Baladiyah which make up about 2.3% of total agricultural land in the area. Most of the irrigation in Ayn Marrah and Dernah Fur Baladiyah comes from wells and springs. In addition, wells were developed for irrigation in the El Fatayah area in the late 1960's. Irrigated land in El Marj Baladiyah and El Marj Fur Baladayah is only 1.7% and 4.0% of the total arable land, respectively. It is concentrated in the El Marj plain in the lowest part of the Gharigh Basin and on the south fringes of the plain the Zarada area.

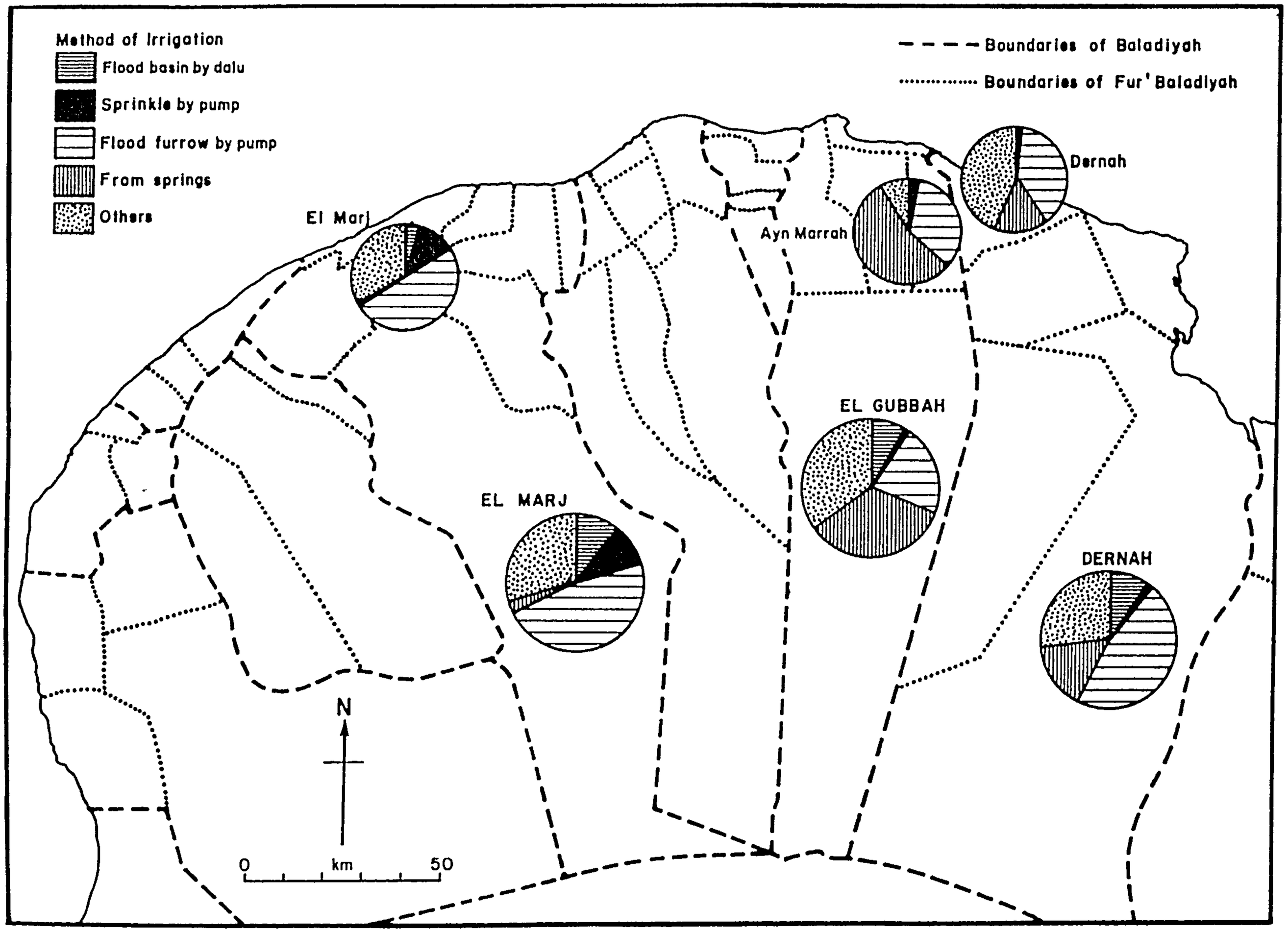
Table 8.1 illustrates the average size of irrigated farms at different localities. There are more irrigated farms in Dernah Fur Baladiyah than in El Gubbah Baladiyah or Ayn Marrah Fur Baladiyah. El Marj Baladiyah and El Marj Fur Baladiyah have the smallest number of irrigated farms. Despite this, the two latter areas have much irrigated land with an average irrigated farm size of 12 and 8 ha. respectively.

Table 8.8: Type of Land Utilisation with Method of Irrigation:

Administrative Division	Total Agricultural Land ha.	Cultivated Land Irrigated ha.	Rainfed ha.	Total ha.	Unproductive Land ha.	% Irrigated to total Cultivated land	% Rainfed to total cultivated land	% Unproductive to total farm land
El Marj Baladiyah	110,068	1,782	102,602	104,385	5,683	1.7	93.2	5.1
El Marj Fur Baladiyah	23,024	912	21,253	22,166	858	4.0	92.3	3.7
Dernah Baladiyah	15,259	257	14,248	14,305	753	1.7	93.4	4.9
Dernah Fur Baladiyah	6,227	142	5,623	5,766	461	2.3	90.3	7.4
El Gubbah Baladiyah	16,583	267	14,813	15,080	1,503	1.6	89.3	9.1
Ayn Marrah Fur Baladiyah	2,429	115	1,963	2,079	349	4.7	80.8	14.5

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Tables 6:15: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 6:16: (in Arabic)

Fig. 8·6 PROPORTION OF IRRIGATED FARM LAND BY METHOD OF IRRIGATION



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

In Dernah and Ayn Marrah Fur Baladiyah the average size of the irrigated farms is much smaller (0.37 and 0.96 ha., respectively). In these two areas the larger farms are dry-farmed and have an average size of 25.9 and 11.0 ha., respectively.

The variation of farm size in the two areas is due both to inheritance and the limited availability of water from wells also the physiographic unit defines a pattern of small farm plots, as in the terrace farms in Dernah Wadi (Plate 8.2). The same situation exists in Ayn Marrah further increasing the amount of unproductive land.

A factor affecting the agricultural area near Dernah City particularly is the urbanisation of agricultural land. On the other hand, at Ayn Marrah the main factor causing loss of agricultural land is soil erosion, particularly land slides on the slopes of the valley which especially affect Dernah valley terrace farms.

These factors act against an extension of traditional irrigated farms. However, El Marj plain has increased the number of modern irrigated farms for the following reasons : firstly, El Marj plain has a vast amount of arable land without physiographic limitation; secondly, the water resources in the area are from deep, underground water; and thirdly, the farmers have invested capital in order to obtain the optimum use of irrigation water and so increase their production as commercial enterprises. Therefore, the size of irrigated farms in El Marj plain is larger than in other areas. The irrigation method is basin or furrow irrigation which ensures a reliable and controlled flow of water and maintains the fertility of the soil which has contributed to the development of a highly productive agricultural system. This process is critical from the point of view of the long term stability of

Plate 8.2 Wadi Dernah terraced farms

the system.

The attempt to make more effective use of the region's water resources has resulted in the disappearance or transformation of many small scale irrigation systems. Even where locally constructed and controlled systems have not been incorporated into large scale multiple purpose projects, they have frequently been 'modernised' with permanent diversion structures and concrete-lined distribution can also be seen in certain farms in the Dernah City and Ayn Marrah areas. In addition, some farms in the El Marj plain have developed a sprinkler irrigation system and others are experimenting with a subterranean irrigation system.

While the pace of change has undoubtedly accelerated in the last decade in the country as a whole, traditional methods of water management are still to be found within the region as can be seen from Table 8.9 and Figure 8.6.

However, traditional methods of utilisation of ground water have been affected by the spread of modern well-drilling and pumping technologies, particularly in El Marj Fur Baladiyah and El Marj Baladiyah, where as much as 61% and 56% respectively of all irrigation areas use pumps. In that instance the level of pump wells is small compared to irrigation areas in the remainder of the region. This is due to most traditional farmers depending upon hand-dug wells for water supplies which have been adopted to modern electric or diesel pumps.

Irrigation from springs in El Gubbah Baladiyah and Ayn Marrah Fur Baladiyah is quite high, comprising 34% and 55% of all irrigation of these two areas respectively. This percentage is very low in El Marj region and is about 15% in the Dernah area. (Table 8.9).

Table 8.9: Agricultural Water Resources:

Administrative Division	Holdings with Water Resources No.	Holdings with Water Resources Area ha.	Water Resources: No. of Wells Dug	Water Resources: No. of Wells Artesian	Water Resources: Cisterns	Water Resources: Springs	Percentage of Irrigated Area ha. Method of Irrigation: By dalu	By Pump: Sprinkle	By Pump: Flood	Area Irrigated: Springs	Area Irrigated: Other	Total Irrigated Area
El Marj Baladiyah	2,001	74,027	478	98	5,554	64	10.5	10.3	46.6	2.8	29.8	100
El Marj Fur Baladiyah	360	14,854	126	25	412	4	4.2	12.0	49.8	0.5	33.5	100
Dernah Baladiyah	350	4,752	141	32	104	16	9.4	1.4	46.8	15.5	26.9	100
Dernah Fur Baladiyah	255	3,502	74	26	51	1	0.3	0.5	39.5	15.8	43.9	100
El Gubbah Baladiyah	369	3,347	161	120	72	58	8.0	1.0	22.0	34.0	35.0	100
Ayn Marah Fur Baladiyah	162	1,112	58	62	34	36	1.0	-	36.0	55.0	9.0	100

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Table 39:136: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 39:133: (in Arabic)

a

b

c

Plate 8.3 Traditional irrigation system (a) irrigated reservoir (b) feeder canal (c) Jadula irrigation system

Some changes are occurring in the methods used to apply water to the soil, although surface methods of application, where water is spread across the field by gravity flow, continue to predominate. Surface irrigation usually involves the use of earth embankments enclosing irrigated plots in small basins or "Jadula" (Plates 8.3). The embankments serve to retain irrigation water on the land, and to mark property boundaries, particularly in the traditional farming areas of Dernah City and Ayn Marrah. This method of irrigation has increased throughout the region in recent times. Also, 'furrow irrigation' has been generally established in the El Marj area and has begun to make its appearance in the other two main areas. It is dominant in the developing areas and on traditional farms which use foreign labour. On the other hand, sprinkler irrigation is still used to a small extent due to the structure of the heavy clay soils and crop patterns which do not suit this method or irrigation and it needs heavy capital investment, further to the small size of traditional irrigated farms such as in Ayn Marrah and Dernah.

Off farm employment

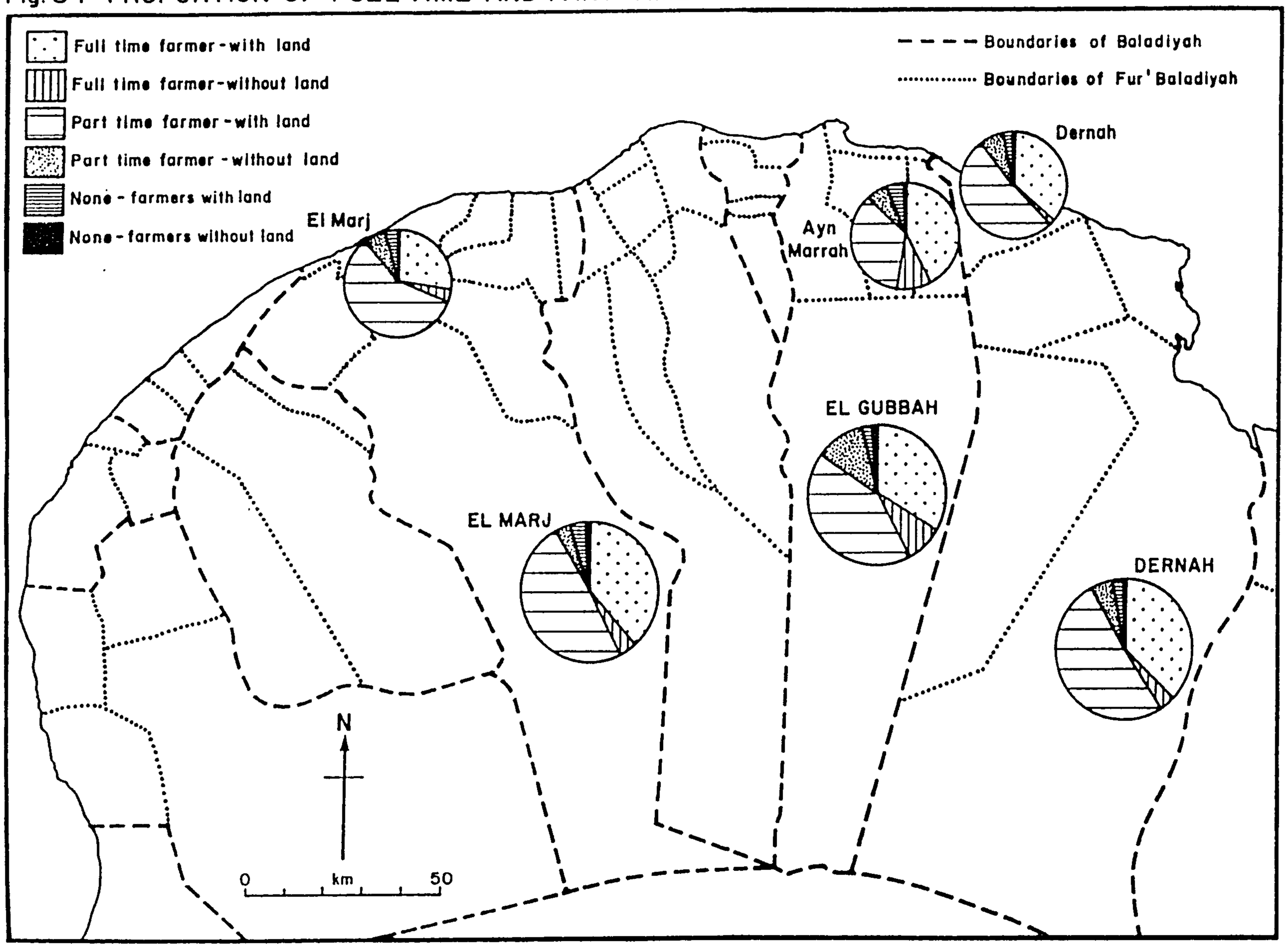
Table 8.10 and Figure 8.7 deal with the principal off-farm occupation of the farmer. This data indicates a high percentage of off-farm employment in the areas of El Marj Fur Baladiyah, Dernah Baladiyah and Fur Baladiyah with more than 50% of farmers employed off their farm. Ayn Marrah has the highest percentage of full-time farmers due to the settled agriculture in this area and the size and function of the population. Although El Marj and Dernah have a more favourable agricultural environment than El Gubbah and Ayn Marrah, the percentage

Table 8.10: Off Farm Employment of the Farmer:

Administrative Division	Full Time Farmer With Land	%	Full Time Farmer Without Land	%	Part Time Farmer With Land	%	Part Time Farmer Without Land	%	Absentee Farmer With Land	%	Absentee Farmer Without Land	%	Total	%
El Marj Baladiyah	1,578	38.6	163	4.0	2,021	48.5	145	3.6	152	3.8	28	0.7	4,087	100
El Marj Fur Baladiyah	271	27.3	40	4.0	569	57.5	62	6.3	40	4.0	9	0.9	991	100
Dernah Baladiyah	446	37.3	44	3.7	609	51.0	63	5.2	29	2.4	4.0	0.3	1,195	100
Dernah Fur Baladiyah	164	36.6	5	1.1	233	52.1	31	7.0	13	3.0	1	0.2	447	100
El Gubbah Baladiyah	719	33.9	173	8.2	900	42.4	249	11.7	56	2.6	26	1.2	2,123	100
Ayn Marrah Fur Baladiyah	138	43.7	32	10.0	111	35.4	22	6.8	18	5.5	2	0.6	323	100

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Table 4:10: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 4:14: (in Arabic)

Fig. 8·7 PROPORTION OF FULL TIME AND PART TIME FARMERS



Source: Ministry of Planning (1979) The 1974 Census of Agriculture, Tripoli, Libya (in Arabic)

of off-farm employment is greater in the former areas because of their greater urban development.

There is a strong inverse relation between off-farm employment and crop diversification, because crop diversification is time-consuming. This is in direct conflict with off-farm employment. In addition, the contradiction of the latter with the type of land tenure and pattern of land utilisation have shown the comparative advantage of the spatial pattern of agriculture in the region (Jones, 1984). This is explained by increasing the number of rainfed farms (mainly cereals) accompanied by growth of rented land for a fixed amount in El Marj area. The predominance of rainfed production, mainly cereals, is in inverse relation to crop diversification. The same is repeated in Dernah Baladiyah area.

Nevertheless in Dernah Fur Baladiyah, El Gubbah Baladiyah and Ayn Marrah Fur Baladiyah, the percentage of off-farm employment decreases crop diversification and share-crop production increase. Ayn Marrah Fur Baladiyah, has the highest proportion of full-time farmers (Table 8.10) because of the high percentage of squatter's in this area (Table 8.6). An increase in off-farm activity is related to an increase of rented land, involving up to 51% of the total land tenure in El Marj Fur Baladiyah (Table 8.6). Taking an off-farm job is seen as a risk reducing action owing to the unreliability of farm income in the region (Jones, 1982).

The ratio of full-time and part-time farmer without land has increased because they have invested capital in livestock and have employed other people as shepherds on fixed wages. This percentage has increased in the grazing areas of El Gubbah Baladiyah while in Ayn

Marrah Fur Baladiyah the percentage of part-time farmers without land has decreased as a result of the new pattern of static irrigated agriculture. The proportion of absentee farmers varies from 2.4% in Dernah to 5.5% in Ayn Marrah reflecting differences in rural to urban migration.

The Use of Mechanisation:

Table 8.11 : Agricultural Machinery

Administrative Division	No. wheeled tractors	Total Cultivated land ha.	Average hectares per tractor
El Marj Baladiyah	447	84,224	188
Dernah Baladiyah	101	14,449	143
El Gubbah Baladiyah	204	14,423	70

Source : Computed from : Secretariate of Planning (1979) Agricultural Census 1974, Jebel El Akhdar, Tripoli (in Arabic), Table 40: 140; and Secretariate of Planning (1979) Agricultural Census 1974, Dernah, Tripoli, Table 40; 136-37 (in Arabic).

Table 8.11 shows that the amount of mechanisation is small in relation to the agricultural operation. It also indicates that there is regional variation in the use of machinery. This is due to : firstly, the intensity of cultivation is greater at El Gubbah and Dernah Baladiyah than El Marj Baladiyah respectively; secondly, growth of agricultural population density in El Gubbah and Dernah Baladiyah; thirdly, the predominant private holdings have encouraged farmer investment in agricultural machinery; fourthly, to compensate for farm labour shortage, and part-time farmers. On the whole, the standard of

mechanisation is low by comparison to other developing countries. It is also evident that there is an imbalance in the distribution of mechanisation within the Jebel El Akhdar. For example, El Marj Baladiyah has an area of cultivated land which is six times larger than Dernah and El Gubbah Baladiyah, but El Gubbah has twice as many tractors as Dernah and two and a half times as many as El Marj. Although there is government assistance for purchasing agricultural machinery, there are still problems with the lack of skilled operators and repair shops.

So the use of agricultural mechanisation is necessary at the moment because of the lack of agricultural workers in the busiest times and to increase production. With regard to the sort of mechanisation which was prevalent in the region by the 1980's, most farmers have used machines to replace animal power in farming. Most farmers do not need a large number of labourers for ploughing, irrigation and the threshing of grains.

The increase in the number of agricultural machines is a result of the development of agriculture since the beginning of 1980. The co-operatives bought the machinery and hired it out at low prices to the farmer. Hence the small farmers became able to use agricultural machinery like others. The government has encouraged the private sector to invest in agricultural machines free of tax. Many of the rich farmers bought modern machines for their farm and for hire at a low price to other farmers.

Agricultural Productivity

Overwhelmingly, the aforementioned inputs are summarised by variation in agricultural production in the area. Crop yield varies

Table 8.12: Agricultural Productivity in the Region:

Administrative Division	Wheat		Barley		Peas			Beans		
	Seed kg/ha	Yield kg/ha	Seed kg/ha	Yield kg/ha	Seed kg/ha	Yield kg/ha	% Irrigated Area of seeded	Seed kg/ha	Yield kg/ha	% Irrigated Area of Seeded
El Marj Baladiyah	50.4	284	49.9	387	50.0	350	66.6	202.0	750	91.6
Dernah Baladiyah	35.8	258	29.1	408	65.0	141	28.0	69.0	344	100.0
El Gubbah Baladiyah	36.0	149	31.9	333	41.9	345	98.0	-	-	-

Source: Computed from: (1) Secretariat of Planning (1979), Agricultural Census 1974, Jebel El Akhdar, Tripoli, Table 59:197: (in Arabic).
(2) Secretariate of Planning (1979), Agricultural Census 1974, Dernah, Tripoli: Table 52:192-193: (in Arabic)

from one area to another within the region. Variation is most pronounced in the rainfed crops.

Table 8.12 shows agricultural productivity in the region. This is related to the level of agricultural inputs which is very low. The productivity of irrigated and rainfed areas differs completely. The yield of legumes per irrigated hectare is five times that of rainfed production. Thus water is the decisive factor in land productivity in the area.

The intensity of cultivation, including the frequency with which a parcel of land is cultivated, clearly has a significant effect on the net income and output in farming. It is also a reflection of intensity of cultivation and technology. Hence, a good indication is the low intensity of labour and low standard of mechanisation, leading to low land productivity in El Marj area, but the opposite is true in the other two areas.

The analysis indicates that there is substantial scope for increasing productivity in Dernah and El Gubbah where it occurs in association with availability of irrigation facilities, a high level or agricultural input, small holdings, and a high density of population. In these two areas the physical environment is less favourable than in El Marj, but the manmade environment is more profitable.

Finally, low agricultural productivity is mainly due to the physical limitations of soil and insufficient moisture supply, in addition to low levels of agricultural inputs. This has been indicated by the low yield of grain production per hectare in the region. These phenomena are quite obvious in the dry farming production in the region, but the government has subsidised farm input and output to sustain the

farmer's standard of living and limit rural/urban movement as a result of stagnant agricultural productivity.

CONCLUSION

The specific issues of physical and human resources discussed in this chapter make possible a general overview of the agricultural situation in the Jebel El Akhdar region. Regrettably, the available information has so many gaps and inconsistencies that it is rather difficult to obtain an accurate view of the situation for any single year.

However, the general picture of the region illustrates the pattern of land utilisation, as a result of the farmer's activities. This can be divided into subsistence farmers, and more efficient farms such as commercial ones, or mixed.

On the other hand, the agriculture in the region has faced a number of problems caused by either physical environmental hazards or human aspects. Certainly, the reduction of available human resources between 1964 and 1974 has been a direct result of oil production by encouraging migration away from the rural area. Thus agricultural productivity has become stagnant such that the share of the agricultural sector in the Gross National Product declined to one half from 1964 to 1972. Therefore, the region's agriculture is responding to changes in the country's economy and society as well as to the agricultural development programmes. It faces structural problems of landholding, labour supply and mechanisation which are a reflection, not only of its internal geography conditions, but those pertaining to Libya as a whole.

Finally, the region's agriculture and food production can not be considered separately from the conditions elsewhere. It is far from

being a closed system; indeed, the region is increasingly involved in interregional development. This has been achieved by state intervention through the motivation of the farmers to be sensitive to government efforts to revive productivity in the agricultural sector.

CHAPTER NINE

AGRICULTURAL DEVELOPMENT IN THE JEBEL EL AKHDAR REGION

INTRODUCTION

The present status and development potential of the agricultural sector of the libyan economy has come about through what one might call autonomous changes in behaviour, in response to changes in the natural and human environment. Recent changes in agricultural productivity and output, food production and consumption and general measures of level of living have been used to indicate overall progress in the nation's agriculture.

A brief mention should be made of three concepts that are used throughout this discussion to outline the general features of the Libyan economy during the last three decades. These are the level or structure of economic activity, the rate of economic growth, and the planners view of strategies for the development of the agricultural sector.

General Economic Situation

The development of the petroleum industry has changed Libya from one of the economically least favoured nations in the world to one of the richest countries in Africa, in terms of foreign exchange (Allan, 1981).

Before the advent of oil exports, primitive agriculture constituted the largest sector of the Libyan economy. It employed as much as 70 per cent of the Libyan labour force in 1960, and contributed 30 per cent of the GDP. The reasons for such low productivity were those that

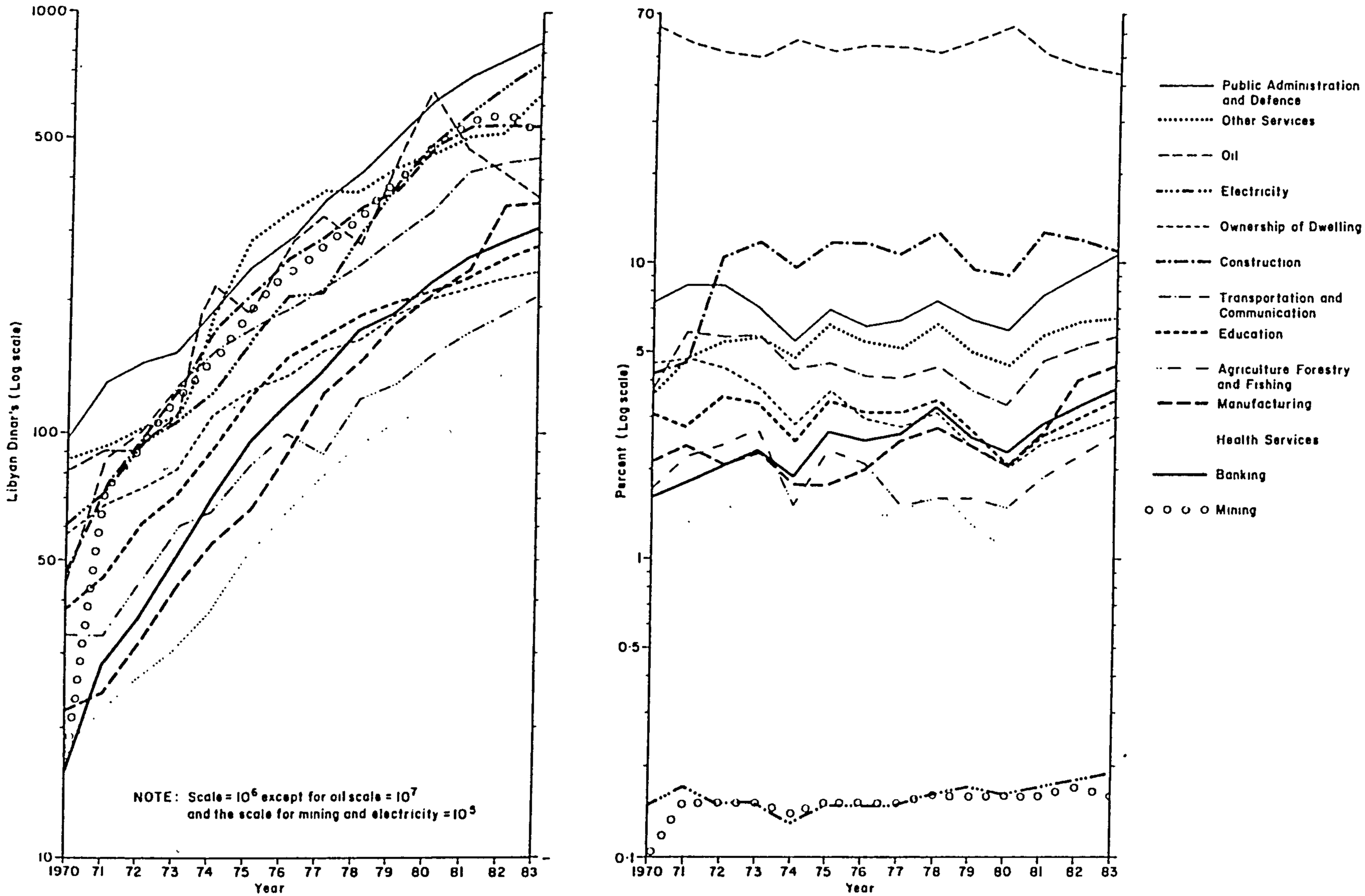
characterise most traditional agrarian pursuits, such as the absence of capital and technology, plus reliance upon poor land with inadequate water resources. The situation did not differ much in the industrial sector of the economy which employed between 15-20 thousand people and contributed 10 per cent of the GDP in 1958. As to the other sectors of the economy their insignificance was primarily due to the absence of any capital investment (I.B.R.D., 1960).

Therefore, during the 1950's roughly one half of all Libyan expenditure came from foreign grants or loans to meet the basic social, cultural and administrative demands of society (Table 9.1), with the result that the per capita income in the 1960's was estimated at 42 dollars per year (LD.14) (Farley, 1971).

In the early 1960's, oil revenues replaced aid and by 1965 Libya was beginning to feel the benefits of oil exports. The effects of the growing oil sector on the rest of the economy has been fundamental and diffuse, as the oil sector plays a dominant role in production and exports and in financing the large development programmes of the country. As a consequence, development planning is restricted by the overall absorptive capacity of the economy rather than by the scarcity of capital, 70 per cent of which is earmarked by law for development and modernisation projects.

In 1964 oil revenue constituted more than 50 per cent of the total domestic product of the country. In 1969, it represented 75.7 per cent of GDP. With the big increase in oil prices at the end of 1973 and at the beginning of 1974 the share of the oil sector in the gross domestic product decreased to 58.4 per cent (Fig.9.1). Although the quantities of oil exports have been steadily declining, the value of exports more

Fig. 9·1 GROSS DOMESTIC PRODUCT AND NATIONAL INCOME OF LIBYA, BY SECTOR 1970-1983 AT CURRENT PRICES



Source Minister of Planning, 1984 Economic and Social Indicators in Libya, Tripoli, Table 6.1, p.25 (in Arabic)

Source Secretariat of Planning (1984) Economic and Social Indicators in Libya, Table 6 2, p 26 (In Arabic)

TABLE 9.1

Summary of public finances 1954/55-1958/59

	1954/55	1955/56	1956/57	1957/58	1958/59
Expenditures	8,797	12,978	15,433	17,031	19,179
Local Revenue	5,549	7,061	8,147	9,595	12,049
Foreign Revenue	5,641	6,270	7,234	12,069	11,045

Source : I.B.R.D. 1960, The Economic Development in Libya, Johns Hopkins Press, Baltimore, Table 1 : 48.

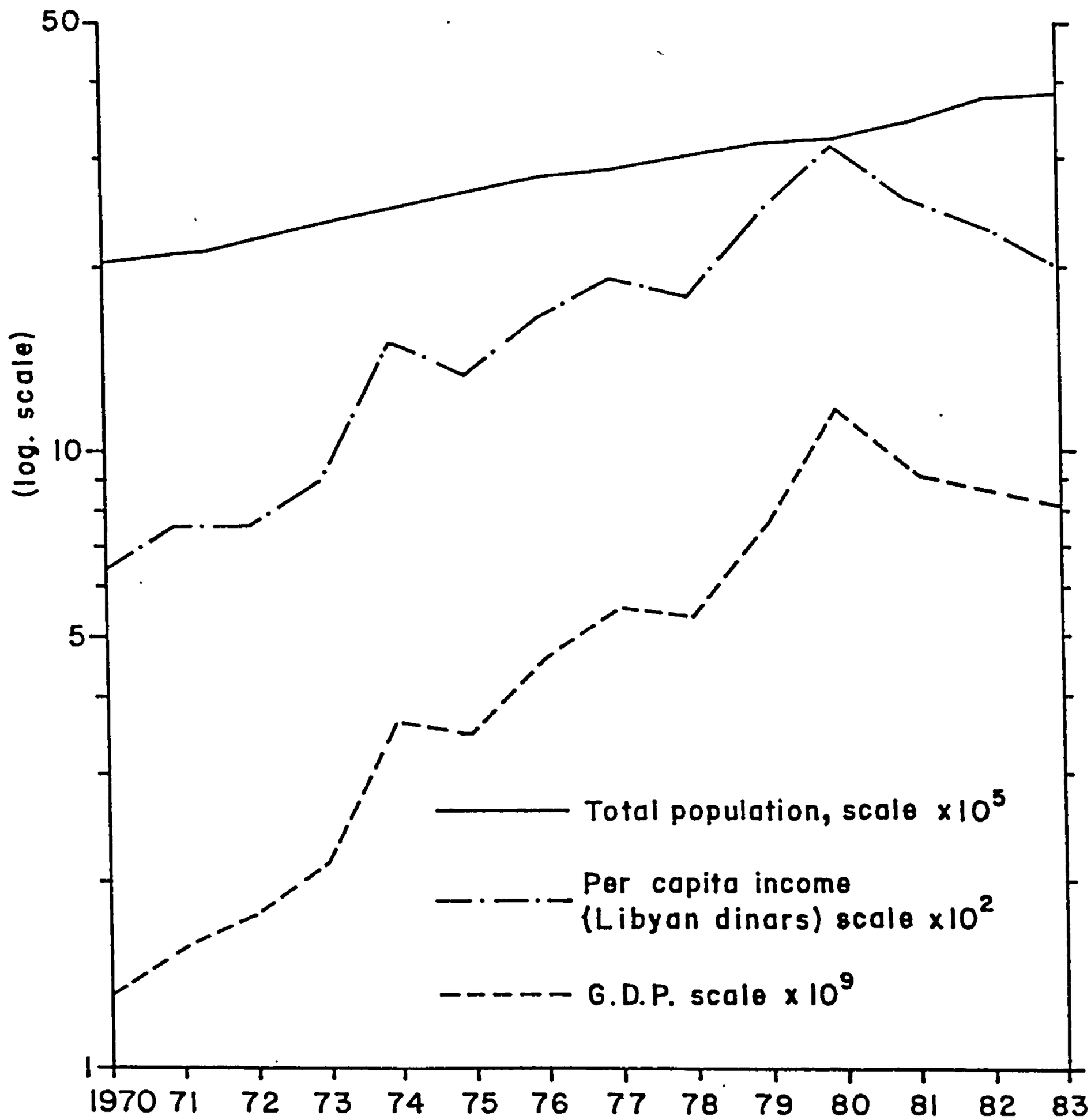
than doubled from 1973 to 1974 as a result of the price increase, and resulted in the government's policy of conserving the country's natural resources for the longest possible period and gearing the oil revenues to overall development objectives (Barker and McLachlan, 1982).

In this way the Libyan economy has been dramatically transformed during the last two decades, from a deficit economy to a surplus economy indicated by the gross national product which has increased every year since 1960 until 1984. Libya's total gross national product (calculated at 1962 prices) was $181 million in 1959 and $475 million in 1963; corresponding per capita GNP has gone from $154 to $379 (Allan, 1981; El Mallalk, 1969; El Fathaly and Palmer, 1980).

Post 1962, the Libyan economy achieved systematic and accelerated progress, primarily as a result of the exploitation of the country's oil resources. GDP annual growth rate 1960-69 and 1970-81 was 18.8, and 21.5 per cent respectively measured in constant prices. At the same time, the average per capita income increased from under £L 104 in 1960 to over £L 300 at the end of 1968 (Allan, 1981) and it continued to rise from LD 642 in 1970 to LD 3,154 (calculated in current prices) in 1980, and decreased to LD 2086 in 1983 (Figure 9.2). The annual growth of per capital income during the last decade was 15.7% which was considered among the highest rate of per capita increase in the world, then it decreased to 9.5 per cent between 1970 to 1983 (Ministry of Planning, 1981). As a result of this, a substantial rise was possible in the standard of living.

However, a comparison of the structure of the economy from percentage of economic activity of GDP during the 1950's with those of the 1960's is displayed in (Appendix 9), and comparison of that for the period after 1969 to 1983 indicated the predominance of the petroleum sector in the last two decades, which formed in 1974 more than 63.0% of the total GDP, then its subsequent relative decline to 52% in 1978, and to 44.6 per cent from GDP in 1983. On the other hand Figure 9.1 showed that the contribution of construction is roughly twice that of wholesale and retail trade and transportation and communication, as a result of the nationalisation of the private sector. Further, the public sector had contributed somewhat more than other sectors to realise the equality and social security for the people. But the production sector, which is mainly represented by the agricultural and industrial sectors, has made

Fig.9·2 ANNUAL AVERAGE PER CAPITA ESTIMATES OF INCOME, 1970-83 AT CURRENT PRICES



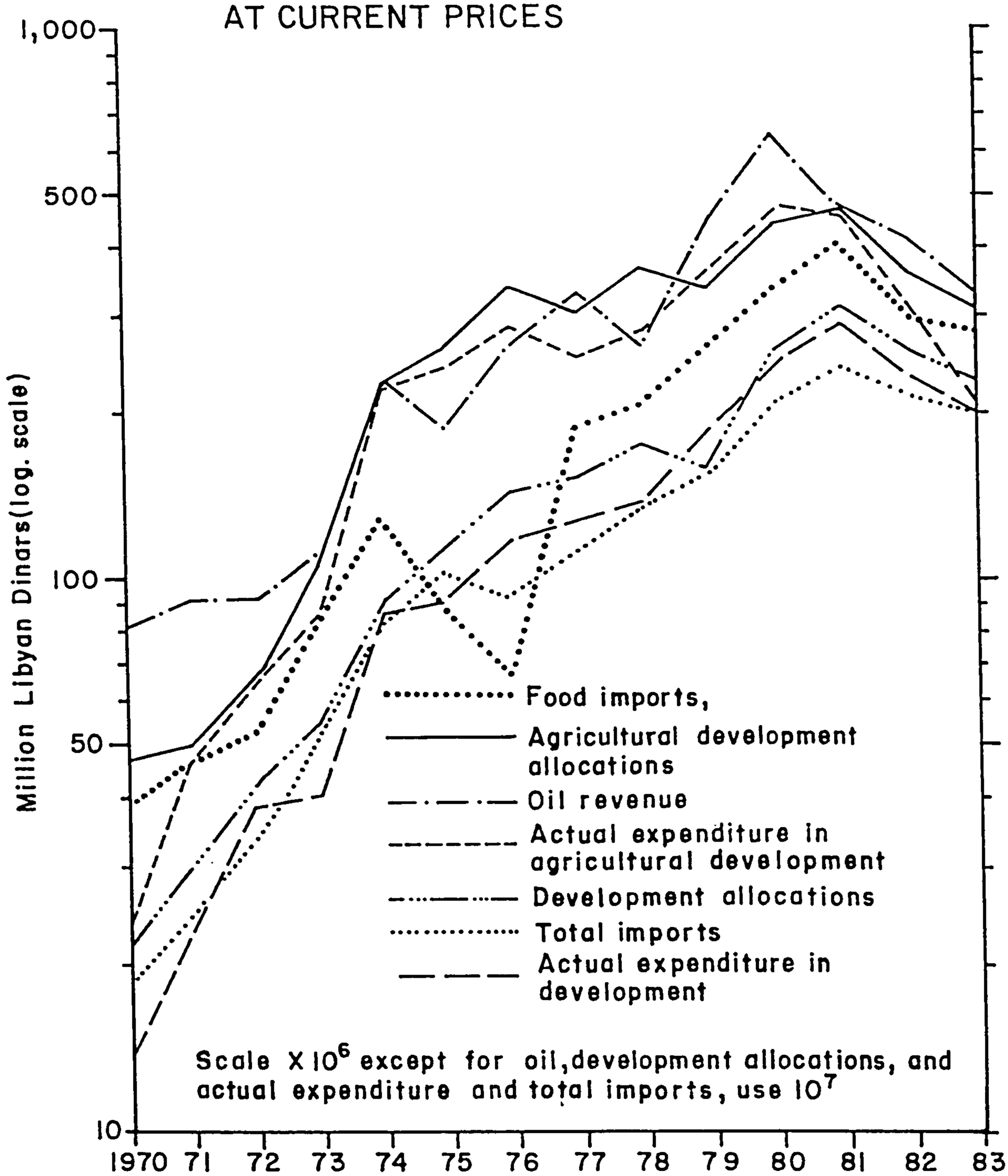
Source: Secretariat of Planning (1984), Economic and Social Indicators in Libya, Tripoli, (in Arabic)

less contribution to the GDP during this period. In other words, the rate of growth in agriculture is declining as other sectors grow rapidly. Agriculture's share in GDP declined in 1958 from 26.1 per cent to 2.6 per cent in 1970.From 1970 to 1980, the proportion of GDP contributed by agriculture dropped from 2.6 to 1.6 per cent; and it increased to 2.6% in 1983, which indicates that it is more or less stagnant in its output. Moreover, the agricultural labour force decreased substantially from 29.1% to 19.6% of the total labour force in 1975 and dropped to 18.9% in 1980. It decreased further to 14.7% in 1983. This provides another indication of the long term decline of agriculture.

The significance of these trends is that Libya is gradually eliminating its options for future food production strategies (self sufficiency and self-reliance). Imports of agricultural products from 1963 to 1981 grew from (LD 85.3mn, to LD 2481.4mn.) an increase of up to 18 per cent per year (in constant prices 1970). Thereafter, it dropped to LD 2040mn. in 1983 (Fig.9.3) and Appendix 12) in particular, imports of such key food items, eg. sugar, tea, rice, flour, coffee, etc. increased revealing rising dependence on foreign sources. The growth of food imports resulted from the low productivity of the land and the availability of oil revenues.

By 1980 the Libyan economy was faced with various problems, mainly the fall in income from oil as a result of the drop in prices and a decrease in production (Fig.9.1). This loss of income affected the country's ability to continue its development planning. This is stated

Fig. 9·3 OIL REVENUES, DEVELOPMENT ALLOCATIONS AND ACTUAL SPENDING IN AGRICULTURAL SECTOR AND FOOD IMPORTS, 1970–1983 AT CURRENT PRICES



Source: Secretariat of Planning (1984), Economic and Social Indicators, Libya, Tripoli (in Arabic)

by Ghanem (1985; 228) :

> "The government felt it could no longer finance this high level of imports and declared its priorities in general terms under the slogan of "maximum arms and minimum food" - policies unlikely, incidently, to encourage widespread popular support. The new 'more guns, less butter' policy meant that military expenditure would not be subject to any reductions and that any economies would be directed towards consumption. The government's first measure was to stop the importation of a number of commodities which it considered 'unnecessary'. It also started preparing what it called the 'commodities budget', which was a sort of quota system for imported goods, including only those it considered necessary". Cars, televisions and videos were 'temporarily' excluded from the list of imports for two years. Despite these efforts, austerity measures on imports did not help to save much money and the government had to resort to applying an austere policy to development".

This statement highlights the economic situation in the last five years, and it explains the drastic cuts in the economic sectors after 1980 (Figs, 9.1, 9.2, and 9.3).

However, the agricultural dynamic could be discussed in terms of food self-sufficiency, which can be measured in respect of the growth of domestic agriculture production (Fig.9.4) and the contribution of these products to the total demand (Table 9.2).

Compared with a population growth rate of 5.3 per cent, these agricultural commodity increases are encouraging. Indeed the average growth ranges between 10-15 per cent, which reveals self-sufficiency in some domestic requirements. The total figures of production reveal that imports are increasing because food production is inadequate.

The country is self-sufficient or nearly self-sufficient in eggs, poultry, barley for human consumption and vegetables. In wheat the self-sufficiency ratio has improved from 18.1% in 1975 to 27.7% in 1980 and is projected to attain up to 45.5% in 1985. Thus, the dynamic of agriculture is less impressive for food self-sufficiency than is indicated by self-sufficiency ratios alone, since the country is heavily

TABLE 9.2: Self Sufficiency Ratios in 1980 and 1985:

Commodity	1985				1980			
	Production	Demand	Import	Self Sufficiency %	Production	Demand	Import	Self Sufficiency %
Wheat*	247.5	544.0	296.5	45.4	122.0	440.0	318.0	27.7
Barley**	34.0	34.0	-	100.0	66.5	66.5	-	100.0
Rice	-	75.9	75.9	0.0	-	51.6	51.6	0.0
Other Cereals	6.0	6.0	-	100.0	6.0	6.0	0.0	100.0
Total	287.5	659.9	372.4	43.6	194.5	564.1	369.6	33.8
Legumes and Nuts	12.0	58.0	46.0	20.7	12.6	29.6	17.0	42.6
Vegetables	779.0	779.0	-	100.0	564.0	168.4	104.4	84.4
Fruits	184.0	358.0	174.0	54.8	160.0	318.0	156.6	50.5
Sugar	-	140.5	140.5	0.0	-	110.0	110.0	0.0
Oils	36.0	74.4	38.4	48.4	23.0	61.7	33.7	45.4
Meat	70.0	164.0	94.0	42.7	53.7	137.7	84.0	35.0
Fish	7.0	48.2	41.2	17.0	4.0	11.7	7.7	34.2
Eggs	30.0	30.0	-	100.0	16.4	16.4	-	100.0
Milk & Milk Products	140.0	310.1	170.1	45.1	110.0	250.1	140.1	44.0

* The difference from total import is due to changes in stock
** Excludes Feed Requirements

Source: Szwed-Cousins, M, (1982), Libya: Industry and Agriculture El Hikma, London

dependent on imports of agricultural inputs and even on manpower for agricultural development. For this reason the state encourages the development of large scale, modern and fully commercial farming enterprises. This contributes to improving food self-sufficiency and more balanced regional growth by basing it on a huge investment in the development of large scale, intensive farms with better utilisation of modern methods and capital resources.

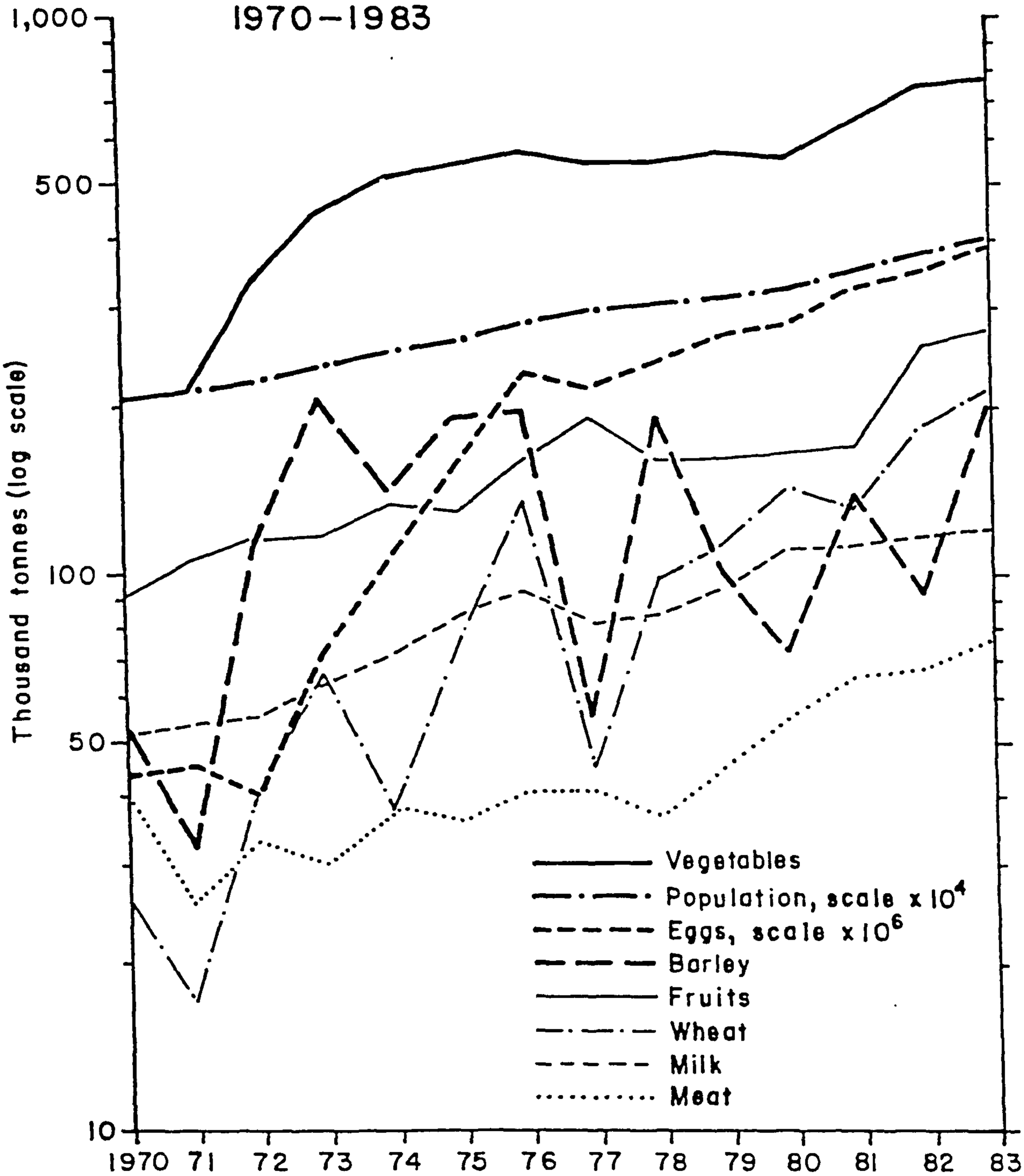
An example of this trend is that land used in commercial farming estates is changed to full economic use such as an El Gharigh apple farm in the El Marj plain and experimental farms in the El Fatayah area, in order to reveal the remarkable value of agricultural land, when it is used more intensively than normal. Consequently, it is recalled that the greater specialisation and professionalism threatens the survival of the traditional family farm systems. In this fight for the farmer, this is another reason to strive for the high level of intensive productivity.

Thus, high efficiency, profitability and competitive strengths in terms of land, labour and capital become the condition of agricultural existence and survival in the country. Thus explains the level of the private sector in agriculture which still exists in a socialist country.

The progress of agriculture in some sub-sectors and areas has been good, but in respect of growth rates, implementation ratios and the output in relation to huge investment, as compared to those in other sectors, the achievement of agriculture falls short of the expectation.

The second agricultural development plan made substantial achievements at the sectoral level which is reflected by the growth rate in GDP. It has been noticed that most sectors have achieved their

Fig.9·4 GROWTH RATE OF POPULATION AND MAJOR DOMESTIC AGRICULTURAL PRODUCT IN LIBYA 1970–1983



Source: Secretariat of Planning, 1984 Economic and Social Indicators in Libya, Tripoli, Table 10·1; P.50 (in Arabic)

planned targets (Table 9.3). Some sectors have even exceeded their planned growth rates such as the Electricity sector which has also witnessed a rapid growth, and which, apart from the role it played in raising the standard of living, has participated in the development of agriculture and industry through the motive power it provides, thus making the latter grow at an annual growth rate of 21.5 per cent. But the growth rate achieved in agriculture is considered as a very low rate in comparison with the planned growth rate and as against the heavy investments in this sector. This rate of 4.0 per cent is considered poor, because the nature of the physical environment of the country limits its planned annual growth rate. In spite of that, the growth of agriculture involved hundreds of thousands of hectares which were reclaimed and thousands of farms which were established and distributed among the farmers (see Table 2.1). It also reflects the substantial increase in the production of crops and agricultural commodities (Fig.9.4) which indicates that agricultural production did not respond adequately to the concentrated efforts in the development plan, because the constraints on the development of the agricultural sector are enormous, embodying physical and human factors (Allen, 1981).

Consequently, the notion of self-sufficiency is, from an economic efficiency point of view, questionable, even if self-sufficiency is defined as balanced trade in food products. Food production was to be accelerated at all costs to reduce dependence on imports (Fig.9.4). But it could be accepted as a basis for food production planning not only at the national level, but also at the state level (Oreibi, 1985; Ghanem, 1985).

As a net importer of food Libya has an economic if not a moral

TABLE 9.3: The Real Growth of the Gross Domestic Product by Economic Activity During 1976 - 1980
(At 1975 prices in LD million)

Economic Activity	1975 (Base Year)	1980 (Provisional)	Realised Annual Growth Rate %	Planned Annual Growth Rate %
Agriculture, Forestry and Fisheries	82.9	100.3	3.9	15.8
Mining of Oil and Natural Gas	1961.1	2399.4	4.1	7.8
Other Mining and Quarrying	20.7	32.3	9.3	10.3
Manufacturing Industries	65.5	171.1	21.2	30.7
Electricity & Water	17.6	46.7	21.5	23.0
Construction	434.7	632.5	7.8	12.5
Wholesale/Retail Trade Restaurants & Hotels	224.6	338.4	8.6	11.0
Transport, Storage and Communications	175.8	242.8	6.7	18.7
Finance, Insurance (Excluding Housing) & Business Services	98.9	181.7	13.0	14.0
Ownership of Housing	131.0	178.8	6.4	10.9
Public Services (Excluding Education & Health)	258.3	549.0	16.2	8.8
Educational Services	122.3	232.5	13.7	14.0
Health Services	51.6	127.7	19.8	12.0
Other Services	29.3	41.4	7.1	10.0
Real Gross Domestic Product distributed between:	3674.3	5274.6	7.5	10.7
Oil & Natural Gas Mining	1961.1	2399.4	4.1	7.8
Total non-oil Activities distributed between:				
Non-oil Activities (Excluding Public Services, Education and Health)	1281.0	1966.0	9.0	15.2
Public Services, Education and Health	432.2	909.2	16.0	10.5

Source: Secretariat of Planning (Undated):
Summary of The Socio-Economic Transformation Plan 1981-85, Tripoli, Table 3:7.

incentive to maintain food trade for the future. It has a food deficient economy (Allan, 1985). Libya is still, in 1984, dependent on food imports and these imports have been steadily increasing.

An important feature of the investment policy during the past decade was the priority given to the productive sector in line with the strategy which has been adopted since the advent of the revolution in 1969, with a view to setting up a diversified and dynamic economy no longer dependent on a single sector, and to avoid increasing dependency on foreign food. This is envisaged by the long term development plans despite natural resource constraints, and the availability of human resources.

Thus to study the government's economic and social development policies and their impact on agriculture is to analyse the different development plans submitted since 1963. The following discussion will outline the general perspective of these plans and examine the planned investments in the main sector of the economy and the relation to these investments to agriculture.

ECONOMIC DEVELOPMENT PLANS

Pre-1969 Development Plan

Pre-revolutionary Libya was faced with many problems in the stagnant productive sectors, such as agriculture and industry. The already huge oil income was used to finance imports and to raise the general standard of living, instead of being invested in the primary and secondary sectors. By 1963 a National Planning Council was created and presented the Five-Year Development Plan 1963-68 (extended to 1969), and

TABLE 9.4: Comparison of the Proposed and Actual Allocations, First Five Year Plan Period 1963-1968:

Proposed in 1963	£Lm	%	Estimated actual expenditure	£Lm	%
Agriculture	29.3	17.3	Agriculture	37.8	12.7
Industry	6.9	4.1	Industry	14.7	4.9
National Economy	2.9	1.1	Economics, etc.	2.9	1.0
Communications	27.5	16.2	Communications	52.7	17.7
Public Works	38.7	26.6	Public Works	87.3	29.2
Education	22.4	13.1	Education	25.9	8.7
Health	12.5	7.4	Health	8.7	2.9
Labour and Social Affairs	8.7	5.1	Labour and Social Affairs	13.8	4.6
Planning and Development	2.6	1.5	Interior	19.8	6.7
Public Administration	6.4	3.8	Housing	29.5	9.9
Total	169.1	100.0		298.2	100.0

Source: Allan, J.A. (1981) Libya : The experience of oil, Croom Helm, London, 84

1968-73 (started and cancelled in 1969). The main emphasis in the plans was on communications and public works, related to prospecting for oil from 1955 to 1970, where the actual expenditure on development totalled £D 298.2mn. (Table 9.4), with the proportion spent on Public works, being 29.2 per cent, on transport and communications 17.7 per cent, on agriculture 12.7 per cent, and on electricity 10 per cent of the total development budget. The sum allocated in this plan for agriculture and industry was mainly for the purpose of preparing research and feasibility studies on projects in Libya generally, but in Cyrenaica the plan provided for the rehabilitation and development of some 1800 ex-Ente farms on the Jebel El Akhdar. The plan specified the necessity for an intensive study of tribal land development and related problems, so as to enable the development of those lands in the future and to encourage settled agriculture, in addition to developing forests and range maintenance. Certain laws were also passed to rationalise its utilisation and the establishment of small forest plantations in El Marj, El Gubbah and Dernah and to increase production of forest seedlings. The range development programme included the establishment of areas for the production and storage of fodder, the encouragement of livestock owners to produce fodder and the training of Libyans in pasture management.

However, in 1969, after the revolution, the regime allocated 25 per cent of the LD. 200mn. to agricultural development for the one year 1970-71, added to the allocation made for agricultural and agrarian reform, and the integrated agricultural development sector which amounted to LD. 61.1mn. in 1972 (Allan, 1981).

One of the main features of this sector is the emergence of four

integrated agricultural products designed and planned for the development of Jefara Plain, Jebel El Akhdar, Al Kufra, Sarir, Al Agal and Al Shatti Wadies and the Tawrgha area. Adequate provision was also made under this sector for reclamation and cultivation projects, animal development programmes and loans, subsidies, etc.

As regards the Jebel El Akhdar, the project was designed in the first stage for the reclamation and cultivation of 54,200 ha. and relevant studies for the construction of Wadi Dernah dam. The first stage of Wadi El Qattara and Wadi Marqas has been completed, and land investigation over 134,870 ha. completed, in addition to the construction of 1000 farm houses, 2000 cisterns, and roads totalling 360 km. Furthermore, pasture development has been started with studies of modern rangeland and regulation grazing in selected areas, in addition to the construction of enclosures and sheds for cattle and poultry and encouragement of egg production in the Benghazi plain (Ministry of Planning, 1973).

In this way, the revolutionary government started its development programmes to encourage and increase the share of the productive sectors in GDP. In order to achieve that, the first development plans between 1969-73 involved the total expenditure of LD £223.9mn (Appendix 10) with priority being assigned to agriculture, transport, housing and local government.

Three Year Plan, 1973-75

The first plan after the revolution was superseded by the three year development programme for 1973-75. This emphasised high growth rates for agriculture and industry, by allocating to them 22 and 12.7

TABLE 9.5: Libya: Development Allocation and Expenditures by Sector (in percentages):

Sector	1981 - 85 Plan Allocated %	1976 - 80 Plan Allocated %	1976 - 80 Plan Spent %	1973 - 75 Plan Allocated %	1973 - 75 Plan Spent %	1970 - 72 Plan Allocated %	1970 - 72 Plan Spent %
Agriculture and Land Reclamation	18.2	17.9	21.8	22.0	25.2	18.9	17.1
Industry (heavy and light)	23.1	15.9	11.2	12.7	12.7	11.6	12.6
Oil and Gas	1.2	10.1	2.9	7.6	6.7	5.2	4.4
Electricity	11.8	7.9	11.4	11.9	9.6	11.9	10.2
Transport and Communication	12.3	13.2	12.2	10.6	10.2	12.4	9.9
Utilities (Municipal)	7.6	9.2	9.0	7.1	8.0	7.0	11.6
Construction (Housing)	10.0	11.6	N.A	13.0	8.7	16.6	18.9
Education	5.9	6.9	4.6	9.2	7.9	8.4	6.9
Health	3.3	2.5	2.8	2.3	2.1	4.3	3.0
Other	6.6	5.0	N.A	3.6	8.7	3.5	6.0
Total Plan %	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Plan in LD million	17,000.0	6,844.7	7,600.0	2,246.7	2,203.1	853.7	788.9

Source: SPLAJ Committee for Middle Eastern Trade (July 1980)
The Socio-Economic Transformation Plan 1981-85 and of Opportunities for British Firms, London, 50

respectively from a total of LD 2,246.7mn (Table 9.5).

This plan had already defined long term objectives and strategies for the economic and social development of the country. It laid out a new strategy based on restriction of petroleum production and diversification of the economy, with particular consideration of the production sectors, and of the elimination of regional inequality in economic and social development. It was intended furthermore to achieve a steady improvement in the general standard of living, which is related to the five year plan 1976-80, and to the long term nature of these objectives.

Accordingly, the main objectives of large development programmes and projects had been foreseen, and initiated with these development plans, with particular emphasis placed on the development of agriculture and with the long term goal of achieving self-sufficiency in the main food commodities, by increasing investment in the development of animal husbandry. The most important feature in the development of agriculture in this plan stressed the need for a complete change in the pattern of agricultural land use in the country by the establishment of new projects.

As a result of heavy investment in these programmes and projects, particularly in the agriculture, industry and infrastructure sectors, a long period was required for their implementation, and the limited supply of local labour caused an increasing demand for a foreign labour force in different sectors of the economy. Therefore, the share of non-Libyan workers in the labour force grew from 11.5% in 1970 to 33.9% in 1975 and increased to 34.0% in 1980 and reached 48.0% in 1983, as indicated in Table 9.6. The agricultural labour force grew steadily

Table 9.6 : Composition of the labour force, Libyan v. Non-Libyan (in thousands)

	1970		1975		1980		1983	
	No.	%	No.	%	No.	%	No.	%
Libyan	383.5	88.5	454.1	67.0	532.8	66.0	617.4	52.0
Non-Libyan	50.0	11.5	223.0	33.0	280.0	34.0	562.1	48.0
TOTAL	433.5	100.0	677.1	100.0	812.8	100.0	1179.5	100.0
Agricultural Workers	126.0	29.0	133.4	19.7	153.4	19.0	173.0	15.0

Source: Secretariat of Planning (1984) Economic and Social indicators in Libya, Tripoli, Table 2.1; 5 (in Arabic).

following the growth of the foreign labour force from 0.8% of the total in 1970 to 1.3% in 1975 and to 5.9% of the total in 1981, then it decreased to 3.3% in 1983. This was a consequence of rural urban migration by Libyans and the government initiated a new policy to limit the unskilled foreign labour force particularly in agricultural sector.

The foreign labour force used agricultural methods similar to those in their home land, but forgot the nature of the physical environment in the new land. The impact of the foreign labour force on agricultural land use had a positive effect in the short term of increasing production, but in the long term has had a detrimental effect on natural resources - particularly in the semi-arid region of Jebel El Akhdar where there are limited water resources, and heavy clay soil (a terra rossa soil) which needs special management.

The plan of Economic and Social Transformation, 1976-80

The main objectives and the priority given to different sectors in all the development plans did not vary much, but relative priority can best be illustrated by comparison of the different sectors and their percentages of the total budget allocation of the plan as indicated in Table 9.5, which shows that agriculture has always been the largest single recipient of public investments. The outstanding percentage of growth of the expenditure in agricultural development has always been less than the original allocation (Fig.9.3), because the absorptive capacity of agriculture has been less than the ambitions of the planners, in terms of government intentions, as reflected in plans and budgets (Allen, 1983c; 1985). They give an idea of the size of investment in various general aspects of agricultural development, with

respect to the further development of a number of environmental problems, which have been revealed by the process of agricultural change.

The ambitious five year development plan for 1976/80 aimed at a growth rate of 10.5%, and was given priority over productive sectors in line with the strategy of diversifying the structure of the economy. It also aimed at a productive economy, as well as the liberation of the national economy from foreign influence and domination in the form of military bases and almost complete control over the economic activity in the country, and to eliminate Libya from its position as a rentier state, a term which was applied to Libya in the 1960's by Robert Mabro (Wright, 1982); El Fathalay and Palmer, 1980). Accordingly, the agricultural sector received about 17.9% of the total investment, while industry and electricity received about 15.9% and 7.9% respectively. Furthermore, the social services got a large share in order to encourage a balanced socio-economic development. In the same plan, the housing sector's share was 11.6% of the total, education 6.9%, health 2.5%, and others 5.9% of the total investment (Table 9.5).

Big agricultural projects have been introduced to realise the main aims of the plan in achieving full self-sufficiency in barley, legumes, vegetables, eggs and fresh milk by 1980, and increasing the self-sufficiency rates for a number of other commodities, such as fruits to 92%, wheat 74%, meat 78% and olive oil 54%. In order to achieve this the area of cultivated land was extended from 719,000 ha. to 1,076,000 ha., with the area of irrigated fields increasing from 168,000 ha. to 268,000 ha. and dry farming from 551,000 to 808,000 ha. (UNDP, 1976).

The Second Five Year Socio-economic Transformation Plan 1981-1985

Table 9.5 indicates that in this plan, some LD 17,000mn. with a reserve of LD 1,500mn. bringing the total amount up to LD 18,500mn. ($62.5 billion) was allocated for development (Ministry of Planning, 1980). For the first time in Libya's development planning, industry is allocated the major share of the investment, with 23.1% of the total, while agriculture, including land reclamation, occupies the second place with 18.2%, electricity and desalination receiving 11.8% of the total, which means the non-oil productive sector is allocated just over half the total investment (52.1%). The petroleum sector's share remains low at 1.2%, reflecting the aims of development plans to diversify economic activity. In addition, the other major sector allocations have remained fairly constant, due to the continuing need to develop essential utilities.

Greater emphasis had already been given to the development of industry under the 1976-80's plan, which is continued in the 1981-85 plan, by the implementation of industrial schemes under construction. Furthermore, the most distinctive phenomenon in the most recent plan is the concentration of heavy industry, and food production industries, which mainly depend on raw materials from agriculture.

Agriculture takes second place in this plan although it received the major share of development expenditure in the period following the revolution. From 1970 to 1983, actual expenditure on agriculture amounted to 18.4% of total expenditure of LD 18,501.4mn., demonstrating that over LD 3,396.9mn. (Fig.9.3 and Appendix 10) has been put into the land in various forms over a period of 14 years.

Proposal Frame of Economic and Social Development Plan 1986-90:

From what has been described in previous sections, it is obvious that the state has changed its development policies, but it still gives great emphasis to agriculture and industry. Thus, the objective of agricultural development as explained earlier, namely increasing food production to attain self sufficiency is of general importance. Emphasis has been put on project implementation to provide more autonomy for local government and a more self-reliant economy.

Oil revenue has decreased dramatically from 9.5 billion dollars in 1985 to 4.9 billion dollars in mid 1986. The result has been acute in the development planning budget, a fall in the number of development projects and the repatriation of foreign workers. Despite this, oil and related operations continue to dominate the corporate sector with total revenue.

In the first draft of development plan for 1986-1990 a total amount of 10 billion Libyan Dinars has been allocated. The plan provides LD 2100mn for industry (heavy + light). LD 1250mn for agriculture, LD 1100mn for electricity, LD 850mn for transport, LD 1400mn for housing, LD 650mn for education and LD 500mn for health-Table 9.7.

It is planned that agriculture should grow at a rate of 6.5 per cent per year with an allocation of LD 250mn per year, in order to attain food self sufficiency. It is expected that wheat production will rise from 52% of total consumption in 1985 to 80% in 1990, legumes from 58% to 68% of total consumption, meat from 45% to 49%, fish 41% to 53% and milk and its products from 37% to 43% of total consumption.

This plan seems to be facing funding problems, at the same time the planners are trying to launch it with a different approach, one based on

decentralisation for each Baladiyah, in order to achieve the aims of the plans and to integrate the different sectors. The significant emphasis is to improve and maintain the agricultural projects of the last decade.

Table 9.7: Development Allocation Budget Plan 1986-1990

SECTOR	ALLOCATED	%
Agriculture	1250	12.5
Light industry	500	5.0
Heavy industry	1600	16.0
Oil	500	5.0
Electricity	1100	11.0
Education	650	6.5
Health	500	5.0
Housing	1400	14.0
Transport	850	8.5
Economics	200	2.0
Construction	1000	10.0
Others	450	4.5
Total Plan in LD Million	10000	100

Source: Secretariat of Planning (1984) Preliminary frame of economic and social development plan, 1986-90, Tripoli, (in Arabic) (Unpublished).

Regional Agricultural Development Planning

Regional economic impact and the impact of projects on the local economy are particularly important for political decision-makers, since there have been local increases in production and in the income of the rural population, even if national benefits are negligible or negative. From a regional point of view, the national plan for development consists of a number of specific investment decisions that can be conventionally summarised by sectors of the economy.

The geographical distribution of these investments within a given economic sector is spelled out in the plan according to the regional dimension to be investigated, such as the impact on general features of landscape, where there is a complete change in land use in the country as a whole and in the region in particular, and where a proper weighting of alternative regional investments is a pre-requisite for the preparation of a satisfactory development plan. As a first step in preparing regional plans after 1969, the Ministry of Agriculture identified appropriate economic areas. Geographically the agricultural sector of Libya includes various environmental zones, which are represented by five climatic zones : the central zone, the steppe zone, the Jebel area, the pre-desert and desert zones. Only the first three have any agricultural significance (Taylor, 1981, 1985 and Knight, 1982), and then only after a very considerable investment has been made, particularly in the field of integrated agricultural development and agricultural and agrarian reform. Regarding the integrated agricultural development, fund allocation is given for five regional projects in the plan for 1976-80. Of the total allocated funds, 25% of the total is allocated to the Jebel El Akhdar project (Doxiadis Associates, 1978a). At the same time, under agriculture and agrarian reform schemes special consideration is given to animal husbandry, loans and subsidies, in addition to reclamation of land.

Emphasis is on land development programmes such as the development of new areas by regional projects. North eastern Libya has a vast area of land suitable for the production of food, amounting to about 32% of all the agricultural land available for development in the country. In spite of this, the government is under increasing pressure to realise

their objectives of maximising land utilisation. Small plots of land have already been reclaimed under the Jebel El Akhdar regional project (Table 9.8 and Figure 9.5) which indicates the development programme for individual projects during the last fourteen years. There is considerable investment at a regional level. The share of the Jebel El Akhdar area in the first five year plan 1976-80 was 40% of the total funds allocated for agricultural development in the north eastern region of the country (J.A.A., 1978). This was mainly devoted to land reclamation and the creation of new farming systems in the region to increase production and to provide significantly better living conditions for a substantial number of citizens by the encouragement of settled agriculture in the region and rangeland development projects. By 1985 there were about 12 projects established, covering nearly 2,250,247 ha. (Table 9.8 and Figure 9.5). The total planning programme included 1,211,099 ha. By the end of 1985 a considerable amount had been achieved, although less than was planned. Table 9.8 shows that by mid-1985 about 44.0% of the total land for which development was planned was distributed to the farmer. At the same time 42.5% of land reclamation planned had been completed, which indicates the slow process of development during this period. This may be attributed to such obstacles as shortage of financial support, inadequacy of feasibility studies in certain areas, poor management and also lack of co-operation between sectoral planning agencies.

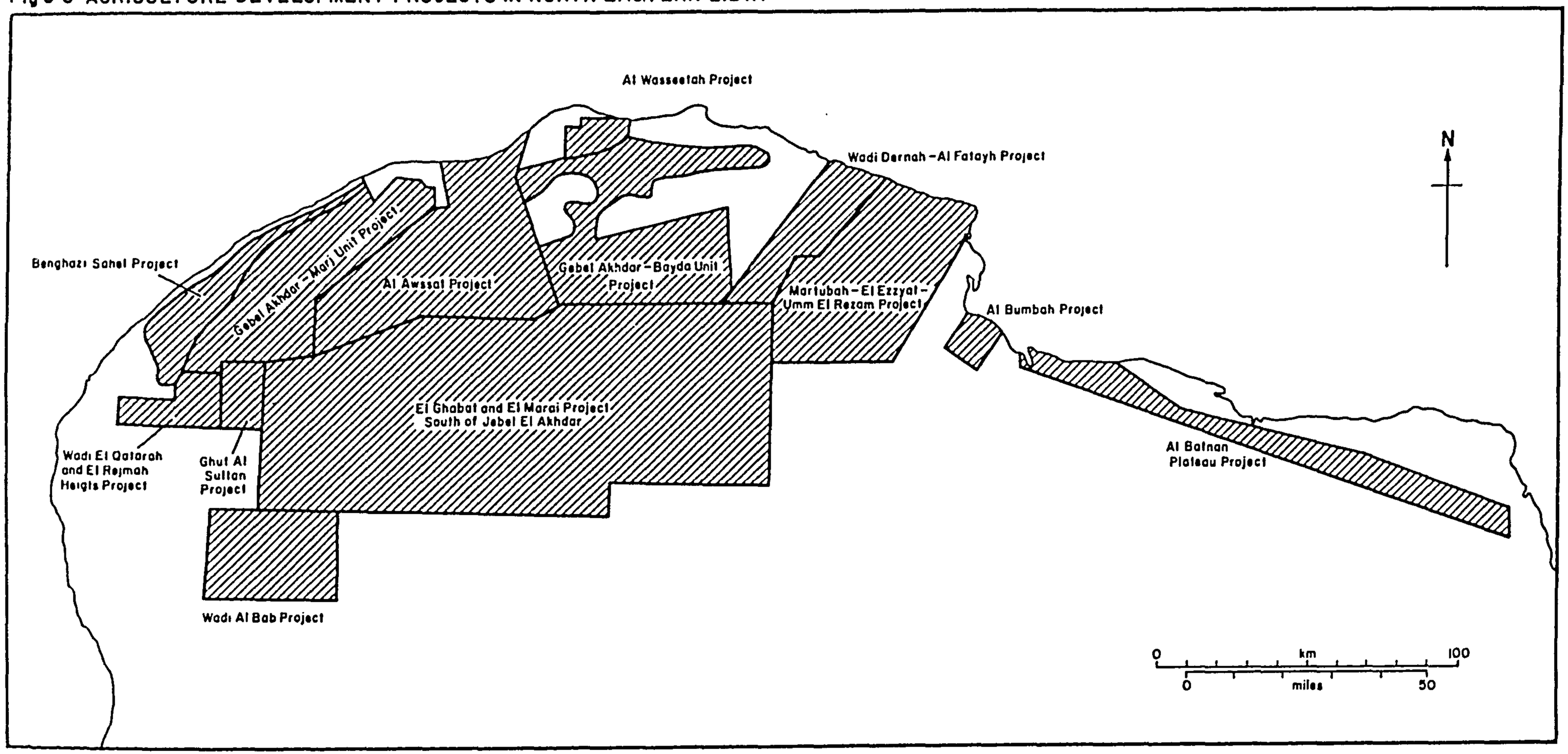
Furthermore, with respect to ecological considerations the region is unique in its physiographic units which are suitable for agricultural activities, particularly dry farming production and livestock raising. On less suitable land, sedentary agriculture is the primary use except

TABLE 9.8: Total Land Reclamation Programme with Reference to Achievement up to 30/6/85 on a Regional Level:

Project	Land for Agriculture Development Land	Land Reclamation in ha. Planned	Achieved by 30/6/85	%	Farm in Possession of Farmer in Unit Planned	Achieved by 30/6/85	%
Jebel El Akhdar	304,455	29.424.0	234,460	80.0	522		
Benghazi Plain	58,500	40,600	28,938	71.0	565	528	93.0
El Gatlara Project		1,350	1,350	100.0	134	130	97.0
South West Benghazi	110,000	111,000	61,950	56.0			
Wadi El Bah	200,000	51,000	54,500	107.0	350	-	-
Forest & Pasture	900,000	312,672	37,406	15.0	600	-	-
El Fatah Project (El Marj /El Abayer)	98,795	83,330	40,330	48.3	3,177	1,677	52.7
El Awssat Project	317,000	101,000	24,850	30.0	456		
Alwesseta	4,100	2,000	1,848	82.5	83	83	100.0
El Gubbah & El Fatayeh Projects	76,065	78,065	9,582	12.0	644	422	65.0
El Batannar Plateau	135,832	135,832	9,060	6.0	65	65	100.0
Total	2,250,247	1,211,099	514,274	42.5	6,590	2,905	44.0

Source: Computed from: Secretariate of Agriculture (1985)
Following Reports on Agricultural Development Project, Tripoli, Part I. (Unpublished)

Fig 9·5 AGRICULTURE DEVELOPMENT PROJECTS IN NORTH EASTERN LIBYA



Source J A A (1978)

where it is constrained by the availability of water. The potential exists in the region to develop unused land and to intensify land use with tree crops and pastures. Much of the land in this category permits a degree of planning of rural landuse rarely encountered in areas with substantial physical environmental hazards. In the region particularly, and the country generally, the use of potentially good rangeland for wheat and barley, which involves destructive cultivation practices, was already generally recognised as inappropriate. Overgrazing leads to depletion of the plant cover and replacement of good forage species by others which are not consumed by livestock (see Allan, 1981; Bansil, 1982) resulting in denudation, desertification and erosion. In Libya, particularly in the past 25 years, the encroachment of dunes known as "desert creep", has been noticed at a rate of 200 to 2000m. per year as a result of over-grazing and cultivation of marginal land (F.A.B. 1974). Doxiadis recorded more than 3.6 million ha. exposed to potential erosion in the eastern zone (Doxiadis Associates, 1978a).

Diversified Farming Opportunities

In such a situation opportunities to increase productivity and to expand the area of agriculture are of critical concern, as the present area of arable land is insignificant as indicated in Table 9.9.

Of the total area of Libya, about 1,760 million ha., about 2.2% or 3.8 million ha. are suitable for cultivation but only 1.8 million ha. are actually cultivated. Of this farmland 1.215 million ha. depend on rainfall and 133,000 ha. are under irrigation.

Table 9.9

Land Use : Libya

	Area in Km^2	% of Total
Urban	500	0.03
Agriculture :		
Arable and Orchard	18,000	1.10
Pasture and Grass	70,000	4.00
Forest and Scrub	5,000	0.30
Waste Land	1,666,500	94.57
TOTAL	1,760,000	100.00

Source: Secretariat of Municipalities (1979) National Physical Perspective Plan 1981-2000, Tripoli, 36.

A further study of the regional distribution of the total geographical area according to rainfall (Table 9.10) would show that total geographical area to be only 72,023 thousand ha. of land, ie. 3 per cent falls in the region over 250mm, of which, as much as 72 per cent lies in the Jebel El Akhdar region and the remaining 600 thousand hectares in the Jefera plain. Meanwhile the total geographical area over 300mm of rainfall in the whole of Tripolitania region is only 101 thousand hectares, but Jebel El Akhdar has a lion's share in this category, about 92 per cent from the total 1,320 thousand hectares.

In the country as a whole, the geographical area with 250 to 600mm of rainfall will sustain crops and horticulture, range management and forest production occurring with rainfall of 150 to 250mm, such as south of Jebel El Akhdar and El Solul El Akhdar. No agriculture of any type is possible in the Kufra, Sarir and Fezzan region without irrigation,

due to predominant ecological limitation.

In the eastern region the zone of steppe climate covers the area lying between Jebel and the sea, the southern part of the Jebel, and the Marmirica plateau at the eastern end of the country. Rainfall ranges between 150 to 250mm, and the average temperature is from 20°C to 45°C. Therefore pasture grazing and range management are common with some barley being grown in favourable locations. In the high Jebel area precipitation ranges between 300 to 650mm and the temperature is lower than in the steppe zone. The main products are cereals and fruits and irrigated vegetables are grown where there is access to water.

Arable planned land is estimated at only 1,211,089 ha. of which 312,672 ha. are for pasture and forestry (Table 9.8). All this is available for development land suitable for agriculture and must be reclaimed and put to appropriate use in the near future for further production, but not to the stage of full sufficiency in food production.

The current, highly capital intensive, method of agricultural development is especially reliant on fertiliser and machinery which necessitates the use of land of very high agricultural potential, especially in terms of rainfall, land capability, slope and soil texture. Land meeting these requirements is very limited in the country as a whole, but it is sufficient in the Jebel El Akhdar region. At the regional level currently only plateaus, alluvial basins and valleys in the region have been utilised for rainfed agriculture (Table 9.8, Fig. 6.5). Most of the potential new land for agricultural production is also in the region, with the exception of limited irrigation development in El Marj, Benghazi plain, a semi-irrigated area in El Fatayah and south of the region. In addition to that, the

TABLE 9.10: Land (Ha) and Rainfall Distribution (thousands):

Regions	Over 25mm	Over 50mm	Over 100mm	Over 150mm	Over 200mm	Over 250mm	Over 300mm	Over 350mm	Over 400mm	Over 450mm	Over 500mm	Over 550mm	Over 600mm
Total Gefera Region	13,480	8,592	4,473	2,535	1,468	600	100						
Tripoli	318	318	318	318	318	233	46	46					
Zawia	882	882	882	392	171								
Gharian	9,782	5,326	2,526	1,168	489	116							
Khoms	2,498	2,066	747	657	490	251	56						
Misurata	4,260	2,026	1,127	422	194								
Khalig	5,451	3,720	1,632	221									
Total Jebel Akhdar Region	5,849	4,137	3,084	2,415	1,924	1,572	1,218	817	489	100	61	20	16
Benghazi	1,800	1,482	1,216	933	637	448	240	31	3				
Jebel Akhdar	1,576	1,257	1,112	1,007	913	824	740	628	416	76	53	20	16
Dernah	2,437	1,398	756	475	392	300	238	164	70	24	8		
Total Country	29,040	18,457	10,316	5,593	3,604	2,172	1,320	817	489	100	61	20	16

Source: Bansil, J.C. (1978), Libyan Agriculture Towards 2000, Aprograstic Approach, Tripoli, (Table 4)

development of traditional irrigated farming within rainfed agricultural areas such as in Ayn Marrah will substantially increase production.

The overall objective was to maximise a set of economic aims such as regional production and minimise rural to urban movement while meeting the cost of constructing and operating farms, forests and transport systems. It was also stressed that there should be environmental objectives such as minimising soil erosion and the destruction of significant natural areas, while protecting the renewable groundwater available in the region, and increasing the utilisation of surface water by the construction of dams such as the Wadi El Qattara and Wadi Dernah schemes.

Model of farming area Development

After 1969 the development plans for agriculture in the region concentrated on land reclamation and farm settlement which represents a radical departure from traditional agriculture towards modern practices, and the development of livestock breeding, over a vast area in the Jebel El Akhdar region covering nearly 3 million ha.

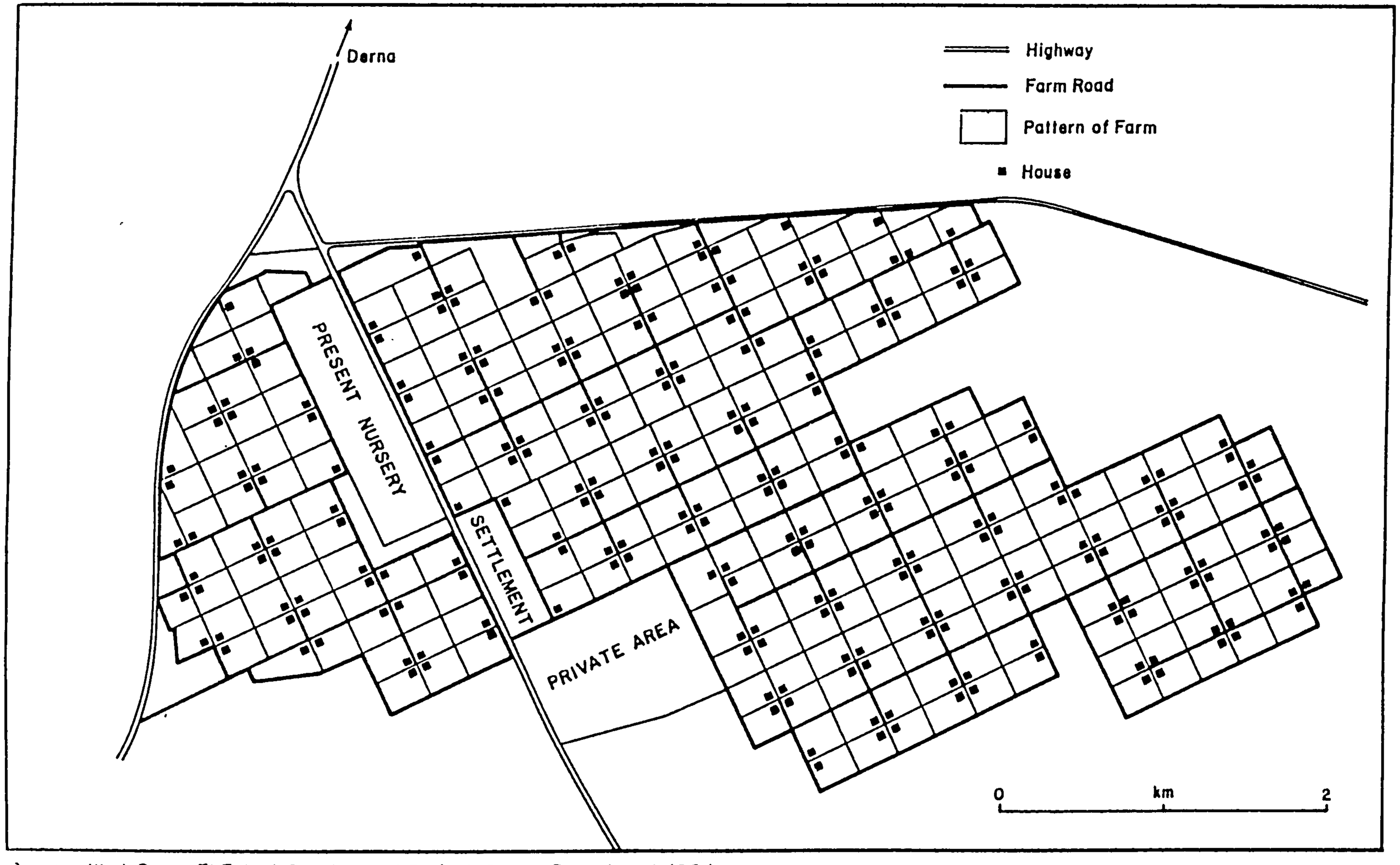
Six agricultural settlements have been created ranging in size from concentrating single farms into hamlets to new agricultural villages. Among them the basic objectives of the development of Wadi Dernah can be seen as characteristic of the general development plan for the Jebel El Akhdar region which has just been mentioned. As far as Wadi Dernah development is concerned, the emphasis is on developing water resources for agricultural use by utilising spring water, seasonal surface water, and underground water in Wadi Dernah basin. To achieve these aims an amount of DL 22mn. is allocated for the projects. The outstanding

feature of irrigated farming on about 1,340 ha., in the El Fatayah area. Before the scheme was initiated, the area contained only one irrigated private farm which was provided with water by a drilled well, in addition to the remaining total area of the project of about 3500 ha. which was devoted to dry farming and pastures.

The El Fatayah project consists of 262 farms, each farm is 5 ha. in size, and is provided with a house and courtyard and is connected with other farms by paved roads (Fig.9.6). The pattern of land use has been laid down with grain, fodder, vegetables and fruit trees (Table 9.11), which is expected to give a net annual income of about 1000 Libyan Dinars, compared to income from dry farming and irrigated farming (Table 9.11). The settlement was constructed as a model of a new agricultural village in the centre of the area to provide a social service to the farmers as a growth centre in order to encourage a balanced growth or a balanced distribution of economic opportunity in rural areas Darwent, (1969) Hansen, (1972) Gruchman, (1972). In other words the growth centre provides service for the rural area and stimulates the economic and social development of the area around it (see Gilg, 1985). Such agricultural settlements demonstrate that peasant agriculture, using modern methods, can provide standards of living equal to those in urban areas.

The procedure adopted and the general appearance of the settlement have been broadly similar in all areas. Land held in communal tribal tenure was acquired and, after survey, a master plan was prepared by specialist consultants such as in Figure 9.6. The village was built with complete infrastructure and nurseries for tree crops established. The land was reclaimed and cleared and holdings of appropriate size laid

Fig.9·6 EL FATAYAH MODERN SEMI-IRRIGATED FARMING AREA



Source: Wadi Derna El Fatayh Development Project, Survey Department, 1984

out, depending on land capability, and type of farming. Irrigated farms in the El Fatayah area, were 5 ha. in size, while dry farming holdings and irrigated farms in the El Marj basin varied in size between 25 and 50 ha. In other projects, in Jebel El Akhdar, the size of dry farming holdings was up to 120 ha. in the case of fodder farms. The size of farm was carefully selected so that all farms would yield equal returns for the same effort, but this has changed with changes in agricultural development policies.

The aim of agricultural development in the country in general, and in the El Marj region particularly, has been to provide a holding which can be worked by the farmer and his family as a family farm and which will provide the farmer with a net income of some LD 1500 a year (in constant 1970 prices) as indicated by cost-benefit analysis. It is estimated that annual income per hectare increases twenty-fold after irrigation is applied. Each farm is expected to give a net annual income of about 1000 Libyan Dinar, as shown in the comparison between dry and irrigated farming (Table 9.11).

Based on this assumption the irrigated farm is defined in size as five hectares and dry farming in first and second land capability class 50 ha. although irrigated farms had been designated an average size of 25 hectares originally. Both aim to secure a high standard of living for the farmer, and to resettle the nomad and semi-nomad in the region. Shifting cultivators were replaced by settled farmers in order to arrest rural migration. To achieve such aims, various combinations of crops have been adopted as shown in Table 9.12 for the case of the El Fatayah farming system and pattern of land use. Meanwhile the proposal for dry farming in the El Marj basin is indicated in Table 9.13.

Table 9.11

Cost Benefit Analysis for a Five-Hectare Farm
(in constant Price 1970 LD)

	Irrigated	Dry Farming	Difference
Gross Return	2921.00	175.00	2746.00
Production Cost	1874.00	125.00	1749.00
NET INCOME	1047.00	50.00	997.60

Source : Abdullah, A. (1974) Assessment of Wadi Dernah project. Unpublished paper presented to the first Geographical Conference on the Geography of Libya, Benghazi University.

The system of dry farming is generally well adapted to the environmental conditions and depends on an average rainfall of over 250mm. Wheat and oats are cultivated but where the rainfall is below 250mm the cereal cultivated is barley. The size of holding varies in accordance with the quality of the soil and the quantity of rainfall.

The average output per hectare, according to first estimates amounts to 1.2 to 1.5 tons of wheat, 2.0 tons of barley and about 5 tons of oats (J.A.A., 1978). By 1982 wheat yields were averaging 1.8 tons per hectare compared to 0.5 tons before and farmers were carrying their own sheep on medicago pasture at a stocking rate of between 1.5 and 2 ewes per hectare compared with one ewe to every two hectares at the commencement of the project (Denver, 1985).

The main settlements are those on arable land in the Jebel El Akhdar region. Among them there is included one of the sample detailed study areas. To provide additional income, farmers are encouraged to keep poultry, as well as cultivating food and cash crops. The farming system still represents a very considerable change from the farmer's

Table 9.12

Pattern of land use for five hectare farms in Fatayah

Crop	Hectares	%
Grain, Barley & Wheat	2.0	43.0
Fodder	1.5	32.3
Vegetables	0.15	3.2
Fruits	1.00	21.5
TOTAL	4.65	100.0
Additional Buildings & Roads	0.35	

Table 9.13

Proposed land use pattern for fifty hectare farms in El Marj plain

Crop	Hectares	%
Wheat	14	28.0
Barley	7	14.0
Fruit trees	5	1.0
Improved grazing	14	28.1
Fodder crop	7	14.0
Building and Roads	3	0.6

Source: J.A.A. (1978).

traditional agricultural practices moving from subsistence agriculture to cash crop cultivation, by utilisation of all possible means of overcoming physical and human obstacles. This seems to be the only viable solution for agricultural development in Libya.

Pasture development in the Jebel El Akhdar projects has its share in total agricultural development through the extension and improvement of grazing land through fertilisation and management and by sowing it with specimens of fodder and grazing grasses, such as medicago fodder which is imported from Australia, in order to increase the output per hectare. Assistance is given to individual farmers in management of their herds, and credit facilities offered for individual projects so that the greatest advances have been in poultry farming. Poultry has been adopted as a source of cash income and the government has allocated 200 to 360 chickens for each farm in the El Fatayah and El Marj area projects, mainly to produce eggs. However, many individual poultry farms have been established, some on a considerable scale, due to long term loans (see Appendix 13), but the outstanding feature is that the operators of these farms have often been businessmen rather than farmers. This explains the growth of egg production (Fig.9.4).

Furthermore, in accordance with the plan of increasing sheep output in the region, 60 head of local (Barbery) sheep were distributed to every farmer in El Marj Farzougha, and the El Fateh zones; 20 to 40 head to each farmer in the region of El Byada, El Gubbah, El Abrag and its neighbouring areas. The distribution is fixed according to the size of the farm, its productive capacity and its agricultural cycle (J.A.A., 1978). The integrated agricultural development projects in the region are the state plantations and ranches, the development of which

represents a marked change of policy since 1969. Since self-government, the regional development corporation has established a considerable number of new plantations (Fig.9.5) mainly for dry farming, grazing and with some partial irrigation.

Most large scale projects have been concerned with cereals and tree crops. Large, mechanised, arable farms have been established on El Marj plain. In addition, several large scale livestock enterprises have also been developed where the Authority of Jebel El Akhdar has established four fundamental projects for increasing the quantity of grazing land and forest. About 165,000 ha. are designed as grazing land in the Wadi El Bab, the forest area, and Benghazi plain where the area has been cleared and divided by fences to organise raising. A similar ranch has been established by the J.A.A. in the southern region of Jebel, defined by the 50 and 200mm isohyets, which covers more than 250,000 ha. in the region. The government has also created several dairy farms to produce milk at Benghazi, Tokra, El Marj, El Bayda, and Dernah, in addition to poultry farming, to attain self-sufficiency in this product .

Horizontal expansion has been achieved by increasing the percentage of cultivated land, and by reclaiming land fit for agriculture. The great emphasis has been put on vertical expansion for increasing agricultural production and this is done by wider dissemination of modern techniques among the farmers and construction of modern productive schemes such as using greenhouses to produce summer vegetables in the winter period. Under this system plants are grown under fully controlled environmental conditions which act to minimise the consumption of water. The yield experienced using this system is extremely high so that the average yield is reported to be ten times

higher than in corresponding cultivation under normal conditions. As a result it has been extended into Jebel El Akhdar at different localities in El Marj, El Gubbah, Dernah and Tobruk where the latter has soil and climatological conditions which are extremely unfavourable to production. The mean product of this type of agriculture is about 135 tons per hectare compared with open agriculture where the mean product is 15 tons per hectare (Secretariat of Planning, undated). Further vertical extension in agricultural production is made by developing irrigation systems when the drip irrigation system was introduced into the Executive Authority Projects at the beginning of 1977. It has been used for irrigation of vegetables and fruits - on Projects since the beginning of 1977. Experiments have shown a substantial reduction in water consumption to 70% of other irrigation systems such as sprinkle and surface flow (J.A.A., 1978). In addition, J.A.A. started to test subterrainean irrigation systems which have proved their efficiency but needs special management and heavy investment. The last five year plan enabled the Jebel El Akhdar region to reclaim and complete the development process of the El Awssat project, which includes 317,000 ha. of which 101,000 ha. is arable land. Some 450 farms have been planned with sizes ranging between 40 to 120 ha.

The pattern of land use laid down by the Authority of Jebel El Akhdar is mainly related to land capabilty and physiographic units where cereal production is on first class and second class land, and the third class land is utilised for fodder production. The difficult topography of the terraces are used for fruit trees, as well as afforestation.

The most important emphasis in this plan is to make a considerable quantity of fossil water available in the southern region, from Tazerbo

and west of Sarir to the main population areas on the coast, through a pipeline extending over 1000km and capable of transporting some 2m.cu.m. of water a year, to exploit the development of agriculture (Secretariat of Planning, undated). This is considered a major project in the Middle East in general, and in north Africa particularly.

Critical Review of the Development Programme

The agricultural development programme has concentrated on non-traditional agricultural development in the region. It is shown clearly in the development of such activities in the northern flank of the Jebel El Akhdar. Here the main emphasis has been on family farm settlements, compared with the southern flank of the region, where plantations have been the distinctive feature such as the forests and fodder farming of the south valleys. It also shows that little development has taken place in the eastern end of the region (Tobruk area), attributed to environmental hazards and dispersion of settlements in this part of the region. Because of these problems agricultural development programmes have done little to alter the major imbalance in the distribution of agricultural development and land resources.

Consequently, few projects are yet at a stage where they can make any major contribution to production, and there have inevitably been teething problems, in part resulting from lack of sufficient management and inadequate co-operation between farmer and consultants (agricultural advisers). The lack of co-operation between sectoral planning agencies may also negate development. For example, the main obstacle until now has been delay in implementation of ground water utilisation in Wadi Dernah planned to supply irrigated farms in El Fatayah area.

As a result, the benefits of higher yield and better quality produce have yet to be fully demonstrated, although there has been considerable investment. Nevertheless such a scheme is likely to prove most suitable for this type of production, where careful handling and relatively elaborate processing is required. In their regular layout and homogenous cropping, the pattern of farming provides a marked contrast with other land units in the region, which are mainly based on the variation in precipitation and land capabilities, as aforementioned. These indicate that the pattern of farms in the El Marj plain varies from scattered farm plots and terrace farms in the El Aw ssat project to vineyards and fruit trees in the El Bayda and Labrage areas and dry farming in the El Gubbah area where re-development to hill farms was considered in a previous period and, all in all, are of a different type from the El Fatayah farming system. They create a dilemma of design.

The main contrast between these farm systems is shown by the size of each holding and the management of each one. All of these factors would create a discrepancy in financial return, which needs re-adjustment in the near future.

Land reclamation, has been the main influence on the general features of the landscape and as a result land use has changed completely in the country. Wherever the land area available for productive use is limited, there is a need for scientific studies to secure optimum returns from every piece of land, Therefore, it is obvious that realisation of these plans puts even greater pressure on the scarcest commodity of the coastal area of the country. Land values have increased in the coastal district and competition between the various forms of land use (residential, transport, commerce, industry,

education, recreational, military and agricultural) have become very intensive because of the possibilities for expansion of the land area through reclamation. From the beginning it has been clear that the revolutionary government has given top priority to the productive sectors. Agriculture had the main priority in a large country in which nearly 90% of the total population is concentrated in the northern narrow coastal belt. This is also traditionally the main agricultural region in the country. This creates problems of over-exploitation and exhaustion of natural resources in locations most favourable as farming areas.

In this context Hodder (1973) and Hunter (1969) have demonstrated that this kind of abrupt rural change causes problems in developing countries not only in relation to the human resources of these regions, but also in respect of economic and ecological conditions.

Heavy investment in agricultural development depends on the extent to which the projects are regarded primarily as agricultural development schemes rather than measures to alleviate local problems. At whatever cost, inefficiency is a danger which is particularly acute in large scale enterprises, also where there are hazards, and some resources have been misapplied or have failed to benefit those for whom they were intended, such as deterioration of underground water in the northern coast of the country. In the case of Jebel El Akhdar, an El Awassal project Plates 9.1, after intensive clearing of the scrub, particularly on slopes, the soil is subject to erosion. It also applies to irrigated farms in the El Marj plain which will effect the underground water reservoir (see Chapter IV). Meanwhile, the counterpart exists between

a

b

Plate 9.1 El Awssat project (a) Newly terraced farm (b) Farm terraces after one year

the El Fatayah project and the Sidi Awan project as irrigated fodder farms north of El Fatayah project, which mainly depend on water from Martubah area. Both rely on the same or single underground reservoir, and it is questionable what the future for these new farming areas will be.

Many of the farms have had subsidies and loans which have mostly been spent on personal conspicuous consumption farming operations, and a disproportionate number of those participating in farming were not originally farmers, particularly those farmers who obtained family farms. Thus they have faced a lot of problems, because they have little knowledge of agricultural management. This has had a bad influence on the pattern of land use in the new farm schemes which, however, are attractive because they produce visible results and they may well have an important catalytic effect.

In addition to physical environmental constraints there is an acute manpower problem on the land in general in terms of both quantity and quality. This has arisen because most old people tend to remain in agriculture, and old farmers are less innovative and less sensitive to government efforts towards productivity, while young people do not want to be farmers. (see Arnon, 1981 Foster, 1973 Djurfelds, 1982). However, the development projects of the current period have also created a large number of jobs for which Libyan labourers lack adequate education of skill and motivation.

Agricultural development in the region particularly, and in the country in general must be seen in connection with the overall change in society. The agricultural sector can not isolate itself from processes of modernisation and integration in the rest of society. For example,

education and training have changed the quality of the labour force, including agricultural workers. Nowadays farmers in the region face a shortage of unskilled farm labour. Subsequently some project managements did not give great attention to farmer training. Also, modern farm operations have to offer high wages and an improved working environment in order to attract skilled workers for livestock and agriculture production. This is only feasible with a corresponding increase in productivity and efficiency. Thus, capital and labour in the agricultural sector have to be considered competitively in relation to alternative investment and employment opportunities in the rest of the economy.

These problems along with others limit response adequately to the concentrated efforts in the development of the agricultural sector, and a further great investment was allocated in the development plan 1981-85, the major projects of which are in line with those for 1976-80 (Table 9.5). This indicates that there is not a big difference between total allocation of land reclamation during 1976-80, compared with 1981-85 due to the main emphasis in this plan being to complete the targets of previous plans. At the same time, horizontal expansion has declined in some parts of the country, particularly in the northern coastal strip. This is attributed to the ground water system in most of the area being exhausted, and sea water incursions in the Gefara plain in north western Libya (Allen, 1981), one of the main farming areas, where the target of the development agricultural plan 1981-85 has been to reduce the irrigated area from 124,300 ha. to 31,300 ha. On the other hand restrictions were placed on the planting of citrus fruits, tomatoes and water melons, all crops which use water heavily

(Secretariat of Planning, undated) in order to limit the decline of water table to as low a proportion of the land as possible.

Consequently, Libya is still dependent on food imports (Appendix 12), to meet more than 40 per cent of its requirements. By 1985 it was hoped that increasing local food production will have reduced this figure, based on the objectives of the 1981-85 development plan, which has allocated LD 2.7 million to agricultural and water resources. Priority has been given to the completion of ongoing projects with particular emphasis on major reclamation and irrigation schemes, in which a substantial concentration has been already made in the southern region of the country.

Finally, the agricultural development programme has been achieved and the indications are that it will continue to progress satisfactorily. It contributed very greatly to social stability and political goals. It gave a number of destitute people land, and so relieved the acute problem of the landless. Agriculture has permitted the maintenance of production from most of the settled land (El Marj) with only minor interruptions (El Fatayah) on a regional scale.

Nevertheless, the agricultural sector in Libya remains significant from the point of view of fresh food supplies and therefore the agricultural problem in Libya is of great concern. Since land use can also be viewed not merely in economic, but also in ecological terms, the role of agriculture can not be overlooked.

CONCLUSION

Investment in agriculture in the first ten years after independence increased almost ten times, but in spite of that agricultural output has

stagnated or declined since 1958 (Appendix 9).

This was a result of the traditional way of life of the people, added to the low density of population, and a widely dispersed agricultural population. Furthermore traditional agriculture was practised on less than 24 per cent of the total of agricultural land of Libya, with a low intensity of land use, with little mechanisation especially. Farming practices in Cyrenaica depended to a great extent on the application of human labour to small parcels of land.

All in all, these factors constrained an adequate response to agricultural expenditure during this period which was mainly provided by multinational corporations. Meanwhile, low productivity subsistence farming was characteristic of most traditional agriculture, resulting from a combination of the aforementioned forces, added to the lack of capital investment, which all acted to restrict the growth of output.

In the first five year development plan, after oil revenue was obtained, about 70 per cent of revenue was allocated to the development plan, with agricultural development concentrated on studies for certain projects in the country.

If all the plans had been fulfilled as projected by the end of 1985, the projects would have occupied something like 3,021,354 ha. in the country. However, at the end of 1985 only 42% of the total programmes had been completed. Their importance should not be exaggerated, at least in terms of past achievement between 1970 and 1980 when agricultural investment by the regional development authority totalled some LD 301,644 million in the eastern region of the country (Doxiodis Associates, 1978). This indicates the considerable investment in agriculture in the recent period.

However, in the short run at least the major contribution to agricultural production must come from improvement in the farming system, where quite small, but widespread advances can produce large gains. Thus better crops have been planted from many varieties accommodated to the dry conditions and associated poor soils, such as the introduction of legumes into rotation improvement in soil fertility. With special management of sowing it might be possible to push output per hectare to over two tons.

In the long run the farming system has been improved by the appropriation of farms to the farmer; maintenance of soil fertility; training the farmer in the know-how to operate his land, and encouragement of co-operation between farmer and head office or agricultural advisor, which will be discussed in the next section.

CHAPTER TEN

SAMPLE DETAILED STUDY AREA

METHODOLOGICAL AND TECHNICAL BACKGROUND:

Introduction:

Research for this study was divided into three parts: background research, field work and data analysis.

Background research was completed during the first two years between 1982 and 1984. During this period an attempt was made to read and evaluate as much of the relevant English and Arabic literature as possible concerning not only the area of detailed study, but also relevant literature of all kinds. Personal communication with established researchers on Libyan land utilisation was also carried out.

Reconnaissance work was carried out in Libya from the middle of July, 1982 to the middle of October, 1982. During this time archival information was gathered from the following institutions: the University Libraries at Benghazi and at Tripoli; the Executive Authority for Jebel El Akhdar; the General Water Authority (Benghazi, Dernah and Tripoli branches); the Secretariat of Agrarian Reform and Land Development at Tripoli; the Secretariat of Communications at Tripoli; the Meteorological Department and the Survey Department.

In addition, data on population and economic development was collected from the Department of Statistics in Tripoli as well as from individual municipalities (Baladayat) within Jebel Al Akhdar. Informal interviews were carried out with officials in relevant government offices and with other individuals in both Libyan and foreign companies.

There was also discussion with members of the academic staff of Benghazi University.

In the United Kingdom, libraries in the following institutions were consulted: Newcastle University, Durham University (Geography Department, Centre for Middle Eastern and Islamic Studies), School of Oriental and African Studies at the University of London, Meteorological Centre at Bracknell, and several others.

Given the researcher's stated general aims and in the light of his experience of field research, a decision was made early to adopt a problem orientated approach in relation to the stated hypotheses rather than adopt the deductive approach. It was felt that this had several advantages which recommended it to the researcher. Therefore, the formulation of a series of hypotheses was undertaken in the light of previous general background studies, known recorded observations and identified problems, which helped to clarify the nature of the study to be undertaken.

Field Work Procedure:

The actual field work survey lasted approximately two months commencing in September 1984 and terminating in November 1984. During this period, the questionnaires were carefully translated into the local Arabic dialect and the total number of farms in the detailed study area was determined. There were 602 farms which had been allocated to settlers in the modern farming areas of both El Marj and El Fatayah up to the end of 1984. There were also about 200 traditional farms in Ayn Marrah.

The field study was primarily concerned with farms, resulting from

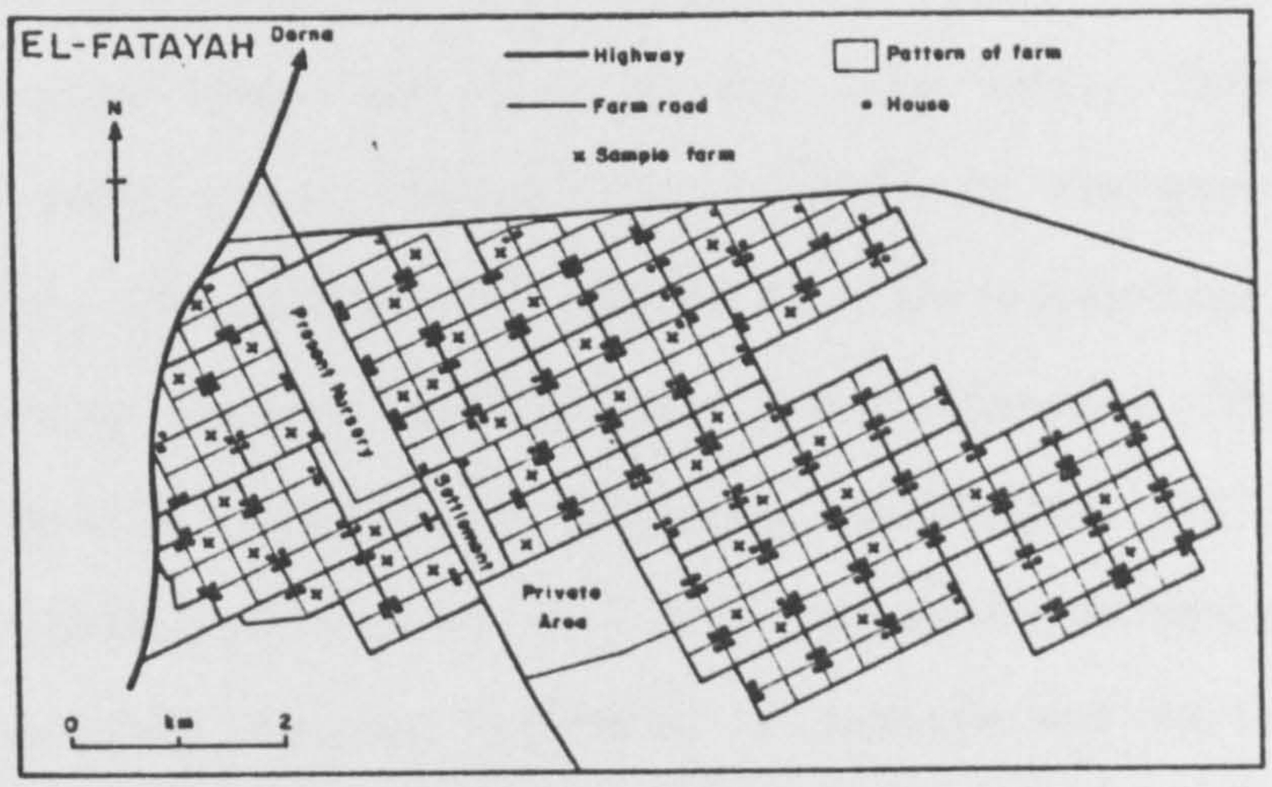
agricultural development schemes in the region. Private traditional farms or gardens predominate in irrigated agriculture in the region. The variation in acreage and crop patterns could be classified and subsequently, they could be identified and analysed. Whatever the importance of this study, it clarified the standard of new farming management and the trends of agricultural development in the region. Large private farms were excluded from the study because of lack of information. Most of the farmers on these farms would not answer the questionnaire. Those that did, answer the questionnaire did so in such a way that the information was virtually useless.

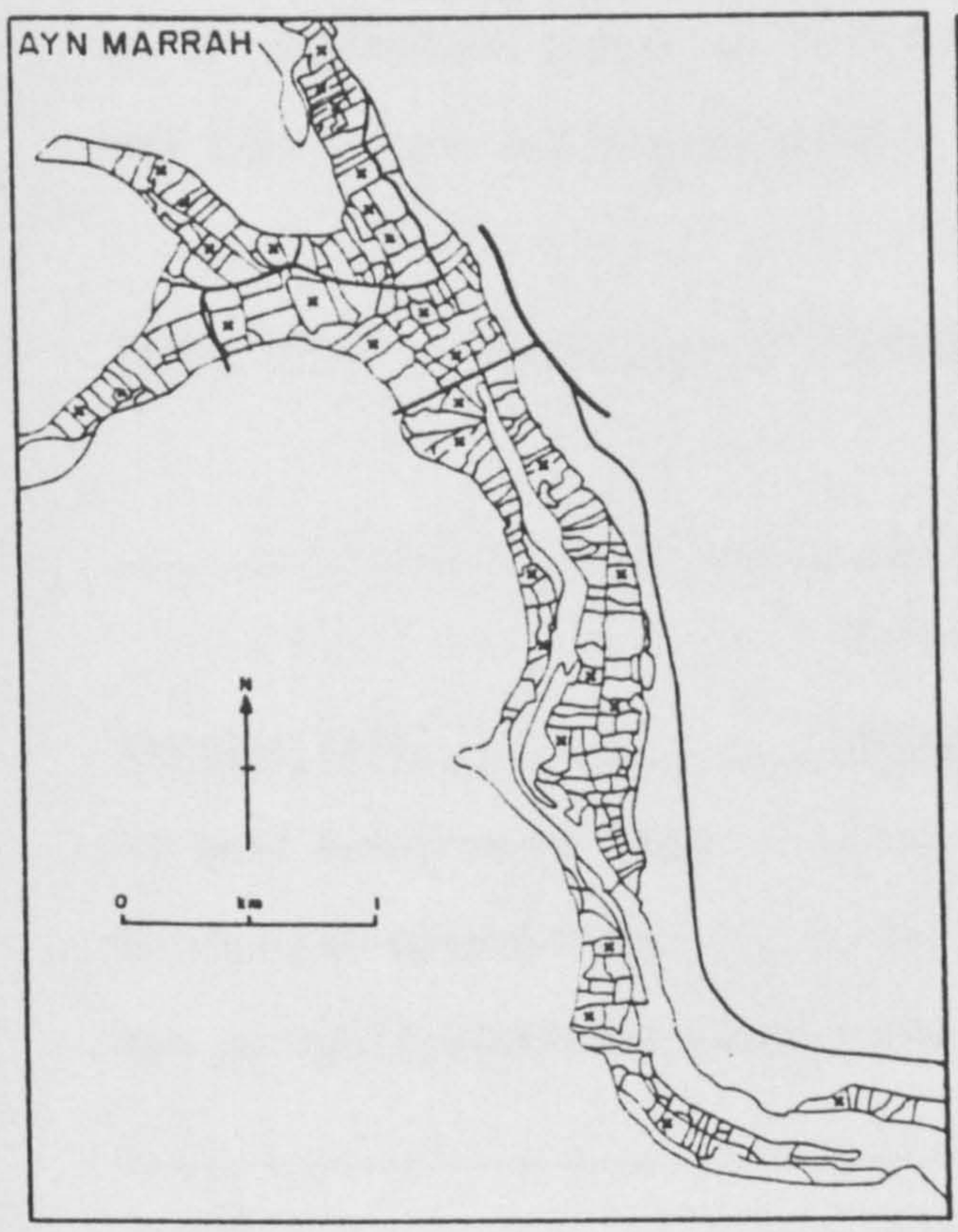
Method of Selecting the Sample:

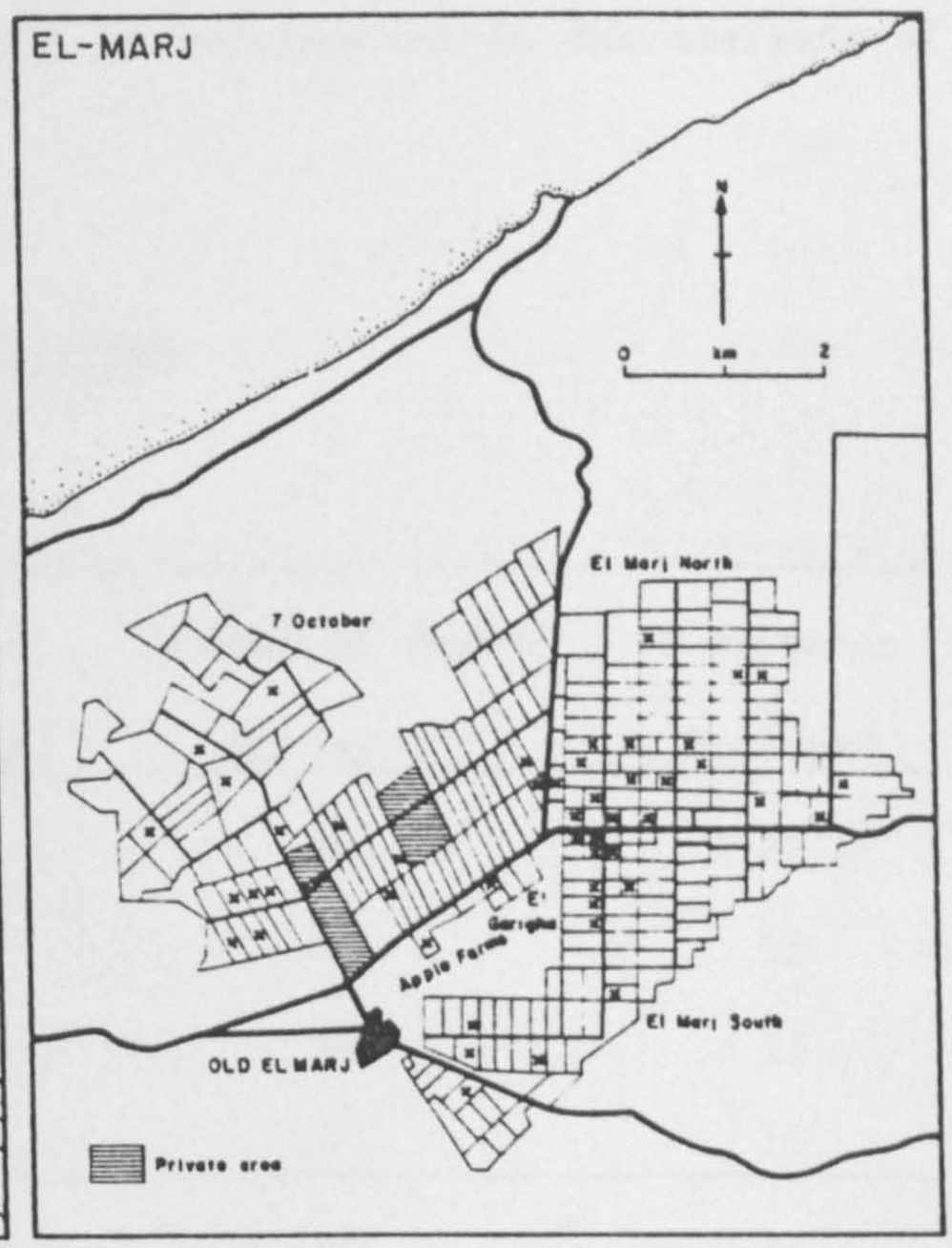
With limited time and facilities at the researcher's disposal it would have been difficult to question all farmers in the study areas. Therefore, a random sample was selected. Random number tables were consulted to determine the actual farms to be sampled in both the modern farming areas of El Marj and El Fatayah. These were identified from maps of each area (Fig.10.1). On the other hand, the traditional farm samples were identifed from aerial photographs at a scale 1:20,000. Farms have been plotted on a map at a scale 1:20000 using a zome transfer scope (Fig.10.1), then enlarged to a scale of 1:50,000 to provide a base map for field survey. Serial numbers were marked on the farm maps, then a sample farm was identified on the map; at the same time the field location of the sample farm was identified from the areal photograph, for the interview.

Lists of farmers' names in Ayn Marrah, as shown in the records available in the Secretariat of Agrarian Reform and Land Development

Fig. 10·1 CASE STUDY AREAS







(Dernah branch) were consulted. These lists were also checked with the records of the agricultural cooperatives in the administrative units to gain as high a degree of accuracy as possible in order to establish the validity and reliability of the research (see Blaut, 1959).

The sample frame was based on the farm unit. This is a static phenomenon which gives strength and validity to the study. (Dixon and Leach, 1984). The samples were chosen from three separate areas because of the varying farm conditions and farming systems. The samples are thus representative of these differing conditions and systems. The sampling proportions were in each area, as equal as was practicable to secure reasonably accurate estimates of aspects and variables, as well as of sufficient number in each area to be compared in the analysis of the data (Dixon and Leach, 1978).

Table 10.1: Proportion of Sample Farms

Farming Area	Total Farms	Number of Farms Surveyed	% of Farms Surveyed
El Marj development farm	340	50	15
El Farayah modern farm	262	40	15
Ayn Marrah traditional farm	200	30	15
Total	802	120	15

The percentage of sample farms from each area is approximately the same. The number of sampled farms and the percentage of the total farms

in each of the three areas is shown in Table 10.1. Of the 120 farms sampled, 90 are modern farms and 30 are traditional farms.

The above methods ensured that the range of variation was adequately assessed and avoided unbiased assessment of farm structure in the data analysis.

THE QUESTIONNAIRE CONTENT:

The questionnaire was designed in four parts:

Firstly, information concerning the farmer, his family and his occupation was sought. This information was needed to differentiate the farm population characteristics of the study areas, for example, young farmers just starting out and those who may be approaching retirement; and also to be able to relate land use to such things as off-farm or secondary occupation, or the amount of labour employed on the land.

Secondly, the farmer was asked to indicate how he used his land and what activities took place on his farm.

Thirdly, questions were asked concerning land use change, and the farmer was asked to consider any changes he might anticipate in the future. This was to ascertain the farmer's view of the future of his land and his thoughts concerning problems which may be encountered in the region.

Fourthly, the questionnaire included questions about farm costs, yields and sales of farm produce.

Pilot Study:

Prior to the main questionnaire survey, a pilot study of 20 randomly selected farmers in the area was carried out by the writer.

The results of this pilot study were helpful as a basis for modifying or eliminating many questions in the questionnaire schedules.

Research Assistance:

Research assistants to help with the survey were chosen on the basis of their previous experience at field surveying, their knowledge of the region, and their ability to speak the local Arabic dialect. One high school teacher and two Geography postgraduate students were chosen as assistants; they were given an intensive two days of training prior to the survey. The researcher himself worked in the field with the survey team assigned to survey the modern farms, and the writer carried out the survey of the traditional farms by himself. At the end of each day, the collected data was summarised in order to give further guidance to the survey team for the following day's work.

METHODOGY:

The detailed base maps of the study area were obtained from Jebel El Akhder Authority at their El Marj and Dernah branches. They are at different scales; a 1:50,000 map was used in the work survey of the modern farms, while the field survey in the traditional farming area was carried out with a large scale map 1:250,000. This latter map was also used to collect data on unit areas and on boundaries of cultivation. In addition, the areal photographs listed in Table 10.2 were used. They were viewed with stereoscopes and a mosaic and interpretation was effected according to the classification shown in Table 10.2.

Intensive field work was also carried out to check and modify the interpretation and classification. This was in order to improve it as a basis for extending the area of various land use changes. The areal

photographs of El Marj plain were taken in 1965 and 1979, while the Ayn Marrah area coverage related to 1974. The most recent ones for El Fatayah and Wadi Dernah areas were in 1981. Each set has a different scale. Thus, area measurement was completed by means of a square, the area under different crops was measured by superimposing a grid on the photographs and counting the squares in which each crop occurred. In addition, two unclassified satellite images were used to indicate more detailed information. The areal imagery did not cover the whole of the study area. Consequently, the only possible comparison over time was based on the areal photography coverage for 1964 and 1974 for El Marj area.

Table 10.2: Areal Photographs and Images used in the Study

Date	Area	Scale	Type of Product
Aereal photos			
10 August 1965	El Marj plain	1:25,000	Airphoto NASA
18 June 1979	El Awalaiya	1:6,000	Airphoto small strips of PASCO
18 June 1979	El Marj plain	1:15,000	Airphoto small strips of south El Marj plain PASCO
April 1974	Ain Marrah	1:20,000	Airphoto Terratest Sweden
27 July 1981	El Fatayah & Wadi Derna	1:15,000	Airphoto small strips PASCO
Satellite images			
18 November 1972	Agglomeration	1:250,000	Landsat NASA
15 June 1978		1:250,000	NASA

Limitations of the Study:

From the outset, one of the most difficult problems was to obtain data relating agricultural production to farm size. This was due to the fact that most farmers were reluctant to give details about their income, and usually only mentioned their approximate gross income. In addition, the education level of most farmers was insufficient to keep detailed records of the farm operation. Therefore, the data is dependent on the farmer's memory, without any official records, and so may not always be entirely accurate.

Furthermore, the farmers in the study areas, particularly in the traditional farming areas, were not familiar with research surveys, and often associated the writer's survey with a government redevelopment survey. Similar misunderstandings occurred in the Development Farms and Private Farms in the El Marj area. As a consequence, farmers in both areas were reluctant to divulge detailed information. In addition, during the field survey of El Marj area, a rumour had started that the Secretariat of Agrarian Reform and Land Development was going to limit the size of individual farms in the area and re-allocate some land to new settlers. Consequently, the survey team had some difficulty in convincing the farmers that this survey was of purely academic interest. Apart from the field survey, other problems were encountered in the statistical data from Libya, mainly because of the change in the administrative boundaries since 1964. The writer is aware of many errors and inconsistencies which exist in the official figures, particularly the population and agricultural production data.

It is difficult to compare data from the four censuses of population of 1954, 1964, 1974 and the preliminary result of 1984. In

the same way, it is impossible to compare agricultural data for 1960, 1974 and the preliminary result of 1984. At the level of Baladiyah, inconsistencies exist between the number and type of data sets regularly prepared by local authorities. The writer's previous field research experience, his farm management background, and his fluency in the local arabic dialect enabled him to overcome the majority of these and other, less significant problems during the field survey.

SAMPLE AREA:

Which area? Why?:

Three areas have been studied in detail in order to examine the intensificatiion of farming in different land systems within the Jebel El Akhdar region. The first is an area in the El Marj plain 100 km. east of Benghazi in the Baladiyah of El Marj which forms part of Fur Baladiyah El Marj. The area is defined by the 300 m contour line, and contains 24,000 ha. This area includes both irrigated and dry farms. This area has good quality land and its climatic condition is favourable for agricultural development. Furthermore, nearly all of El Marj plain is suitable for agricultural use without special reclamation work because the main physiographic unit of the area is flatter and has been under cultivation since the earliest agricultural settlement.

In the earlier traditional farming methods, single, rainfed crops were grown. This system became unviable and consequently developed into a diversified system which combined animal husbandry with arable cropping, resulting in greater yields. After 1971, the executive authority of Jebel El Akhdar was established and further agricultural expansion was made. The irrigated area was increased five-fold. New farm patterns were established in the drained area, land was allocated

to new settlers, and the density of settlement increased in the area. Cropping became more diverse and agricultural output increased rapidly due to advanced farming methods and to the mild winters in which sub-tropical fruit and vegetables could be grown for the local markets.

The second sample area is El Fatayah sited 10 km south east of Dernah city in the Fur Baladiyah of Dernah city. This area comprises 1500 ha. The outstanding feature of this area is that agricultural land use has completely changed following agricultural development programmes in the region. Previously this area was used by semi nomadic farmers for shifting cultivation and grazing land. After 1970 this area was connected with the wadi Dernah Development Project to maximize the rational use of irrigation water from surface and underground reservoirs in wadi Dernah. Dernah City and its valley have an abundance of ground water and great agricultural potential (Plate 10.1).

One of the most significant potential agricultural areas in Libya which are not rationally used are the wadis. The importance of wadi culture in the country was appreciated long ago and this is indicated by the dams existing from Roman times which in some places are still serving to slow down the flow of water (see Baker, and Jones 1981; 1984). The precipitation and the flow of the water create different types of wadis each with a different socio-economic significance and density of population which form a sort of traditional agriculture in the country. Thus, the third sample area is the Ayn Marrah area 30 km west of Dernah city and 10 km east of El Gubbah town. The area of 43 ha. is in the upper part of wadi El Nagah which flows into the sea 8 km west of Dernah city. The main physical and ecological features have been discussed in the preceding sections. This area has many of the

Plate 10. 1 Dernah City small irrigated farms

Source : PASCO, Airphoto, 1981

characteristics of traditional farming such as pigmy farms as a result of fragmentation, the pattern of land ownership and inheritance and sharecroppers, and a system of land utilisation based on a high intensity of labour (both Libyan and non-Libyan). In addition, the problem of part time and full time farmers and family structure have affected agricultural land use in this small area.

Farm Structure:

Farms have been classified into irrigated rainfed, or mixed. However, this fundamental classification comes from the development point of view. It may now be useful to recognise that within the tripartite classification there are five major types of farms. These are distinguished by size, location, type of organisation and management. They are as follows:

1. Traditional or multi-activity family farms which may be termed "gardens" instead of farms. They are mainly for the self sufficient farmer.

2. Private farms or full time holdings of a medium size and backed by cooperative organisations.

3. Settlers farms which are on state sponsored projects (for example El Marj and El Fatayah farms, amongst the case study areas).

4. Public sector farms which are under direct state management. They operate on a large scale with sophisticated technology, skilled management and great capital investment, as for example El Gharigh apple farms, dairy projects and greenhouses.

5. Livestock holders whose main occupation is livestock raising. They depend primarily on natural range grassland, for grazing their animals but also undertake same rainfed farming.

However, the great contrast between the general agricultural economy of the country and the particular economy of the region has produced a very broad national system in the country generally. Therefore, it is necessary to examine farm structure by a detailed study of the sub groups as follows:

1. Traditional farms include two types of farming systems:

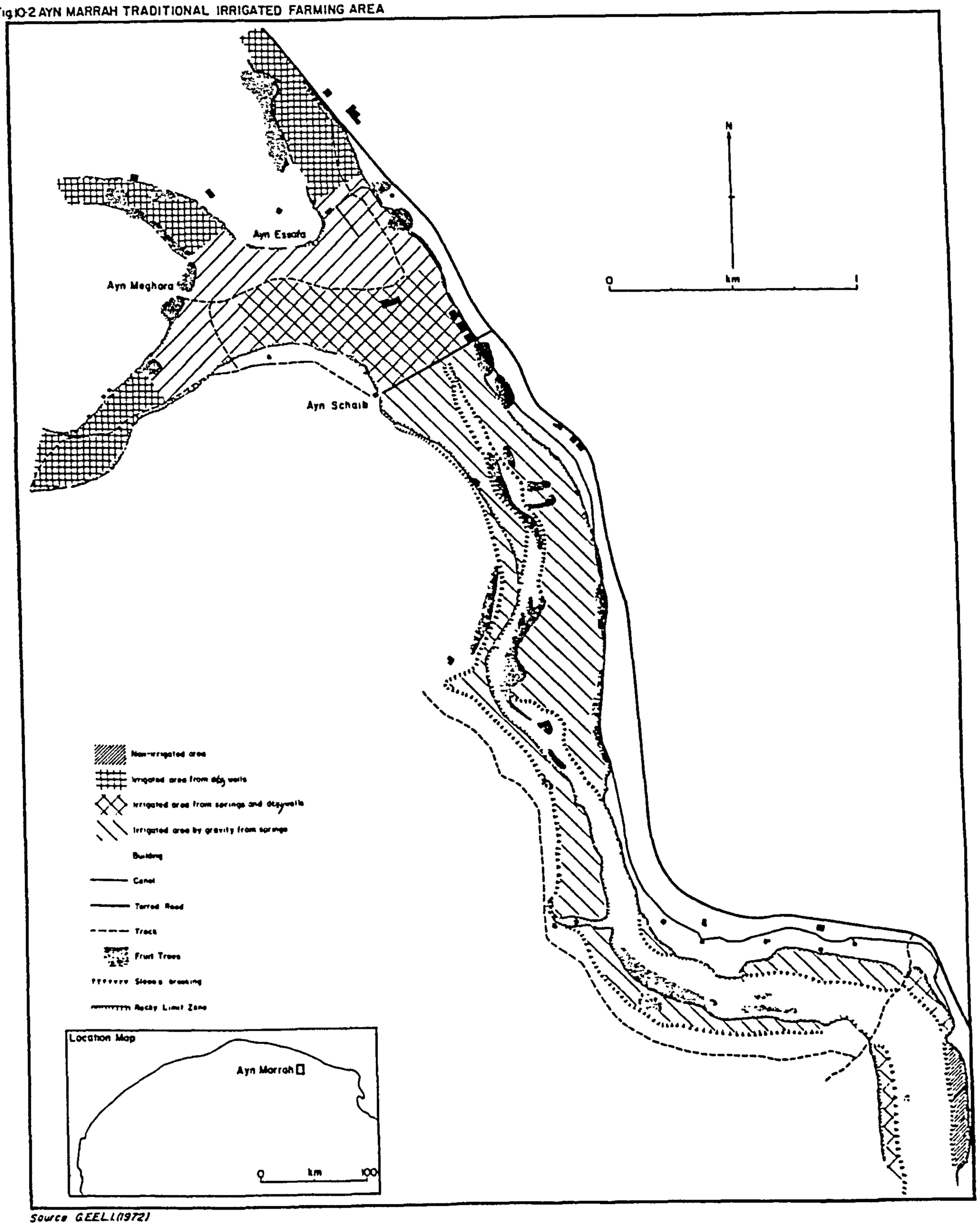
   a) Traditional irrigated farming such as in the case study area

of Ayn Marrah. This is a sedentary farming system and it contains all kinds of traditional irrigated agriculture. The land is intensively cultivated, with irrigated water being drawn from the phreatic aquifers, particularly in the upper part of the area (Fig. 10.2). The irrigation water was usually lifted by animal power, but it is now being pumped from shallow aquifers called locally "Barka"(pool). The water table is 4 to 8 metres deep.

The gardens in the lower section of the valley in Ayn Marrah are irrigated by springs. This water is conducted by gravity or pumpage from the springs via concrete channels. Some of the farms are irrigated by gravity from springs with supplementary pumpage from the aquifer. Consequently, the cultivated area is divided into four distinct zones based on the source of water use as follows:

- Area irrigated by pumpage from the Meghara and Essafa springs 8.85 ha
- Area is irrigated by gravity from the springs 6.20 ha

Fig 10-2 AYN MARRAH TRADITIONAL IRRIGATED FARMING AREA



Source GEEL (1972)

- Farming irrigated by springs and supplementary pumpage of shallow aquifers 20.69 ha
- Area irrigated solely by pumpage from the aquifer 7.05 ha
- Dry farming 0.50 ha
- Total traditional farming area 43.09 ha

This type of farming system is known by the term Saniya (Plural - swani). It is a specialised horticultural type of farming predominant mostly on the valley terraces and in the coastal area of the region, such as Dernah city gardens, swani Karsah and Lathrun villages (Plates 10.2 a, b and c).

Small gardens or swanis are separated from each other by stone embankments, mud retaining walls or barbed wire. These form the pigmy farms in the region. Their size is about 0.22 ha. per parcel. The majority of farmers employ traditional equipment and hand tools. Nevertheless, some have recently started to install mechanical pumps as well as using more modern equipment and machinery to maintain their position relative modern and development farms nearby (Plate 10.2a).

Traditional farms are characterised by the practice of close intercropping of field and tree crops. They follow traditional cultivation methods, such as using animals for ploughing. They do not follow a rotation system due to the increased degree of fragmentation of cultivated plots. All they do is to lay aside a piece of their land and leave it uncultivated for some time, particularly in wetter periods.

Crop patterns in Ayn Marrah are much the same as in other traditional farming areas in the region. Most of the vegetable crops are grown in both winter and summer. However, a slight break in cultivation occurs in December and January because the effect of

a

b

c

Plate 10. 2 Traditional small irrigated farms

micro-climatic conditions limit the growth of certain crops, especially the minimum low temperatures in January. The most striking phenomena in Ayn Marrah crop production is that the yield of beans, peas and radishes is higher than in any other area, and the area also produces good quality fruits such as table grapes. At the same time there is variation in both quality and quantity within the same area. For example, farms in the main stream of the valley suffer from declining soil fertility because of over use and their yields are lower than yields on farms in the valley's tributaries.

Since fields are very small, intercultivation is necessary in each basin or Jedula. There is a distinctive routine for cultivation. The year starts in the Autumn which is the time for preparing the land for winter crops with the planting of vegetables such as cabbage, onions, turnips, radish and also broad beans as a summer crop, as well as alfalfa on that part of the farm being used to produce fodder for animal husbandry.

There is a lack of adequate modern farming knowledge in th area under consideration. About 83.3% of the total farmers interviewed were illiterate and had not had any agricultural training. Nevertheless, most of the farmers have recently started to recognise the importance of adopting improved agricultural management, especially crop rotation, the use of proper fertilizer, particularly green manure, and the use of machinery, modern equipment and tools, as well as improved seeds and plant varieties. Although all of these have been introduced recently, shortage of financial assistance remains the main obstacle to progress.

b) The second type of traditional agriculture is shifting cultivation, mainly growing wheat and barley. This is influenced by

the physical environment which is discussed in the section on climate and crop ecology. However, traditional practice in shifting cultivation gradually led to its demise. The farmers have begun to use machines for sowing, ploughing and combine harvesting. Mechanisation is virtually limited by physiographic obstacles where shifting cultivation has been practiced in small plots around the main farming areas.

2. Modern farms include several types. These are as follows:

a) Commercial irrigated farming. In this type farming is mostly carried out by machinery. The cultivation is intensive and the products intended for local markets. They exist in El Marj plain where the agricultural land is Class I and II on the land capability classification further, the water balance is favourable for the development of irrigated crops. Land is used more efficiently than in other types of farming with large units permitting the full and most efficient utilisation of agricultural machinery, full scale application of fertilizers and employment of adequate foreign manpower.

Consequently, the production per hectare and yield per unit are in fact much higher than an the farms cultivated traditionally in the nearby area. In general, this type of farming is dominated by mixed cropping of field crops, vegetables and fruit for a local sale, field crops, vegetables and fruit, with the raising of dairy cows and other livestock for farm family self sufficiency, (Plate 10.3).

b) Semi-irrigated farms: These have been set up in El Fatayah area as a result of the newly developed underground water system of Wadi Dernah. It is likely to become one of the best partially irrigated agricultural areas, especially in the orchard plantations in the east of the Jebel El Akhdar.

Plate 10.3 Mixed-crop farm pattern in El Marj plain

This type of farming differs from rainfed farming in that small amounts of water are applied to the crop, mainly vegetables, with an area of about 0.5 ha for each farm, for farm self sufficiency. Water is also provided at the planting stage of orchards, up to the first rainfall or at critical times. This would not have been possible under an entirely dry system. The critical point of this system is its cost and the time factor due to the fact that the water has to be brought from long distances in tanks for irrigation, (Plate 10.4).

c) Modern rainfed farms: The is the most widespread farm type developed in the region and they are most closely adapted to the local environment. Cereal crops are selected on the basis of their suitability to the nature of each region. The climate and average annual precipitation permit the cultivation of winter crops such as cereals, barley and fodder crops as well as orchards on each holding, (Plate 10.5).

Livestock farming is not separate from other types of agriculture particularly in the sample detailed study area. Livestock and cultivation are mutually supportive and interdependent and form a single farm type. Sheep, cattle and goats are the dominant animals in this region in addition to a number of poultry for each farm, especially on state farms in El Fatayah area, (Plate 10.6).

Farming Methods:

Traditional agricultural production is not carried out commercially, although a high percentage of the area is in intensive cultivation. Farmers found themselves unable to develop their land or improve their living conditions. This led to continuous migration from

Plate 10. 4 Traditional method of irrigation on a semi-irrigated modern farm in El Fatayah area

Plate 10. 5 Land-use pattern on rain-fed modern farm in El Marj plain

Plate 10. 6 Symbiotic crop-livestock enterprise

the farm, part time farming and a decrease in the cultivated area. It has been demonstrated that there is no investment in agriculture directed towards the development of traditional farming. Indeed, this needs emphasis in this context to underline the discrepancy in agricultural development in the country. The government has paid great attention to developing new land rather than encouraging traditional peasants who are really entitled to have a share in agricultural development which could then contribute in some way towards food self sufficiency.

The detailed results of the surveys revealed remarkable features in the small farms of Ayn Marrah. They showed that about 63.3% of sample farmers are full time farmers but they also receive off farm income. This trend is a result of insufficient farm output, particularly for Libyan farmers. Therefore they are more likely to be part time farmers than full time farmers. The remaining 36.7% are actually part time farmers.

They are served by cooperative organisations whose main policy is aimed at improving their technological level, and helping them regarding intensification of input use and raising their income, particularly for livestock farmers. These depend primarily on natural grassland and their success is related to the preservation and improvement of range resources. However, increases in livestock production have been achieved by subsidies and imported fodder. This has had a negative effect on agricultural intensity in the traditional sector which is mainly reflected in neglected farming in the area.

Non-Libyan workers have increased substantially in the traditional sample farming area to 40% of total sample farmers. They have occupied

the land as sharecroppers farmers. Each sharecropper has to cultivate more than three parcels in order to earn sufficient income. This, in turn, has led to greater fragmentation of the traditional farms.

However, the effect of foreign labourers on agricultural land use in the case study areas has been indicated from survey data. Most of the foreign workers are from Egypt and Palestine. The first impact of these foreign workers has been change in agricultural practices and crop patterns on the holding. For example they have changed the irrigation system from the traditional basin method of Libyan farms as in Jadula to the system of furrows, which is mainly suitable in a system of abundant irrigation water, such as in the terraces of the Nile Valley in Egypt.

Secondly, they have used chemical fertilizers more than organic manure in order to increase farm output. But some types of chemical fertilizer which have been used in the farms do not compensate for deficiencies in certain elements in the soil, This practice has a bad effect on agricultural soil in the long run, especially on traditional irrigated farms where soil has been exhausted by a long period of exploitation.

Thirdly, the sharecropping system has been dominated by vegetable production and the sharecropper has neglected to maintain trees and fruit production leading to production losses.

Finally, conflict exists between foreign workers and Libyan farmers because non-Libyan farm workers have brought with them knowledge of different farming methods. This has resulted in a negative impact on the land in the long run as each person may have an interest which is in conflict with that of others.

Above all, the government has not paid great attention to

traditional peasant methods. This can be shown by the role of agricultural technical advisers in farming where more than 96% of surveyed farmers have never been visited by technical agricultural advisers. At the same time, the farmers badly need instruction in farm management, especially as they have recently faced various kinds of problems as a result of misuse of pesticides and fungicides. For example, one bee keeper with about 20 hives lost his bees over the last two years because of the effect of pesticides used in the farm area. These types of problems stem from the low priority given traditional agriculture in national development plans and this often causes governments to concentrate resources in areas and on farmers where the potential for change is greater Arnon, (1981); Hunter, (1969).

Access to Government Assistance:

Table 10.3 Government Assistance

Items	30 Traditional Farms of Ayn Marrah %	50 Modern Farm of El Marj Area %	40 Modern Farms of El Fatayah %
All loans	6.7	26.0	37.5
Subsidised agricultural equipment	0.0	10.0	17.0
Subsidised farm inputs	3.3	14.0	10.0
Other aids	0.0	12.0	2.5
None	93.3	54.0	4.0

Questionnaire data

A common feature on both state and private farms is of a great importance to enable farmers to adopt modern farming methods (Goodman and Redclife, 1981). Only 2 farmers 6.7% interviewed on traditional farms obtains loans. These loans were used for purchase of fodder and purchase of a tractor for custom hiring. On other side, 26.0 and 37.5 percent of the modern farms of El Marj and of El Fatayah areas respectively received loans (Table 10.3), in order to off-set the cost of modern farm methods. In El Marj farming area, the credit was mainly used for pumps to improve production of irrigated vegetables, where in El Fatayah area loans take the form of government grants towards living expenses for the first 3 years following the establishment of the farm and assistance for the purchase of new equipment for the farm.

Government official credit runs into fewer practical difficulties, when it is given to farmers who are already on the way to modernisation as on the state farms and who are at the stage when they need to buy expensive capital equipment.

In the study area credit has not been evenly distributed and so it does not play as constructive a role as it could. This is because all modern farms have been developed with all essential equipment. Loans to small traditional irrigated farmers have not led to the adoption of new farming methods. This type of farmer has had to rely on his own off-farm income as a part-time farmer and his own creative mix of production strategies in order to generate capital for the implementation of modern farming methods.

The agricultural Bank and the Co-operative agricultural society loan funds, which enable farmers to meet the operating costs involved in

planting, and acquiring machines and animals (imported cows and poultry are expensive). Many farmers receive more money in loans than they actually use to pay for immediate production costs.

There is a general tendency in the developing countries for farm credit institutions to come under heavy political, economic and administrative pressure to lend the bulk of their funds to large farmers. Loans to small farmers are more costly, difficult to administer and have high default rates (Arnon, 1981).

However, as funds for loans are limited and there are not enough to go around only a minority of farmers receive credit. Repayment is strictly enforced. Loans are dependent on security being offered by acceptable individuals and are made more often to farmers who appear best able to repay. Therefore, the combination of political position, social status, bureaucratic procedures, loan security rules and even occasional outright preference for credit to intensive irrigated farms and large rainfed farms have always favoured the large farmer.

All new state farms receive credit occasionaly. They also have major structural improvements financed by the government either directly through bank loans or special loans from the co-operative society, or indirectly through subsidised farm inputs. These later were ended in 1984 which has had a great effect on the economic position of farms. It has led to increases in the cost of farm production and it is reflected in higher prices of farm produce to the consumer.

Today loans, direct or indirect, are only important for those farmers who practise capital intensive farming. As most of these farms are not cost effective, the use of capital intensive technology would not be profitable without subsidy because of the severe environment.

However, the majority of these farm owners are wealthy outsiders who are more interested in speculative investment in land and in farm improvements which increase farm value rather than in actually farming for profits particularly after the government nationalised the private enterprises. Most of the farmers who receive credit do not really need the money to finance their farm operations. The loans permit them to free capital for investing in other non-farm activities such as personal consumption i.e., furnished new accommodation, cars and wives.

Therefore, loans and technology level may be associated but what is basic to both is the type and size of the farm and the class position of the owners, which enable them to obtain loans in the first place. Those who receive the loans do in fact have a higher technology level, but the relationship is such that the additional capital made available by credit is of marginal importance in intensifying farming methods. Indeed, credit is important for small holders utilising a developed type of irrigation in the way Hunter (1969) stated, i.e., when they are at the stage where expensive equipment is needed. As their capital is limited, loans enable them to buy their own pump, or a better one, as well as to meet high operating costs. Instead loans go to modern farmers who already have passed this critical stage.

Farming Mechanisation:

The need for various kinds of machines and therefore the degree of farm mechanisation in the sample area has increased considerably in the last decade. This is due mainly to the expansion of the farming area. The new modern farms in the El Marj and El Fatayah areas practice the main mechanical agricultural techniques and have acquired the necessary

requirement of machines, for example tractors and ancillary equipment. This has led to a tremendous improvement in servicing facilities and better management of the farm. Mechanisation compensates for the shortage of agricultural workers.

In the last decade, farm mechanisation has relegated most of the implements associated with agricultural development to the modern farming areas in the region. Today, tractors are proportionately fewer or non-existent in the traditional farming area. Therefore, in most seasons it is possible to find implements that belong to one of the holdings being used on other farms under a tractor-hire system. This system is still in existence in modern farming areas particularly for harvesting and haybaling by combine and balers repectively.

The degree of mechanisation is quite different between modern and traditional farms, as shown in Table 10.4. On modern farms each farm is supplied with a tractor by the government. Thus, El Marj farming area has 18 tractors per 100 ha, or about .18 tractors per ha. The level of mechanisation is greater in El Fatayah area, with about 2.5 tractors per 100 ha. The reason for this regional difference is mainly due to changes in development programmes. In the early stages of development farms ranging between 25-50 ha. being set up in El Marj plain, and later farms of 5 ha. were established in El Fatayah area. It is noticeable that these areas have not only tractors but also trucks and pickups.

Although there are more machines on the modern farms traditional farming equipment is still in use, particularly on the irrigated and semi-irrigated farms. Here, hand tools are still used for irrigation control, sowing and cropping. Those farms that do not make use of modern techniques and implements have usually been too small to make

TABLE 10.4: Level of Mechanisation in Case Study Areas

Area	Index	Tractors	Combines	Balers	Ploughs	Seed Machines	Cars	Others
Traditional	Max.	1.00	0.00	0.00	1.00	0.00	1.00	0.00
30 Farms of	Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ayn Marrah	Mean	0.06	0.00	0.00	0.26	0.00	0.26	0.00
Area	Std.Dev.	0.25	0.00	0.00	0.25	0.00	0.25	0.00
Modern	Max.	3.00	2.00	1.00	6.00	1.00	2.00	2.00
50 Farms of	Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Marj	Mean	1.16	0.10	0.20	2.24	0.78	1.16	0.49
area	Std.Dev.	0.46	0.36	0.4	0.87	0.05	0.42	0.71
Modern	Max.	2.00	0.00	1.00	3.00	1.00	2.00	0.00
40 Farms of	Min.	1.00	0.00	0.00	0.00	0.00	0.00	0.00
El Fatayah	Mean	1.02	0.00	0.70	1.12	0.10	0.95	0.00
area	Std.Dev.	0.15	0.00	0.26	0.46	0.30	0.31	0.00

Source: Questionnaire data

Plate 10. 7 Small scale Mechanization

Plate 10. 8 Large scale agricultural mechanization

mechanisation practical or they have a shortage of capital for investment. The tractors that are in use are of medium power, 35 to 65 HP. There two main reasons for this. Firstly, the lighter weight machines do not depress the heavy clay soils as heavier machines would, and secondly, since farms are generally small, there is no need for the higher powered machines with their high working speeds.

As mentioned above, the tractors are able to secure for the modern farms, a standard of full farm mechanisation where all operations may be done by tractor giving sufficient outputs for economic effectiveness. Thus, mechanisation is one way in which change comes to the modern farms; but the effect of technological innovation is slight unless accompanied by changes in the organisation and practice of farming and in social attitudes and relationships.

At the present time, the existence of cooperative agricultural societies in each area has contributed by enabling the hiring of heavy machinery, in addition to the possibility of hiring combine harversters and balers for the grain and fodder crops. A high level of harvesting has been gained for local production in El Marj plain, and this indicates that both grain and straw harvests are highly mechanised (Plates 10.7 and 10.8). Heavy machinery is most effective in large fields with a flat surface and good standing crops, such as those of the El Marj plain.

The use of mechanised hay balers has greatly improved the output of this crop, particularly in the El Marj area. Before the introduction of the hay baler, most farmers were unwilling to develop this important branch of agriculture because of the large amount of labour involved.

Machinery has not been introduced into vegetable and fruit farming

to any grear extent. This is mainly because of the small, diversified, spatially limited areas in which these crops are grown.

There is still a considerable lack of training in the use and maintenance of farm machinery and this has hindered the introduction of machines into various types of farming. This ignorance of the use of farm machinery in the region hinders all attempts to assess the economics of any aspect of farm mechanisation.

From Rainfed to Irrigated Agriculture

The extension of irrigation has characterised land use change in the Jebel El Akhdar in recent times. The El Marj plain provides an example of a rainfed farming area where the appearance of the land has been altered by economic transformation.

Since the 1960s agricultural development has been taking place. Great emphasis has been paid to water availability which is extremely important for all aspects of life when resettling people. Water was piped from Ayn Dabussia to El Marj and scattered settlements throughout the north face of the first terrace of the Jebel El Akhdar, a distance of about 160 km., and it has led to many changes in the structure of this semi nomadic society. Further agricultural changes have been noticed in the El Gharigha area where irrigation from some wells in the plain allowed diversification to take place.

During the 1960s, irrigation was not used except on a few hectares in the experimental farms at Zarada and on two private farms. The two private farms reported irrigation of a total of eight hectares using their own wells. Irrigation on the Ente farms was restricted to the irrigation of newly planted trees (Burau 1965).

After the 1970s a transformation occurred in the context of the Jebel El Akhdar project which aimed at creating new agricultural settlements and at the redevelopment of the old farms in the region. This project started with land reclamation and the development of water resources in the region, both underground water and surface water. The development programmes have been planned for rainfed farms and a small proportion of irrigated farms.

Irrigated farms were established in the El Marj plain due to the active economic development programme of the Executive Authority of Jebel El Akhdar. It gave priority to the El Marj area in agricultural development because it is the most fertile area in the eastern part of the country and it had already been planned in the previous decade. Therefore, the redevelopment of the area would result in rapid increases in output.

However, the El Marj area project shows a great contrast between rainfed modern farms and irrigated agriculture in various aspects. This is indicated by the crop combinations shown in Table 10.5. It shows that the land use has completely changed in recent times; the mixed farms reveal an extension of irrigated land. About 17% of total farm development in the area is fully or partially irrigated.

Table 10.5: Land Use on Irrigated and Rainfed Farms Studied in the El Marj Area

Land use	Area ha.	25 ha. Irrigated Farm N=18	Area ha.	50 ha. Rainfed Farm N=7
		%		%
Vegetable area	7.25	29.05	0.07	0.14
Interplanted area	1.20	4.77	0.64	1.28
Grape area	2.5	10.05	2.28	4.57
Tree area	3.8	15.22	5.42	10.85
Fallow land	.15	0.61	0.00	0.00
Cereal	6.22	25.05	29.85	59.71
Fodder land	2.4	9.66	9.35	18.57
Farm building	1.48	5.94	2.5	5.0

Source: Areal Photos - June, 1979, PASCO

The irregular pattern of irrigated farms within the area is a result of the availability of groundwater. The average irrigated vegetable area is 29 per cent of each irrigated farm, or about 7.25 ha. of fully irrigated land for each farm. Of the 18 sampled farms in the area, the maximum irrigated area per farm is 15 ha. and the average is 7.7 ha. The great majority 94.1% of farmers own wells, and the remaining farmers share wells with other farms.

From the survey data it can be seen that in the case study area, one well will irrigate on average 7.6 ha, because of the type of water lifting methods used. In 96% of irrigated areas electric power is used for irrigation and the remaining percentage use both electric and diesel pumps. Moreover, they also practice the traditional methods of irrigation.

Overwhelmingly, the great significance of introducing mechanization for the enlargement of the irrigated areas can be seen in the modern farms, but in fact attention must be paid to the rational use of water in order to maintain the balance of underground water reservoirs.

New Area of Irrigated Farming:

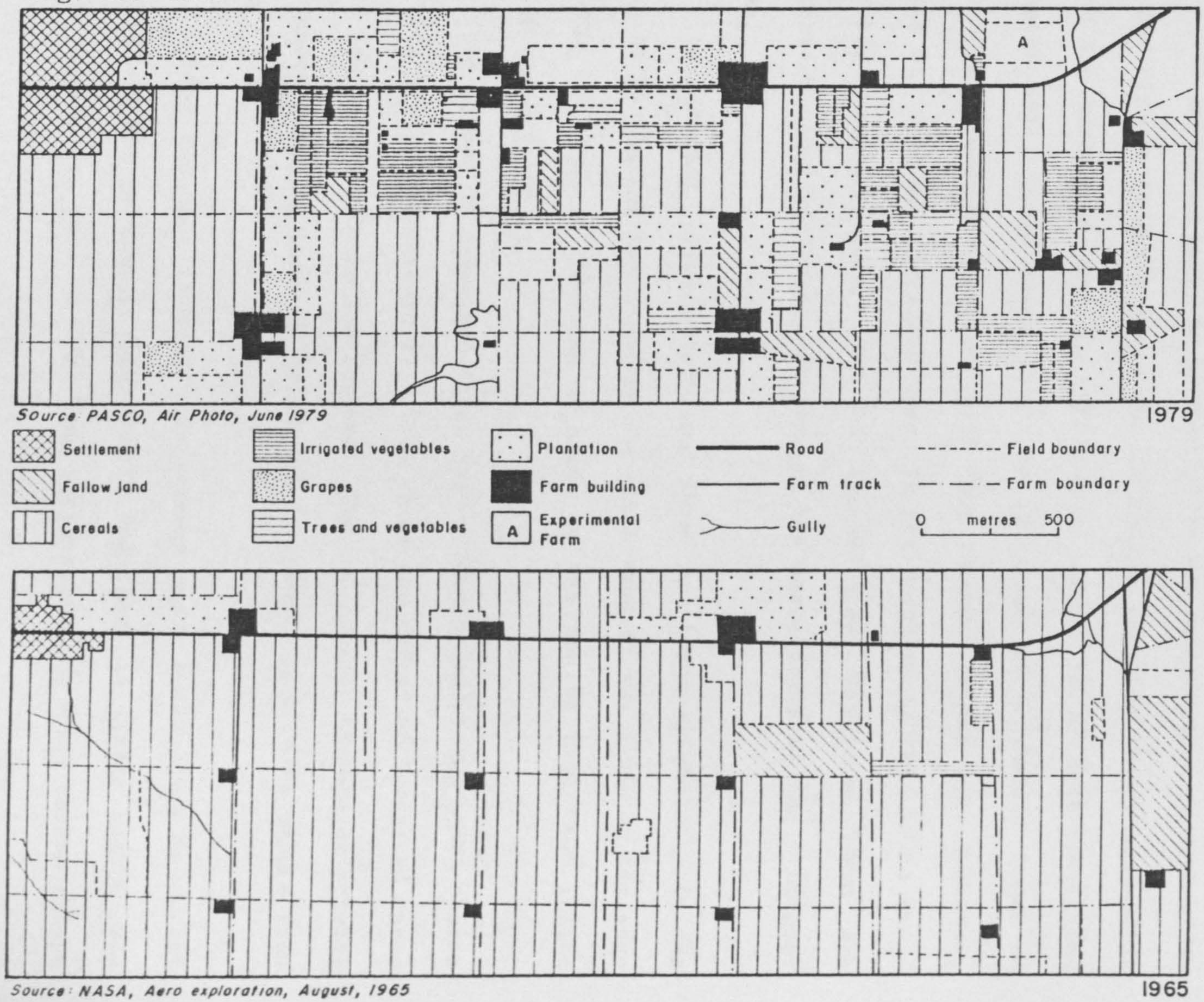
El Marj area is valuable agricultural land, and is intensively farmed. About 14% of El Marj plain farms are completely irrigated. These were set up in dry farm areas which changed in the 1970s following the arrival of resettled farmers. Most of them are from the El Marj region, as is indicated by the land tenure system on the modern farms which is virtually a system of squatting. In order to improve the land tenure system the government development programme divided the land into farms of varying size ranging from 25 ha. for irrigated farms to 50 ha.

Source, PASCO, Air Photo, June 1979

Source: HASA, Aero exploration, August 1965.

Plate 10. 9 Land-use change in El Marj plain 1965-1979

Fig. 10.3 LAND USE CHANGE IN EL MARJ AREA 1965-1979



and more for rainfed farms.

There is a continuity of agriculture in this area, nevertheless changes now predominate in land use patterns. The newly irrigated farms occupy land of first class capability. This is indicated by comparing aerial photos for the two years, 1965 and 1979 at various scales (Plate 10.9 and Fig.10.3).

The irrigated farms in El Marj plain are concentrated on both sides of the highway to Beyda where the irrigation water is easily accessible from the Miocene aquifer in hydrological unit 2 of El Marj plain (See Chapter IV). These farms have the advantage of a shallow level of groundwater and good quality soil (see Chapter IV and V). Moreover, there are some new irrigated farms in the northern El Marj plain and 7 October (saora) areas. In the latter area, irrigated farms are privately owned amd scattered amongst the state farms of the 7 October area.

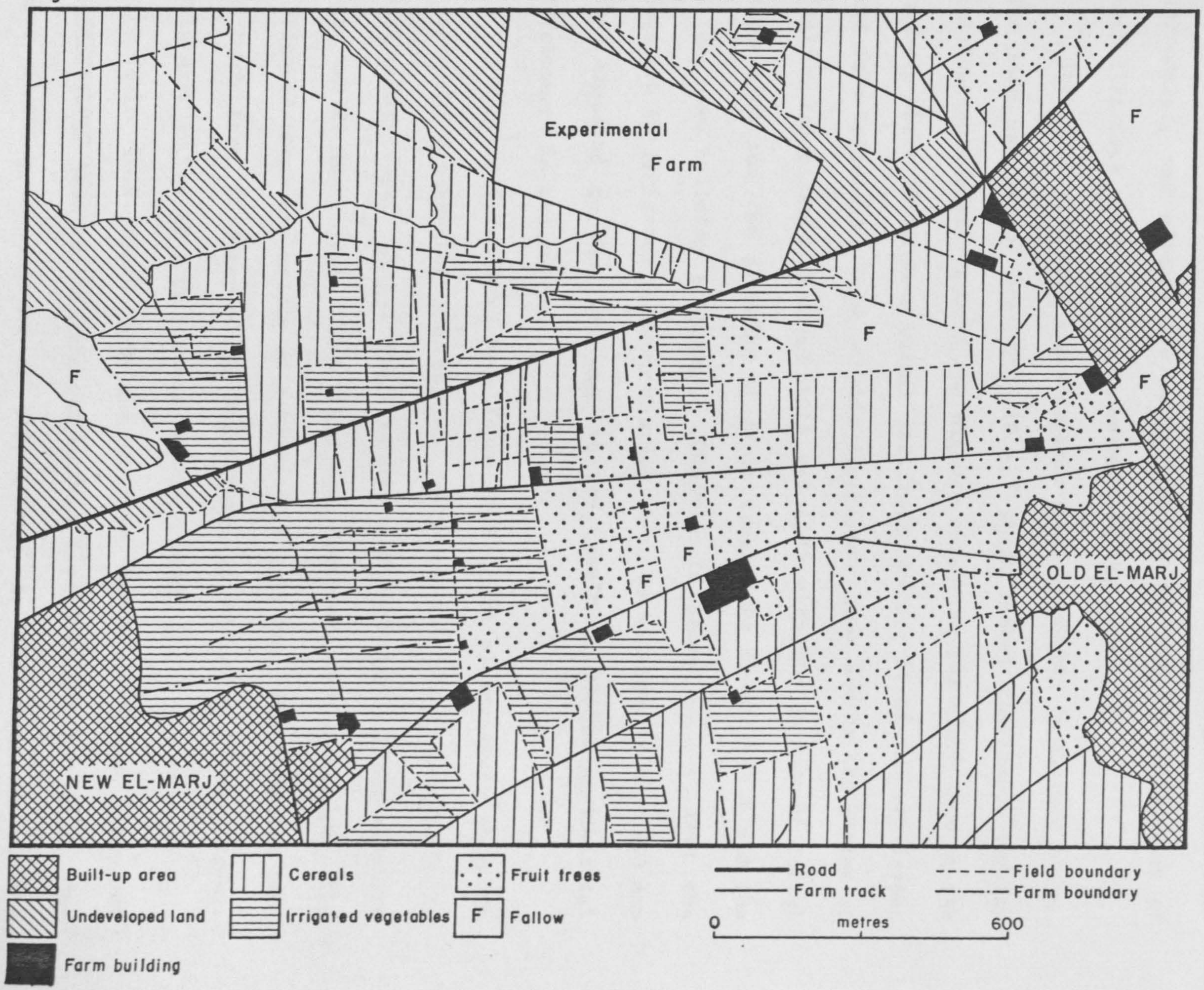
In addition, private irrigated farms are found extensively in the east of El Gharigh basin and in the south east of the plain in the edge of the basin where they are adjacent to the new El Marj town (Plate 10.10 and Fig. 10.4).

The spread of irrigated farms can be seen by comparing aerial photos of 1965 and 1979 (Plate 10.9). This shows the spread of irrigated farms over land previously in dry farming. The outstanding feature of private irrigated farms is intensification of cropping. Their size ranges from 18 to 70 ha.

During the last 15 years the acreage under cultivation in the El Marj plain has increased considerably and there is little arable land left unused: as late as 1984 land reclamation was still active (Plate

Plate 10.10 Private farming area on El Marj plain

Fig. 10·4 LAND USE PATTERN ON PRIVATE FARMS IN EL MARJ PLAIN



Source: PASCO, Airphoto, June 1979

10.11). El Marj plain has been intensively cultivated and a growth in population has been noticed in this farming area. The new agricultural project of El Fatayah a new farm pattern including irrigation has been introduced, and efforts are being directed towards diversification of both livestock and crop farming methods in the area.

The cultivated area has increased most remarkably in El Marj plain. The land use map of 1965 (Fig.10.3) shows almost continuous rainfed cultivation (cereal) around the highway except on the north side of the highway where there were grapes and fruit trees. It shows farm layout and farm buildings. Much of this development came during the period of Italian colonisation between 1911 and 1932 with the growth of cereal production and the planting of fruit trees (see Chapter VII) and the large road building programme. However, it seems that the increase in irrigated cultivated areas which is apparent on the 1979 map when compared to the 1965 map, is the result of recent agricultural development in the region.

Irrigated farms have been found in El Marj plain, where there is access to groundwater and certain parts of the plain specialise in particular crops. Cereal and tree areas are dominant in the southern area of El Marj plain where they are combined with livestock. The irrigated farms are mainly of a mixed crop pattern. The irrigated land on each farm is occupied by vegetables, interplanted between trees. This part of the farm is intensively cultivated.

Table 10.5 shows how the acreage in the various types of agricultural land use has changed between irrigated and dry farms. The most striking development of this period is the expansion of the vegetable area compared to other crops. The farmers were quickly

Plate 10.11 Land reclamation being carried out in 1984 on Al Awssat project and El Marj plain

attracted to a crop which brought in a regular income with high profits. Today many bigger irrigated farms are going out of vegetables because of marketing problems, shortage of labour, and an ecologically disastrous shortage of water, and are planting fruit trees instead. The small farmer however, is still extending his vegetable acreage though on a small scale. The great increase in irrigated acreage during the 1970s as shown by Fig.10.3 is almost entirely due to state intervention in the private sector and that part of the agricultural sector which still enjoys free enterprise. Therefore, most of the wealthy people have put their emphasis in agriculture, particularly in the private sector.

As in so many of the changes in land use in the Jebel El Akhdar region generally during the early 1970s, the farmers were the leaders and innovators in the dramatic switch from rainfed monoculture to irrigated monoculture. At the end of the 1960s the only irrigated private farm in the El Fatayah area appeared in the middle of an area of shifting cultivation and pasture. This encouraged the planners to relate the wadi Dernah scheme to arable land in this area. This scheme has been very expensive. In this area the shifting cultivation and pasture was improved in the 1970s, and the area formerly used as an old airport during the Italian colonisation was redeveloped. Within this post war period, non-agricultural land use has increased with the demolition of the airport buildings and the construction of rural settlements. Further there has been expansion of land reclamation and improvement in farm infrastructure. (Plate 10.12).

Irrigation has, in general, increased farmer's incomes and these have often been reinvested in the farm to improve its quality and productivity and to introduce new techniques such as greenhouses,

Plate 10.12 El Fatayah new farms model

fertilizers, pesticides, mechanisation and improved layout of fields.

Many changes in agricultural practices have occurred in this area. Wells used for supplementary water supplies to farms in the region have been enlarged and motorised for more efficient extraction of the water. Traditional methods of irrigation where water is distributed from standing pools, are relatively inefficient. Water loss by these methods can be as high as 45% (Magson, 1981). The proportion of this loss due to infiltration can be reduced by rapid flooding, which disturbs the finer soil particles so that they clog the soil pores and deter infiltration. Sprinkle irrigation would be more effective than flooding from pools because it would eliminate evaportion from standing pools. However, this method has not been used in the study region (though it is used in Western Libya) because of its high initial cost and the general lack of knowledge among the farmers about its use. In addition it is not suitable for vegetables and heavy soils.

A Scale and Intensity of Farming:

The results of the significant shift of the state's agricultural land base is an increasing dependence on land with lower overall quality, more severe climatic limitations and greater susceptibility to organic matter loss. There is an increase in new land reclamation and redevelopment of old farm patterns in different localities. New farm development aims to indicate the size of plot necessary to provide equality of farm output. With these aims a farm layout plan is prepared for each settlement, showing farm boundaries, roads, trading centres and other amenity areas. Whilst land is being prepared for settlement it is farmed by the Executive Authority of Jebel El Akhdar in order to

Table 10.6: Scale and Intensity of Farming

	30 Traditional Farms of Ayn Marrah Area			50 Modern Farms of El Marj Area			40 Modern Farms of El Fatayah Area		
	Mean hectares	Std.Dev.	Percentage of farms	Mean hectares	Std.Dev.	Percentage of farms	Mean hectares	Std.Dev.	Percentage of farms
Farm size	1.05	0.60	-	41.10	14.10	-	1.00	0.00	-
With one parcel	-	-	43.3	-	-	100.00	-	-	100.00
With two or more parcels	-	-	56.7	-	-	0.00	-	-	0.00
Land Use									
Tree crops	0.28	0.33	46.60	8.67	3.67	100.00	3.00	0.00	100.00
Cereals	0.08	0.29	10.00	21.54	12.57	92.00	1.15	0.52	90.00
Vegetables	0.70	0.42	90.00	2.53	4.00	38.00	0.50	0.40	75.00
Fodder	0.00	0.00	0.00	5.08	3.76	82.00	0.07	0.26	37.00
Fallow land	0.00	0.00	0.00	2.84	3.66	50.00	0.20	0.49	22.50

Source: Questionnaire data

maintain the trees already planted.

The new farmers have to meet the full responsiblity of farm management and to be members of the cooperative society for three years in order to qualify for a grant to maintain their farms and to bring them to the stage of full productivity. During the first three years, the farmer receives a maintenance grant. Interest-free mortgages, repayable over 15 years, are also available to the farmer. The average cost of a 5 ha farm in El Fatayah is around 30,000 Libyan Dinars. In the El Marj area the cost is slightly higher, namely 31,000 for rainfed farms and 41,000 for irrigated farms (in constant prices in 1970).

After the reorganisation of the Secretariat of Agriculture, there was a rapid expansion of land development. For example, in the El Marj plain there were 200 new farms planned in the beginning of the 1970s; the number rose to 340 in 1984. This shows a growth rate of 3.5% per year in the last 14 years.

Farm size in the El Marj area ranges between 25 ha and 80 ha. The smaller farms are in the areas of better land where there is high precipitation and plenty of groundwater. The larger farms are in the drier lands.

In 1982 reclamation began in the 7-October area. This comprises 8,451 ha divided into 182 farms, ranging in size from 6 to 120 ha. The smaller farms occur in the south of the area where they often consist of mixed orchard and cereal crops. The size of farms is proportional so that each produces roughly equal incomes.

The aforementioned and Table 10.6 show the variance between types of farms in the region. This indicates that new farming patterns have overcome certain problems, such as fragmentation which still occurs in

the traditional garden area. On the other hand, the average farm size varies from one area to another and the intensity of crops has increased in traditional irrigated farms more than in modern farms. In the traditional farms 90% of the farmers interviewed grew only vegetables while in modern farms this was the practice of 38% of farmers interveiwed in El Marj. In the El Fatayah farming area, about 75% of farmers interviewed used part of their farm for vegetables for subsistence production.

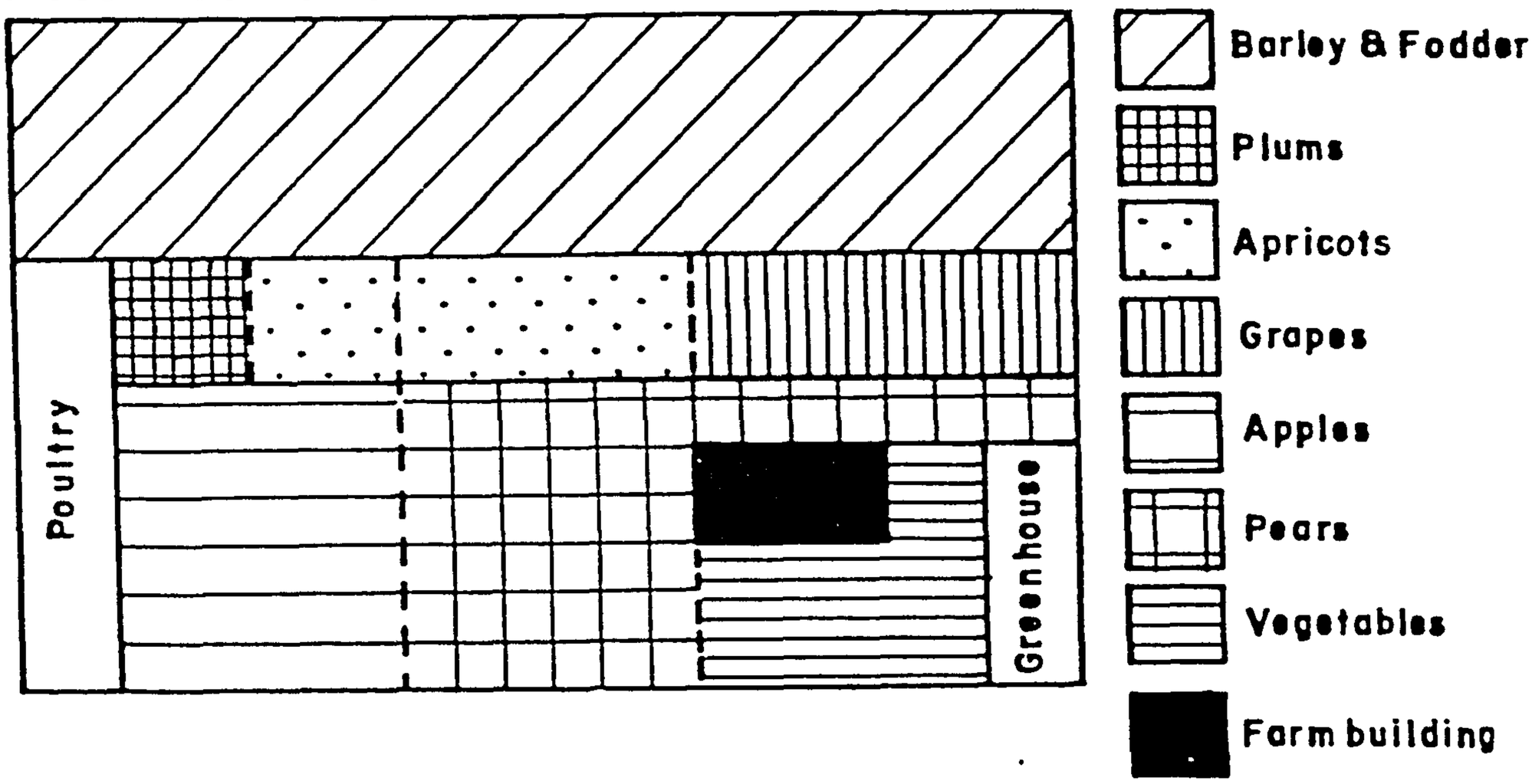
Although crop patterns have been laid out by state planners on modern farms, there are discrepancies between the two case studies areas which can be mainly ascribed to the ecological effect on patterns of land use. Further, modern farms have a vast area compared to traditional farms permitting extensive use of agricultural land and practices of modern agricultural training, such as crop rotation and mechanisation. This, in turn, encourages farmers to increase their investment in the land to attain optimum land utilisation and to improve their level of management.

Table 10.5 deals with the crop pattern in the El Marj modern farms. They indicate the predominance of mixed farms rather than full irrigated farms in the region. The size of irrigated land in each farm has increaseed considerably according to the number of wells for each farm and their capacity. The irrigated farm has 34% an average of its area occupied by vegetables and intercropped planting, and the remaining percentage of area divided between fruit trees, cereal or fodder, fallow land and farm building. On the other hand, rainfed farms are mainly under cereal which occupy more than 80% of farm area, with 20% of farm area divided between trees and farm buildings. These figures deal with

Fig. 10·5 PATTERN OF LAND USE ON FARMS

Modern Settlement Farm

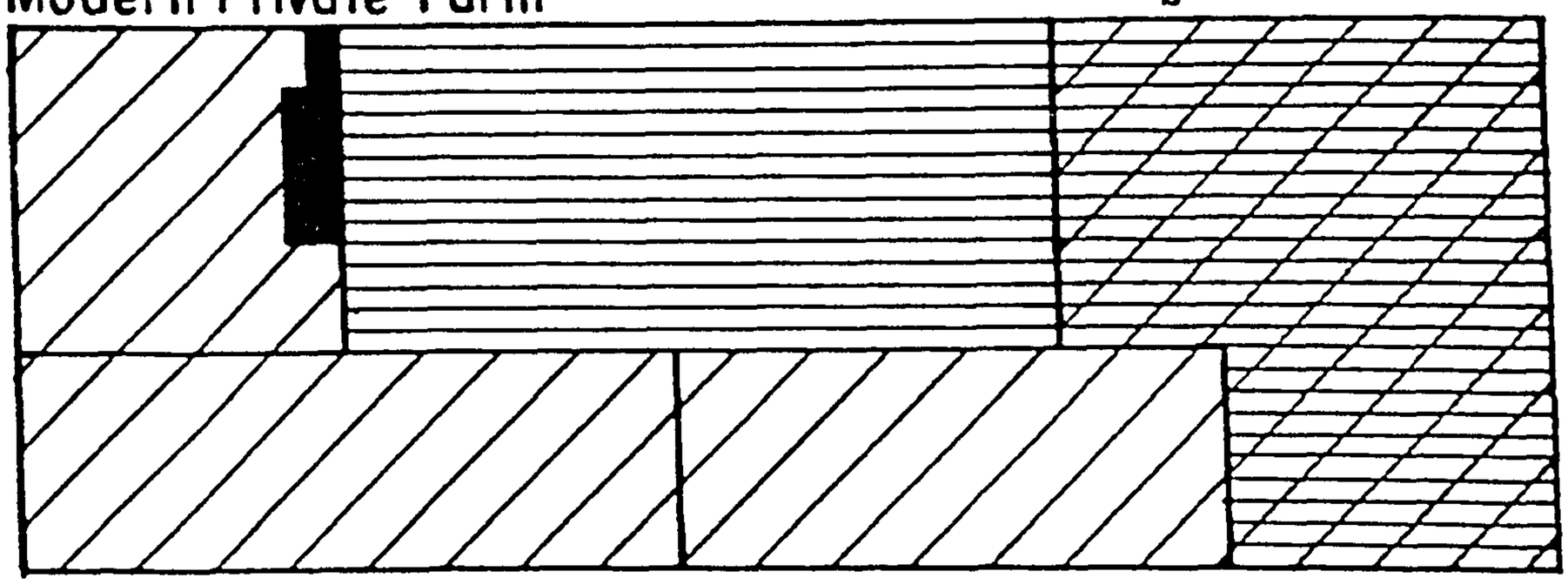
a



AREA OF EACH FARM = 25 ha. (approx.)

Modern Private Farm

b



crop patterns in terms of land utilisation.

Intensity of land use is greater on private farms than on settlement farms because the private farmer has more money invested in his land and must show a profit with less subsidy than the settler. This is indicated by comparing two typical farms (Figs.10.5(a) and (b),

Fig. 10.5(a) represents a modern settler's farm. The farm management on this farm is at a high level so that the farm is a model modern farm. Indeed this pattern should predominate in the area. Whilst Figure 10.5(b) shows a typical private farm in the area with a high intensity of land use.

The farmers' aims have recently changed to allow for new planting of trees instead of vegetables. This is as a result of certain problems which have faced an increase in irrigated vegetables, for example, shortage of labour, market problems and water shortage. Indeed, these limitations and others have greatly influenced the scale and intensity of agricultural land use in the region.

Land Tenure

Table 10.7: Type of Land Ownership

	30 Traditional Farms of Ayn Marrah area %	50 Modern Farms of El Marj area %	40 Modern Farms of El Fatayah area %
Usufruct	0.0	48	100
Squatter's rights	3.3	36	
Inheritance	50.0	12	
Purchase	0.0	0	
Sharecropping	53.3	4	
	* 106.6	100	100

*The total is more than 100% because system of land types of land tenure on some traditional farms two type of land tenure may be found.

Table 10.7 shows the pattern of land ownership on traditional and modern farms in the region. Land tenure varies considerably between the two farm types. The most common type of land tenure in the traditional area is the sharecropping system. This is found on more than half of the traditional farms surveyed. Most of these sharecroppers are non-Libyan.

The second most common type of land tenure in traditional farms is ownership through inheritance. This is a result of Sharia Islamic law. The percentage of inherited modern farms is 12% of total farms surveyed, while 36% of modern farms in El Marj area are occupied by squatters.

The two latter systems of land ownership, on modern farms, indicate the relationship between old farms or re-development farms and new settlers. Most of the modern farms in El Marj area have been allocated according to the old system of land tenure (as discussed in Chapter VII) in order to avoid tribal dispute over the land. This has been achieved by giving priority to the old landlord, or compensation and exchange of his farm. Thus, the patterns of land tenure have developed with the new settler owners. This is as a result of agricultural policies development in the country and after promulgation of land reforms according to law No.4, 1971, which has changed land ownership in the country generally. (See Chapter II, Table 2).

Farm Accommodation and Access:

A typical modern farm house is shown in Plate 10.13(a). In the modern farm areas access is also of a generally high standard, with many paved roads and [illegible] paved access. By contrast, in the traditional farming areas, both accommodation and access are often inadequate (Plate 10.13 b

Plate 10.13a Modern farm house

Plate 10.13b Traditional farm house
Note; unpaved roads in this area

10.13(b)) and many of the farmers in these areas do not live on their farms.

Most non-Libyan workers live on the farm (23.3% of the total farm survey) whilst the Libyan farmers live on farm only 10% of total farms surveyed. Therefore, the importance of farm accommodation and its standard indicates the relationship between the farmer and his land and transport availability. For example, in the traditional farming area of Ayn Marrah the roads are not paved and are in poor condition. This creates many problems in transporting farm produce to the markets.

The average distance from the traditional farms to the market in the Ayn Marrah area is only about 3.5 km, but most of the traditional farmers (73.3%) do not have private transport. They must pay for the transport of their produce to the market, thereby increasing the cost of production. By contrast, in the modern farm area of El Marj (Plate 10.14(a) and 10.14(b), the average distance from farm to market is about 15 km, but 98% of the farmers in this area have their own transport.

Farm Management:

This varied considerably between the farm types in the region. It is measured by a variety of variables. These variables are related to a farmer's agricultural experience. Most farmers of El Marj plain had experience of rainfed agriculture and animal breeding, but only 25% of farmers surveyed had adequate experience of irrigated agriculture, whilst more traditional farmers have a wide experience of agriculture generally, and irrigated farming in particular. On the other hand El Fatayah farming area has a mixture of farmers with a broad knowledge of all types of farming and new farmers with no experience in agriculture. These variations are seen quite clearly in the standard of farm administration.

Plate 10.14a View of modern farm structure

Plate 10.14b Farm road development

Attitude to Farming:

This is indicated by the farmers' answers to particular questions such as whether they wished their children to work on the land and their views of agricultural development. These variables show that the majority of traditional farmers wish to maintain their land as it is. At the same time, the modern farmers in El Marj indicated various views with rainfed farmers willing to have further changes on about 40% of total farms surveyed. At the same time they preferred their children to be farmers. In El Fatayah area, about 42.5% of the farmers interviewed are hoping for further change in the future. They look forward to the completion of the development programme as soon as possible. The failure to implement the development programme in full has had an adverse affect on the farmers' attitudes towards their children's future in farming. The remaining percentage which represented intensive irrigated farming in El Marj area and farmers with no experience in El Fatayah area did not want any changes due to the fact that the former had sufficient income and the latter had no interest in agricultural workers. Farmers did not wish any change in traditional farming areas as they desired to keep the land for future generations to be able to work.

Education Level in Farming

Table 10.8: Education Level and future Plans of Farmers;

	30 Traditional Farms of Ayn Marrah	50 Modern Farms of El Marj area	40 Modern Farms of El Fatayah area
	%	%	%
Illiterate	83.3	58.0	78.5
Pre-secondary school	13,3	32,0	25.0
High school	3.3	6.0	2.5
University	0.0	4.0	0.0
Farmer wishes son to be farmer	86.7	66.0	32.5
Further change in future	36.0	40.0	42.5

Source: Questionnaire data

There is a close relation between the farmer's view of farming progress and education level. The traditional farmers have a lower education level with 83.3% of farmers surveyed illiterate (Table 10.3). The most successful modern farmers of El Marj area had high school or university level of education, for example in the intensive irrigated farm (Fig.No.10.5.a). This supports the argument which states that there is a strong relationship between educational attainment and level of farm management. Education level also influences farmer's attitudes to change and agricultural development. Uneducated farmers are unwilling to change, as is shown by the traditional farmer's view regarding agricultural change. Education affects farm management with farm operational standards expected to developing with improved education (Arnon, 1981, Hardiman and Midgley, (1982), Haswell, (1973).

Changing Labour Availability:

The amount and quality of labour affect farm viability in general. The agricultural labour situation in the country and in the region particularly is characterised by two factors: the size of the farm family and the availability of foreign labourers.

Modern farms were originally planned to be "Family Farms", where the labour was done by members of the farmer's family. The average size of a farm family is 9 members, so that theoretically this is a sufficient number for efficient running of a farm. However, many of the younger members of the family are no longer interested in working on the farm and, in fact, 23.3% of the farms in the El Marj area use outside labour.

Table 10.9: Structure of Agricultural Workers in Study Area

		30 Traditional Farms of Ayn Marrah Area			50 Modern Farms of El Marj Area			40 Modern Farms of El Fatayah Area		
	Units	Mean	Std.Dev	%	Mean	Std.Dev	%	Mean	Std.Dev	%
Farmer's age	Years	53.33	16.75		48.38	15.03		48.72	10.97	
Farm family size	Persons	7.53	4.05		9.08	3.19		9.22	2.87	
Full-time farmer	-	-	-	63.30	-	-	94.00	-	-	90.00
Part-time farmer	-	-	-	36.70	-	-	6.00	-	-	10.00
Full-time family workers	-	-	-	70.00	-	-	90.00	-	-	87.50
Full-time foreign workers	-	-	-	40.00	-	-	32.00	-	-	12.50
Part-time family workers	-	-	-	10.00	-	-	2.00	-	-	15.00
Part-time foreign workers	-	-	-	13.30	-	-	2.00	-	-	10.00
Seasonal family workers	-	-	-	0.00	-	-	12.00	-	-	10.00
Seasonal foreign workers	-	-	-	0.00	-	-	0.00	-	-	0.00

Source: Questionnaire data

Table 10.9 shows the farmer's average age and the size of the farm family on modern and traditional farms. Farmers on modern farms are younger and have larger families than those on traditional farms. These differences are reflected in the pattern of land use in the two different type of farms. Thus, the family structure influences the farmer's view of agricultural changes. Therefore, farmers with large families resident on the farm showed a somewhat greater tendency towards change than others who acquire new property as a new farmer without agricultural experience. In general, the farm population is ageing. In 1974 the average farmer's age was around 45. The present study found that the majority of farmers were between 50 and 70 years old, with less than 5% younger than 40 and more than 20% older than 70. This ageing of the farmers results in less efficient labour and less intensive land use. Further, although the elderly people possess the economic power in the society, their conservatism is thought to be a barrier to progress, see, Arnon,(1981); Foster, 1973; Djurfeldt, (1982)

Members of the farm family are the main workers on 89% of the holdings of the modern farmers interviewed, but are important on only 70% of the sample traditional farms. The reason for this difference is that the first type had been planned as family farms, and their economic return has been sufficient for farmers and their families.

The second type of labour is the foreign worker. They make up about 40% of the labour force on traditional farms and 32% on the farms of El Marj area. They are mainly concentrated on modern irrigated farms in El Marj or in traditional irrigated gardens. In the El Fatayah area, they make up 12% of the labour force on the farms surveyed. These farms

are operated by younger people who have to undertake national duty. In addition, the foreign workers appear on farms run by farmers with an urban background and without experience in farm management. A small percentage of seasonal workers, either family or foreign, is found on the modern farms. Most of these work during the harvest season which coincides with the school summer holiday period.

Not only are members of the farming families leaving the farms,but those who remain often do not contribute to farm labour. It is often more profitable for them to work at a non-agricultural occupation. This is shown by the fact that 36.7% receive income from non-agricultural work. Non-family workers have also become increasingly more difficult to obtain, because of the migration of the young people to urban jobs and to school. In addition, non-agricultural work provides higher wages and is physically easier than farm work. Moreover government social programmes, such as social security to widows and older people, and further rewards for people who had struggled against Italian colonisation, have reinforced this trend on the traditional farms.

Traditional farmers experience problems in obtaining adequate agricultural training in advanced agricultural methods. On the other hand more than 42% of those interviewed on modern farms had been trained in agricultural practices. Most of these are in the El Marj area. Nevertheless a shortage of skilled labour, with a consequent large proportion of expatriate labourers, is a principal obstacle facing farm management. Thus, labour availability affects the choice of crop and the size and type of farming operation. There are various ways in which this problem has been dealt with.

First of all, extensive and more mechanised field crop units are

evidence of the effect on land use in the modern farming area. Secondly, farmers choose to replace scarce and expensive workers with capital, This can be seen in, trends towards planting trees on mechanised cereal production which requires a large parcel of land between 20-50 ha to justify mechanisation. Thirdly, increasing share cropping production in traditional shifting cultivation and in market gardens at Ayn Marrah and Dernah City is a way to solve the problem of shortage of labour.

Eventually, the trends towards less intensive use of land or changing crop patterns on modern farms is attributable, at least in part, to labour shortage, cash problems and above all, government policies which have just promulgated an end to foreign labour in the country by the end of 1985. This has led a great impact on the return of expatriates to their home land which is increasing the problem of shortage of agricultural workers on the land in the country generally, and in the region in particular, with overall a negative impact on optimum agricultural land use.

Agricultural Trends:

Table 10.10 shows general trends of changes in inputs and outputs in the case study area. This indicates that farm production has intensified. There is a close relationship between the change in farm production and land use intensity and increase in the costs of farm production. There is little change in farm size except on modern farms.

The contradictory existence between change in these three indices and the lack of change in reflects land scarity in traditional farming area and government policy in modern farming areas.

Table 10.10: Land Use Changes in Case Study Areas

Land Use	30 Traditional Farms of Ayn Marrah Area			50 Modern Farms of El Marj Area			40 Modern Farms of El Fatayah Area		
	Increased %	Reduced %	No Change %	Increased %	Reduced %	No Change %	Increased %	Reduced %	No Change %
Average size farm	0.00	0.00	100.00	18.00	22.00	60.00	0.00	0.00	100.00
Farm production	93.00	6.70	0.00	66.00	18.00	16.00	82.50	2.50	15.00
Land use intensity	100.00	0.00	0.00	80.00	6.00	14.00	92.50	2.50	5.00
Cost of production	0.00	0.00	0.00	96.00	0.00	4.00	92.50	0.00	7.50
Irrigation	90.00	-	-	12.00	-	88.00	0.00	0.00	0.00
Rainfed farming	10.00	-	-	50.00	-	50.00	0.00	0.00	0.00
Irrigated farming	0.00	0.00	-	36.00	-	64.00	97.50	0.00	2.50
Fallow land	0.00	0.00	-	2.00	-	98.00	2.50	0.00	2.50

* Percentages are based on total number of farmers surveyed.
Source: Questionnaire data

Each farmer, therefore, had to produce more or increase his efficiency of operation just to remain viable. Consequently, the income per farm has risen only through intensification of farming.

However, with high intensity of land use, multi cropping and by specialisation, farmers have managed to compensate for the small size of irrigated farms, average 25 hectares, and maintain the overall high level of output. In the traditional farming area vegetables predominate and orchard plantations have rapidly expanded over the past decade accompanied by increased numbers of foreign labourers and stocks livestock.

Trends in Farm Costs and Income

Of all external factors influencing farm production, rising costs were the most significant according to a majority of the interviewed farmers. For example, costs of fertilizers doubled from 1970 to 1984 (from LD 6 to LD 12) wages rose from LD 2 per day in 1970 to LD 10 per day in 1984. Other items such as machine parts, rose accordingly. The decline in farm profits is also attributed to government fixed prices for some of the farm product. Vegetable farmers have suffered the most, but dry farming products, such as cereals, have also fared badly because the government has paid the farmer for only a portion of his production.

A consequence of this "cost price squeeze" is that most farmers have been faced with market problems where their existing farming scale and activity have been insufficient to ensure continuing adequate returns. Thus, a majority of farmers in both types of farms have changed their crop pattern, particularly in irrigated farming. For example, some have changed from vegetables to tree crops, with 93.3% of

the interviewed farmers on modern farms having intensified and altered their crop pattern. The reason for this was increased cost production and a decrease in the market prices of particular products such as vegetables. Therefore, the general trends within the region are for change from vegetable production to cultivation of tree crops which require less labour and generally give a higher profit margin, especially apples, peaches, plums and pears, and above all, use less water which is essential in light of the acute shortages of irrigation water.

In the dry farming areas, more livestock is being added to farms which were previously dominated by fodder crops. Of the modern sampled farms, 8% had increased the number of sheep (Table 10.11), which required an additional investment from the farmer, but was more profitable ultimately than fodder crops alone.

Intensification of land use, as shown in Table 10.11 is another way in which farmers have adapted to the "cost price squeeze". Most of these changes occurred during the 1970s when the Development Planning Programme was first begun. By the 1970s the financial position of the farmer was so desperate that the local agricultural authority considered that only through an integrated development plan for Jebel El Akhdar could the future of farming in the area be assured. This has brought more economic importance to the region since 1970 and better prospects. Thereafter, a new infrastructure and applied new technology in agricultural practices were reported on more than 90% of farms during the 1970s. The removal of fencing confirms field enlargement. This indicates a relatively small change in farm layout patterns (See Fig.10.3). Similarly tree planting, drainage improvement, gravel

Table 10.11 Percentage of Farms with New Inputs, Crops and Livestock

Farm Input	30 Traditional Farms of Ayn Marrah Area %	50 Modern Farms of El Marj Area %	40 Modern Farms of El Fatayah Area %
New Crops	100.00	90.00	95.50
Farm Buildings	46.60	34.00	15.00
Labour	20.00	40.00	2.50
Machines	3.30	38.00	10.00
Development Irrigation System	0.00	0.00	0.00
Greenhouses	0.00	20.00	0.00
Livestock	6.70	8.00	7.50
Nothing	0.00	2.00	0.00

Source: Questionnaire data

extraction and scrub clearance are directed towards the most economic return use of land according to land capability.

All of these activities involve capital investment in the development of the region. The average level of investment per hectare was LD 100 in 1970. This figure varies considerably between areas and farm type. The cost per hectare in irrigated farms was about LD 165, whilst the cost per hectare in rainfed farms cost about LD 60 in El Marj area. This compares with the cost of LD 6,200 per hectare in El Fatayah area. The reason for this variation is the recent establishment of the farming area in El Fatayah and the small farm size. There is an overall trend towards small, more intensively managed farm units within the region.

CONCLUSION:

It is clear that the objectives and achievements of the agricultural settlement development programmes must be evaluated under two headings: (i) land reclamation and (ii) infrastructure. Farm settlements were intended for a landless rural population who would farm the land, and accordingly better their standard of living. These agricultural development schemes were planned to improve socio-economic conditions and the stability of rural areas and to reduce rural migration to the cities. These settlements have attracted many urban dwellers and thus have led to a reversal of the former migration flow. This trend is quite clear in several growing rural settlements, for example, the El Fatayah settlement, which so far has failed to achieve its declared aims of production because of shortage of irrigation water.

CHAPTER ELEVEN

ANALYSIS OF FARM SURVEY DATA BY SIMPLE CORRELATION AND MULTIVARIATE TECHNIQUES

INTRODUCTION:

Similar and additional variables to those analysed in the preceding discussion have been used in this section of the study to put further emphasis on changes in agricultural land use in the Jebel El-Akhdar. The spatial pattern of agricultural land use has been affected by physical and socio-economic factors. The impact of physical factors has been discussed in the previous chapters. Now, certain socio-economic factors are selected for consideration in relation to different farm types in the study area.

The variables are listed in Table 11.1 with mean and standard deviation for each of the three study areas. These variables have been submitted to multivariate analysis:

I A principal component analysis

II Discriminant analysis

III Cluster analysis.

ANALYTICAL PROCEDURE:

Choice of Analytical Methods:

The factor analysis technique with a Principal Component Solution is employed in this study as a multivariate technique, that reduces a number of variables to their underlying components.

Table 11.1 : Selected Variables Affecting Agricultural Development in the Study Area

TABLE 11.1:

Variable Name	MEAN: Total Study Area	MEAN: Study Area: Traditional 30 farms Ayn Marrah	MEAN: Study Area: Modern 50 farms of El Marj area	MEAN: Study Area: Modern 40 farms of El Falayeh	STANDARD DEVIATION: Total Study Area	STANDARD DEVIATION: Study Area: Traditional 30 farms Ayn Marrah	STANDARD DEVIATION: Study Area: Modern 50 farms of El Marj area	STANDARD DEVIATION: Study Area: Modern 40 farms of El Falayeh
Farmer's age in years	49.70	53.30	48.30	48.70	14.30	16.70	15.03	10.09
Farm family size	8.74	7.53	9.08	9.22	3.37	4.05	3.19	2.87
Farmer's education level	0.39	0.20	0.58	0.30	0.65	0.48	0.78	0.51
Full time farmer (1/0)	0.85	0.63	0.94	0.90	0.35	0.49	0.23	0.30
Gross yearly income in L.D.	2719	1347	4688	1287	2237	254	2283	397
Farm size in hectares	19.05	1.05	41.10	5.00	20.85	0.60	0.14	0.00
Farmer's experience in dry farming (1/0)	0.54	0.30	0.82	0.37	0.50	0.46	0.38	0.49
Farmer's experience in irrigated agriculture (1/0)	1.09	1.93	0.62	1.05	0.99	0.36	0.92	1.01
Agricultural training of farmer (1/0)	0.35	0.0	0.82	0.02	0.47	0.0	0.38	0.15
Number of farm family workers	1.00	0.80	1.04	1.12	0.55	0.55	0.40	0.68
Number of foreign farm workers	0.27	0.40	0.32	0.12	0.44	0.49	0.47	0.33
Land tenure system of usufruct	0.53	0.00	0.48	1.00	0.50	0.00	0.50	0.00
Land tenure system of squatting	0.17	0.10	0.36	0.00	0.38	0.30	0.48	0.00
Land tenure system of inheritance	0.17	0.50	0.12	0.00	0.38	0.50	0.32	0.00
Land tenure pattern of share cropping	0.15	0.53	0.04	0.00	0.35	0.50	0.49	0.00
Land fragmentation, number	1.16	0.20	0.00	0.00	0.39	0.40	0.00	0.00
Vegetable area per farm: ha.	1.39	0.70	2.53	0.50	2.76	0.42	4.00	0.40
Cereal area per farm: ha	9.37	0.08	21.54	1.15	13.11	0.29	12.57	0.52
Fodder area per farm: ha	2.14	0.00	5.08	0.07	3.47	0.00	3.76	0.28
Pasture area per farm: ha	1.25	0.00	2.84	0.21	2.72	0.00	3.66	0.49
Tree area per farm: ha	4.68	0.28	8.67	3.00	4.25	0.33	3.67	0.00
Fodder problem (1/0)	0.83	0.66	0.96	0.80	0.37	0.47	0.19	0.40
Number of visits by agricultural technical advisor	2.38	2.93	2.34	2.02	0.56	0.30	0.62	0.15
Number of animals per farm	40.50	21.46	71.02	16.65	59.12	33.81	73.01	32.62
Number of poultry per farm	29.58	0.00	12.40	73.25	79.29	0.00	55.27	111.8
Quantity of chemical fertilizer input on cereal: kg/ha	26.20	0.00	50.40	15.12	30.27	0.00	24.24	25.79
Quantity of chemical fertilizer input on vegetables: kg/ha	80.12	71.66	148.9	0.50	202.92	176.50	267.42	3.16
Water problem (1/0)	0.72	0.63	0.50	1.00	0.73	0.55	1.01	0.00
Irrigated land per farm: ha	2.10	0.75	3.14	3.50	3.41	0.53	4.99	0.39
Number of tractors per farm	0.84	0.06	1.16	1.02	0.56	0.25	0.46	0.15
Number of cars per farm	0.86	0.26	1.16	0.95	0.53	0.44	0.42	0.31
Off farm income L.D.	599.00	693.00	188.00	1043.00	609.00	563.20	573.40	238.90
Government assistance (1/0)	0.52	0.16	0.62	0.67	0.68	0.46	0.77	0.61
Sale of farm production in local market in the area (1/0)	0.96	1.00	0.98	0.92	0.18	0.00	0.14	0.26
Sale of farm production on farm (1/0)	0.36	0.36	0.66	0.00	0.48	0.49	0.47	0.00
Sale of farm production elsewhere (1/0)	0.41	0.80	0.42	0.12	0.49	0.40	0.49	0.33
Marketing problem (1/0)	0.88	0.96	0.90	0.80	0.32	0.18	0.30	0.40
Farmer's view of further development of his land (1/0)	0.40	0.36	-.40	0.42	0.49	0.49	0.49	0.50
Heavy farm investment (machinery, labour, etc)	1.87	1.83	2.32	1.35	1.22	0.91	1.47	0.80
Farmer's attitude to his childrens future in agriculture(1/0)	0.73	0.86	0.96	0.35	0.44	0.34	0.19	0.48

Principal Component Analysis has been selected as the most useful analytical technique in this case for five reasons:

1. It simplifies and reveals the underlying structure of the original data matrix by searching for and extracting in descending order of magnitude those components or axes that account for the largest proportion of variance within the data.

2. It examines the inter-relation between the variables.

3. It establishes the correlation coefficient between variables before extracting the component. The coefficients are useful sources of information on the network of relationships between the farm system variables.

4. It is a classificatory technique rather than one used for hypothesis testing.

5. It provides an easy solution to the communalities problem, and because of this many statistical texts prefer it to common factor analysis (Blackith and Reyment, 1971; Chatfield and Collins, 1980). Thus, the difference between principal component analysis and factor analysis is obvious in theory and comes from the use of unities in the diagonal of the correlation matrix in the principal component "model" (see. Cattell, 1965), and communalities in the case of factor analysis.

Kendall (1957) pointed out that in principle component analysis, one works from data towards a hypothetical model, whilst in factor analysis there should be some underlying hypothesis.

Therefore, the principal component analysis is the appropriate technique to describe farm structure, and to use this as the basis for hypothesis generation about the relationship between farm attributes. The principal component analysis starts with the farm data matrix in

which each entry is the value of a variable at farm level. Results are based on the similarity between the variables (an R type mode) or similarity between the farms (Q type mode). The R mode analysis employed, focusses attention upon the observed correlations between 'm' variables, here are more correctly attributes. In this study for the three areas studied, (m = 39, 33, and 31), and the cases are the sample farms (50, 40 and 30 Farms respectively). (Henshall, 1966).

Above all, principal component analysis deals with data reduction.

Brief Description of the Method:

In this study the correlation coefficient matrix is used to measure the relationship between variables. This matrix gives the inter-correlation among the set of variables, then, based on the strength of the relationship between variables, the components are extracted. The number of components is always less than the number of variables. The contribution of the variables is measured by the loading of the variables on each component.

The principal loading matrix is rotated to an orthogonal simple structure using varimax rotation, which results in maximation of the variance of the component loadings of the variables on the component (Kaiser, 1958 ; Daultry, 1976). This method produces a new component matrix in which each component is described in terms of only those variables with which it is mostly highly correlated. This affords ease of interpretation and provides a better description of the variable pattern.

The component extracted in the first analysis of sample farms results from the collapse of highly correlated items into a distinctive

cluster of variables. The component loading is the measure of the degree of the closeness between the variable and component. In other words, the component loadings indicate which particular farms are most closely related to the composite type in the farm structure. The highest loading, either positive or negative, suggests the component dimension; positive loading indicates that the variables increase with increasing dimension, and negative loading shows a decrease in the variable as the dimension increased. The number of components extracted is limited to 8 components in the analysis of both 50 and 40 farms, and to 6 components for the 30 farms on the basis of the scree test. The reason for this is that the loadings on the smallest components contribute very little to the overall variance, thus their effect on the analysis is usually minimal. In the remaining components the individual contributions to the proportion of total variance fall below 3.0. At the same time, as Daultry pointed out in 1976, it is possible to retain only those components which can be interpreted on the ground that to analyse scores or components whose physical meaning was unclear was less than logical. The last reason for determining the number of components is background knowledge about the variables and the case study areas, Shaw and Wheeler, (1985).

The components are given descriptive names to identify the farm structure in the study area. Thus each component is a mathematical statement of the relationship of all the variables used in the analysis. Nevertheless, the difficulties exist in interpretation of such variables in this study because the primary variables are either binary (nominally measured in one or zero) or ordinal (continuous variables), and when considering their correlation coefficient the sign (negative or

positive) must be interpreted on the basis of previous knowledge of the problem.

Literature Review:

Multivariate techniques have been widely used in geographical research in the recent past (Yeate, 1974). There is a vast amount of literature on the quantitative approach to geographical analysis, in which both principal component and factor analytic techniques are used, and they are treated in detail in Harman, (1968). In addition, factor ecology as a mode of analysis has been popular in geographical research (Davies, 1984).

The first application of the factor analysis approach in urban geography was by Berry (1971); and more recently by Clark, Davis and Johnston (1974); Taylor and Goddard (1974) and Mather and Openshaw (1974). Further, this technique is often used as a part of factorial ecology or "social area analysis", as discussed by Johnston (1980); Rees (1971) and Berry (1971).

Factor analysis is applied in physical geography by Mather and Doornkamp (1976). They used the classification of scores to locate boundaries in a continuum. Further, the work of Shaw and Wheeler (1985) concerned an analysis of the morphometric and hydrological characteristic of 30 samples of British drainage basins. In addition recently Goossens (1985) and Al-Jerash (1985) have produced a climatic classification of Mediterranean rainfall and Saudi Arabia respectively.

In agricultural geography, which can be recognised as a combination of human and physical aspects in a geographical perspective, factor

analysis was first used to investigate farm structure by Henshall and King (1966); Henshall (1966); Momsen (1969); Allen (1971); Munton and Norris (1969); Munton (1972) and others. They used factor analysis as an analytical technique to analyse and classify the complex network of relationships which exists between biological and economic resources and between these and the system of production selected by farmers.

Many geographers have found factor analysis a useful technique to solve problems of farm classification. The experience of others provides a basis for the explanation of farm structure in Libya.

DATA ANALYSIS:

Variable Correlation and Principal Components Analysis:

Correlation Matrix:

The relationship between variables is shown in Tables 11.2, 11.3 and 11.4. Table 11.2 shows the simple correlation matrix for the 50 modern farms in the El Marj plain. This matrix is characterised by low value coefficients only; coefficients over .33 have significance. Significant values exist between farm size and rainfed crops i.e. cereal, fodder and trees.

On the other hand, vegetable production has a negative correlation with farm size and cereal and fodder production and a positive correlation for employment of foreign workers, and level of mechanization, i.e. number of tractors per farm. This factor has a moderate positive correlation with farm income.

A negative correlation occurs between rainfed crops and irrigated vegetables. It indicates the major distinction between two types of farms: rainfed and irrigated. A positive correlation exists between

TABLE 11.2 **Simple Correlation Matrix for 39 Variables**
1984 Survey Data for 50 Modern Farms in El Marj Plain in Jebel Al Akhder in North East Libya. Rainfed, Semi-irrigated and Irrigated Development Farms

All correlation coefficients shown (i.e. over .33) are significant at the 0.02 probability level

Variable Name	Farmer's age in years	Farm family size	Farmer's education level	Full time farmer (1/0)	Gross yearly income in L.D.	Farm size in hectares	Farmer's experience in dry farming (1/0)	Farmer's experience in irrigated agriculture (1/0)	Agricultural training of farmer (1/0)	Number of farm family workers	Number of foreign farm workers	Land tenure system of usufruct	Land tenure system of squatting	Land tenure system of inheritance	Land tenure pattern of share cropping	Vegetable area per farm: ha.	Cereal area per farm: ha	Fodder area per farm: ha	Pasture area per farm: ha	Tree area per farm: ha	Fodder problem (1/0)	Number of visits by agricultural technical advisor	Number of animals per farm	Number of poultry per farm	Quantity of chemical fertilizer input on cereal: kg/ha	Quantity of chemical fertilizer input on vegetables: kg/ha	Water problem (1/0)	Irrigated land per farm: ha	Number of tractors per farm	Number of cars per farm	Off farm income L.D.	Government assistance (1/0)	Sale of farm production in local market in the area (1/0)	Sale of farm production on farm (1/0)	Sale of farm output elsewhere (1/0)	Marketing problem (1/0)	Farmer's view of further development of his land (1/0)	Heavy farm investment (machinery, labour, etc)	Farmer's attitude to his childrens future in agriculture (1/0)
Farmer's age in years																																							
Farm family size	.15																																						
Farmer's education level	-.40	-.04																																					
Full time farmer (1/0)	-.26	.05	-.35																																				
Gross yearly income in L.D.	-.06	.009	.19	.13																																			
Farm size in hectares	.22	-.28	-.24	.23	-.42																																		
Farmer's experience in dry farming (1/0)	.11	-.18	-.05	.1	-.38	.60																																	
Farmer's experience in irrigated agriculture (1/0)	-.07	.34	.15	-.007	.55	-.74	-.68																																
Agricultural training of farmer (1/0)	.21	-.15	-.25	.32	-.17	.17	.18	-.01																															
Number of farm family workers	.22	.10	-.26	.23	-.23	.37	.30	-.17	.30																														
Number of foreign farm workers	-.24	.15	.31	-.18	.42	-.81	-.57	.63	-.23	-.39																													
Land tenure system of usufruct	-.21	-.07	.15	-.26	-.06	.11	.13	-.22	-.17	-.09	.02																												
Land tenure system of squatting	.29	-.08	-.13	.18	-.11	.09	.24	.02	.35	.13	-.24	-.72																											
Land tenure system of inheritance	.13	.24	-.11	.09	.11	-.17	-.30	.14	-.14	.27	.14	-.35	-.27																										
Land tenure pattern of share cropping	-.20	-.005	.11	.05	.23	-.23	-.43	.29	-.17	-.53	.29	-.19	-.15	-.07																									
Vegetable area per farm: ha.	-.18	.13	.06	-.13	.37	-.70	-.63	.65	-.06	-.39	.76	-.10	-.10	.01	.48																								
Cereal area per farm: ha	.29	-.22	-.23	.15	-.39	.91	.60	-.71	.14	.38	.79	.14	.06	-.10	-.35	-.81																							
Fodder area per farm: ha	-.01	-.18	-.07	.23	-.29	.55	.45	-.50	.14	.36	-.52	-.009	.05	.02	-.14	-.53	.39																						
Pasture area per farm: ha	.09	.10	.004	.08	-.24	.51	.29	-.30	-.07	.28	-.30	.21	-.05	-.15	-.15	-.31	.38	.17																					
Tree area per farm: ha	.03	-.31	-.16	.16	-.19	.42	.16	-.35	.17	.03	-.45	-.20	.25	-.10	.07	-.17	.26	.16	-.17																				
Fodder problem (1/0)	.10	.06	.02	-.05	.06	.05	-.09	-.07	-.09	.02	.14	-.000	-.05	.07	.04	.07	.06	.08	-.12	-.07																			
Number of visits by agricultural technical advisor	.09	-.14	-.40	.12	-.21	.17	.12	-.28	.02	.28	-.11	.006	.04	.06	-.23	-.25	.19	.15	.05	.06	.23																		
Number of animals per farm	.30	.10	-.600	.34	.05	.31	.27	-.09	.18	.24	-.18	-.04	.14	-.11	-.06	-.03	.26	.04	.32	.003	.05	-.15																	
Number of poultry per farm	.007	-.01	.237	.05	.20	-.26	.03	.33	.10	-.02	.33	-.21	.24	-.004	-.04	.22	-.30	-.12	-.14	-.06	.04	-.21	-.21																
Quantity of chemical fertilizer input on cereal: kg/ha	.05	.000	-.103	-.03	.02	.10	.14	-.02	.18	-.04	-.07	.07	-.07	-.006	-.003	-.12	.14	.04	.16	-.21	-.10	-.09	.08	-.003															
Quantity of chemical fertilizer input on vegetables: kg/ha	-.22	-.22	.22	.04	.41	-.63	-.28	.57	-.08	-.40	.52	-.18	.06	-.13	.52	.66	-.71	-.35	-.30	-.12	-.19	-.31	.08	.29	-.13														
Water problem (1/0)	-.29	.001	.39	-.21	.47	-.63	-.40	.52	-.17	-.17	.62	.02	-.09	.18	-.12	.33	-.54	-.34	-.29	-.31	-.10	-.01	-.21	.15	-.13	.31													
Irrigated land per farm: ha	-.18	.07	.15	-.07	.40	-.66	-.67	.63	-.11	-.37	.79	-.13	-.08	.03	.46	.45	-.76	-.50	-.29	-.19	.08	-.27	-.06	.33	-.14	.61	.37												
Number of tractors per farm	.09	.11	-.003	.08	.18	-.49	-.22	.40	.16	.39	.18	-.23	.25	.02	-.07	.41	-.27	-.27	-.09	.04	.07	-.20	.10	.42	-.15	.24	.11	.41											
Number of cars per farm	.000	.11	.08	.09	.56	-.43	-.31	.55	.05	-.13	.35	-.27	.21	.005	.16	.49	.48	-.36	-.32	.10	.07	-.06	.007	.39	-.12	.44	.40	.46	.46										
Off farm income L.D.	.007	.04	.36	-.09	-.01	.15	.04	-.13	-.60	-.21	.01	.27	-.17	-.12	-.06	-.04	.16	-.20	.24	.07	-.11	-.31	.20	-.07	.08	-.11	.04	-.07	-.18	-.12									
Government assistance (1/0)	.07	.02	-.03	.09	.04	.09	.17	.004	.10	.11	.004	-.09	.20	-.05	-.16	-.08	.10	-.12	.03	.14	.03	.10	-.04	.19	-.05	-.12	.24	.003	-.02	.25	.05								
Sale of farm production in local market in the area (1/0)	-.08	-.31	.10	-.03	.04	.16	.30	-.20	-.06	.01	.09	.13	-.19	.05	.02	-.34	.24	.19	.11	-.16	-.02	.16	-.06	.03	.30	-.24	.08	-.25	-.30	-.28	.04	.11							
Sale of farm production on farm (1/0)	.006	.16	-.18	.17	.31	-.35	-.33	.40	.21	.07	.40	-.15	.01	.13	.14	.41	-.39	-.12	-.29	.004	.28	.07	-.08	.16	-.08	.22	.25	.42	.14	.37	.29	.19	-.10						
Sale of farm output elsewhere (1/0)	-.006	-.03	.14	.21	.35	-.27	-.23	.19	-.02	-.08	.37	-.06	.03	-.06	.23	.25	-.35	-.08	-.008	-.03	-.03	.06	-.04	.02	-.19	.27	.37	.31	.006	.35	-.13	.10	.12	.35				
Marketing problem (1/0)	-.08	-.11	-.09	-.06	-.29	.04	.19	-.05	.26	.03	-.20	-.08	.25	-.28	.06	-.02	.07	-.08	-.08	.11	-.06	-.01	-.05	-.009	.005	-.01	-.23	-.04	.11	.12	-.29	.18	-.04	-.09	.01				
Farmer's view of further development of his land (1/0)	.15	.14	.07	-.13	-.08	.14	.38	-.12	-.04	.12	-.21	-.04	.23	-.17	-.16	-.27	.16	-.02	.28	.08	-.04	.19	.29	-.18	-.11	.003	.03	-.30	-.08	-.01	.16	.24	.11	-.01	-.03	.000			
Heavy farm investment (machinery, labour, etc)	-.15	.17	.34	-.12	.39	-.63	-.62	.64	-.09	-.27	.78	-.09	-.06	.12	.19	.61	-.63	-.52	-.27	-.20	.18	-.16	-.21	.41	-.10	.36	.61	.64	.34	.46	.03	.20	-.09	.40	.23	-.12	-.18		
Farmer's attitude to his childrens future in agriculture (1/0)	.25	.13	-.24	-.05	.06	.05	.17	.07	.17	.27	-.07	-.008	.15	.07	-.41	-.12	.10	-.05	.07	-.07	-.04	.23	.09	.04	.27	-.17	.12	-.17	.07	.07	.06	.16	-.02	-.14	-.03	-.06	.16	-.03	

animal husbandry, particularly sheep, and the size of the farm family showing the importance of semi-nomadic groups with traditionally large families in this type of agriculture. The livestock variable has a positive correlation with farm size and rainfed crops, i.e. fodder, whilst it has a negative correlation with vegetable area.

The significant feature of these farms is that farm size correlates positively with the farmer's experience of rainfed agricultural and animal breeding, and it is correlated negatively with gross income and experience of irrigated agriculture. This indicates that small irrigated vegetable farms continue to provide higher returns than the larger rainfed farms.

Measures of farm management are the standard of farmer's education, which is correlated negatively with the farmers age, full-time farming and the number of visits made by the agricultural technical advisor.

On the other hand, education level relates positively to off-farm income, farm input investment, foreign workers and water problems. These correlations distinguish between the older, less educated, traditional farmer and trends of young urban educated people moving away from agriculture.

The farmer's conception of the future of his children on the land has a negative correlation with the share cropping land tenure system, which correlates positively with irrigated vegetables and foreign workers. The contradictory direction indicates the use of non-Libyan workers in irrigated farms that encourage children to move away from the land, whilst rainfed farms mainly are managed as family farms. Therefore they are closer to the land.

The correlations between land tenure attributes show a marked negative correlation between usufruct and land occupied by squatters reflecting the distinctiveness of the usufruct tenure on the new settled farms.

On the other hand, the sharecropping variable is strongly associated with small irrigated vegetable farms operated predominantly by foreign workers to prove the preceding discussion about the concentration of non-Libyan workers on the more profitable land. The sharecropping type of tenure has been adapted to the new farming system of El Marj because it best fits a situation of high product risk, where farmers do not initially possess enough capital. Foreign workers and share croppers still make up the bulk of the irrigation farm workforce. This is a result of capital intensive farm methods and commercial attitudes, accompanied by a general monetarisation of the rural economy with both input and output being paid for and sold in cash. Share-cropped farms have more intensive land utilisation than other farms, but share cropping is usually thought to be a highly exploitative form of farmwork relations, and diminishes the role of waged labourers.

Gross farm income is linked positively with experience in irrigated agriculture and the level of farm inputs such as fertiliser and irrigation and negatively with farm size indicating that intensive cultivation of small irrigated plots provides higher gross returns than extensive larger-scale dry farming.

One of the reasons is poor managerial skills in dry land farming in addition to the environmental hazards of a semi-arid region with a great variability of precipitation, and heavy clay loamy soil.

In the case of the 40 farm sample of El Fatayah area, the simple correlation matrix of 30 variables is discussed using a 0.02 significance level where the coefficients are over 0.36 Table 11.3. It shows the negative correlation between farmer's age and education level whilst it correlates positively with full time farms. This means that farmers are elderly and this has, no doubt, an effect on farm management.

In this area gross farm income correlates positively with off-farm income (.39), experience of irrigated farms (.41), family workers (.43), number of poultry per farm (.55), tractors (.49), and high levels of farm investment (.64) and commercialisation (.60). This suggests that the new farming system is still in a stage of development. Farm income gains from poultry production for markets outside the local area. Farm labourers are family workers, which relates positively with animal husbandry and farm investment. It is explained by the direction of investment in land. On the other hand the contribution of foreign workers is linked to poultry production and farm mechanisation. The reason for the latter is because some of the old farmers could not manage the modern sophisticated equipment e.g. 'tractor'. Moreover, irrigated vegetables correlate positively with poultry and sale of products in the local market. As in El Marj farms with high levels of agricultural mechanisation also have most cars and thus these farmers have mobility and transport for the distribution of farm produce.

In terms of land use vegetables and poultry are closely linked and negatively associated with cereals and pasture recognising the clear distinction between intensive and extensive agriculture in the region. On the other hand, the market problem relates positively with fodder problems and with sale of produce in the local market. It indicates an inadequate market structure.

TABLE 11.3: Simple Correlation Matrix for 30 variables; 1984 Survey Data for 40 Modern Farms in El Fatayah Area, in Jebel El Akhdar, in North East Libya, Semi-irrigated Farms

All correlation coefficient shown (i.e. over.36) are significant at the 0.02 probability level

Variables Name:	Farmer's age in years	Farm family size	Farmer's education level	Full time farmer (1/0)	Gross yearly income in L.D.	Farmer's experience in dry farming (1/0)	Farmer's experience in irrigated agriculture (1/0)	Agricultural training of farmer (1/0)	Number of farm family workers	Number of foreign farm workers	Vegetable area per farm: ha.	Cereal area per farm: ha	Fodder area per farm: ha	Pasture area per farm: ha	Number of poultry per farm	Fodder problem (1/0)	Number of visits by agricultural technical advisor	Number of animals per farm	Quantity of chemical fertilizer input on cereal: kg/ha	Quantity of chemical fertilizer input on vegetables: kg/ha	Number of tractors per farm	Number of cars per farm	Off farm income L.D.	Government assistance (1/0)	Sale of farm production in local market in the area (1/0)	Sale of farm production elsewhere (1/0)	Marketing problem (1/0)	Farmer's view of further development of his land (1/0)	Heavy farm investment (machinery, etc)	Farmer's attitude to his childrens future in agriculture (1/0)
Farmer's age in years	1.00																													
Farm family size	.15	1.00																												
Farmer's education level	-.51	-.09	1.00																											
Full time farmer (1/0)	.56	.29	-.45	1.00																										
Gross yearly income in L.D.	-.18	-.24	-.20	-.01	1.00																									
Farmer's experience in dry farming (1/0)	-.17	-.09	-.25	-.25	.16	1.00																								
Farmer's experience in irrigated agriculture (1/0)	-.09	.004	.06	.01	.41	.01	1.00																							
Agricultural training of farmer (1/0)	.10	-.01	-.09	.05	-.11	.20	.15	1.00																						
Number of farm family workers	.12	-.19	-.25	.06	.43	.31	.17	-.26	1.00																					
Number of foreign farm workers	-.04	.04	.07	.12	.14	.01	.35	.42	-.40	1.00																				
Vegetable area per farm: ha.	.12	.15	-.13	.37	.20	.31	-.04	-.00	.18	-.005	0.00																			
Cereal area per farm: ha	-.08	.01	.13	-.30	-.01	-.32	.32	.10	-.23	.10	-.34	0.00																		
Fodder area per farm: ha	-.06	-.11	.18	.08	.19	.15	.24	-.04	.33	.16	-.004	-.41	1.0																	
Pasture area per farm: ha	.02	-.14	-.10	-.02	-.23	.03	-.35	-.07	-.08	-.16	-.40	-.47	-.11	0.00																
Number of poultry per farm	-.11	-.01	-.06	.19	.55	.30	.40	.18	.29	.43	.41	-.24	.42	-.29	0.00															
Fodder problem (1/0)	.13	.12	-.19	.04	.17	.12	.15	.08	.00	.18	.20	.05	.13	-.29	.33	0.00														
Number of visits by agricultural technical advisor	-.10	-.14	.13	-.07	.16	.17	.24	.03	.04	.08	.14	.28	.06	-.37	.15	.45	0.00													
Number of animals per farm	.22	-.24	-.28	.17	.24	.42	.14	.23	.48	.04	.15	-.38	.42	.09	.42	.06	.11	0.00												
Quantity of chemical fertilizer input on cereal: kg/ha	-.02	.01	-.12	.20	.28	.08	.24	-.09	.36	-.02	.09	.02	-.07	-.06	.19	.06	.14	.04	0.00											
Quantity of chemical fertilizer input on vegetables: kg/ha	-.15	-.01	.21	.05	.04	.20	.15	-.02	-.02	-.06	.19	-.04	-.04	-.07	.03	.08	.03	-.02	.37	0.00										
Number of tractors per farm	.00	-.12	-.09	.05	.49	.20	.15	-.02	.20	.42	.19	-.04	-.04	-.07	.33	.08	.03	.08	.21	-.02	0.00									
Number of cars per farm	.32	.06	.21	.48	.24	.28	.00	.02	.14	.30	.30	-.18	.04	-.09	.15	-.08	-.03	.11	.16	.02	.53									
Off farm income L.D.	-.27	-.17	.16	-.53	.39	-.30	.08	-.06	-.07	-.15	-.18	.23	-.10	-.07	-.11	.02	.09	-.17	-.24	-.06	-.16	-.27								
Government assistance (1/0)	.06	-.10	.07	.09	.22	.07	.31	.34	.09	.32	.18	-.04	.35	-.31	.27	.14	.25	.31	.09	-.17	.08	.04	-.07							
Sale farm production in local market in the area (1/0)	.15	.32	-.01	.22	.01	.02	.10	.04	.05	.10	.36	.26	.07	-.65	.19	.56	.37	-.14	.17	.04	.04	-.04	-.14	.31						
Sale of farm production elsewhere (1/0)	.07	-.21	-.22	.12	.60	.33	.35	-.06	.82	.08	.27	.25	.42	-.16	.57	.18	.08	.52	.36	-.06	.42	.30	-.15	.32	.12	.10				
Marketing problem (1/0)	.006	.08	.17	.04	-.03	.12	.15	.08	.09	.18	.08	.17	.13	-.29	.16	.37	.45	.02	.30	.08	.08	-.08	-.39	.34	.56	.18	.18			
Farmer's view of further development of his land (1/0)	.05	.15	-.10	.11	.44	.16	.51	.18	.28	.28	.05	-.17	.30	.04	.50	-.07	-.03	.37	.16	-.13	.18	-.02	.02	.37	-.13	.43	-.07	.007		
Heavy farm investment (machinery, etc)	.005	-.17	-.13	.04	.64	.43	.40	.11	.67	.26	.27	-.17	.33	-.18	.61	.21	.09	.53	.37	.11	.65	.33	-.10	.27	.12	.86	.21	.43	0.00	
Farmer's attitude to his childrens future in agriculture (1/0)	.07	.05	-.30	.05	.32	.12	.44	-.11	.18	.22	.08	.05	-.08	-.08	.35	.08	.15	.23	.09	-.11	.23	-.05	.10	.01	-.005	.22	-.05	.59	.30	0.00

Animal husbandry correlates positively with a positive view of further changes, high levels of farm investment, government assistance and the sale of produce on the free market. This farm type appears to be the most successful on the modern farms studied in the El Fatayah region.

Correlations for the thirty traditional farms surveyed in Ayn Marah are in Table 11.4. It shows a complex array of correlations for 33 variables and 30 farms with values greater than ±.40 at significant level of 0.02. The correlation coefficients themselves are generally of higher value than those of the modern farms in the other two sample areas. It is evident that these farms have very distinct structure differences. Positive correlations exist between characteristics such as age, family size, animal husbandry, experience of dry farming, off-farm income and farm income.

A positive correlation occurs between off-farm income and farmer's family size, and a negative correlation exists between off-farm income and full time farmer job and number of farm family workers. These mean inadequate farm output, as a result of the fragmentation which relates positively with family size, inheritance of land, and it relates negatively with a share cropping system of land utilisation. This supports the argument that insufficient one-parcel farms are available. These facts encourages the migration of Libyan workers from the land, where they are substituted by non-Libyan workers.

However, the obvious explanation from the simple correlation coefficient matrix is the predominance of a dual economy (dry farming, and animal breeding on the one hand versus irrigated farming) which

TABLE 11.4

Simple Correlation Matrix for 33 Variables
1984 Survey Data for 30 Traditional Farms in Ayn Marah
in Jebel El Akhdar, in North East Libya, Small Irrigated Farms

All correlation coefficients shown (i.e. over .40) are significant at the 0.02 probability level

Variables Name	Farmer's age in years	Farm family size	Farmer's education level	Full time farmer (1/0)	Gross yearly income in L.D.	Farm size in hectares	Farmer's experience in dry farming (1/0)	Farmer's experience in irrigated agriculture (1/0)	Agricultural training of farmer (1/0)	Number of farm family workers	Number of foreign farm workers	Land tenure system of inheritance	Land tenure pattern of share cropping	Land fragmentation, number	Vegetable area per farm: ha.	Cereal area per farm: ha	Tree area per farm: ha	Fodder problem (1/0)	Number of visits by agricultural technical advisor	Number of animals per farm	Quantity of chemical fertilizer input on vegetables: kg/ha	Water problem (1/0)	Irrigated land per farm: ha	Number of tractors per farm	Number of cars per farm	Off farm income L.D.	Government assistance (1/0)	Sale of farm production on farm (1/10	Sale of farm production elsewhere (1/0)	Marketing problem (1/0)	Farmer's view of further development of his land (1/0)	Heavy farm investment (machinery, etc)	Farmer's attitude to his childrens future in agriculture (110)
Farmer's age in years																																	
Farm family size	.42																																
Farmer's education level	-.44	.17																															
Full time farmer (1/0)	.16	-.36	-.11																														
Gross yearly income in L.D.	.40	-.27	-.17	-.16																													
Farm size in hectares	-.36	-.08	.37	-.10	.48																												
Farmer's experience in dry farming	.42	.51	-.18	-.10	-.03	.18																											
Farmer's experience in irrigated agriculture (1/0)	-.13	.02	.07	-.14	.10	-.21	-.28																										
Agricultural training of farmer	.44	.60	.15	-.40	-.32	-.01	.37	-.06																									
Number of farm family workers	-.33	-.50	.08	.62	.20	.12	-.38	.15	-.10																								
Number of foreign farm workers	.24	-.15	.09	.25	-.10	.15	-.21	.06	-.08	.18																							
Land tenure system of inheritance	.25	.48	.14	-.06	-.10	-.12	.36	-.18	-.61	-.40	-.33																						
Land tenure pattern of share cropping	-.19	-.42	-.30	-.01	.28	.17	-.26	.19	-.59	.35	.08	-.80																					
Land fragmentation, number	.11	.40	.08	.03	.02	.22	-.16	.21	-.07	.30	.29	-.33	.39																				
Vegetable area per farm: ha.	-.56	-.16	.30	-.13	.51	.69	-.14	.31	-.22	.34	.10	-.28	.41	.38																			
Cereal area per farm: ha	.13	-.09	.00	.21	-.07	.28	.18	-.90	.000	.000	.28	0.5	-.19	-.09	-.20																		
Tree area per farm: ha	.001	-.03	.16	-.13	.38	.68	.26	.01	.17	-.13	.04	-.04	.09	.13	.25	-.02																	
Fodder problem (1/0)	.34	.46	.14	.04	-.20	.03	.30	-.13	.39	-.14	.00	.42	-.37	-.04	-.08	.20	-.03																
Number of visits by agricultural technical advisor	-.24	.06	.31	-.24	.11	.29	-.12	.03	.06	-.15	-.06	-.18	.17	.16	.13	-.05	.39	-.26															
Number of animals per farm	.42	.17	-.04	.31	-.18	.19	.41	-.21	.24	.006	.24	.19	-.22	-.05	-.07	-.38	.16	.45	-.11														
Quantity of chemical fertilizer input on vegetables: kg/ha	-.28	-.12	.29	-.22	.40	.39	-.06	.07	-.07	-.02	.18	-.29	.27	.24	.41	.04	.35	-.25	.67	-.11													
Water problem (1/0)	.40	.50	-.08	-.33	-.03	.16	.53	-.15	.32	-.44	.04	.000	.05	-.02	-.18	.11	.33	.00	.15	.28	-.03												
Irrigated land per farm: ha	-.49	-.22	.26	-.16	.47	.70	-.17	.26	-.20	.25	.15	-.38	.47	.44	.89	-.13	.40	-.13	.44	-.04	.63	-.12											
Number of tractors per farm	-.18	-.06	.44	.20	.003	.25	.11	-.69	.09	.05	-.08	.26	-.28	-.03	-.12	.61	.07	.18	-.04	.07	.00	-.05	-.12										
Number of cars per farm	-.05	-.005	.22	.14	.12	.45	.26	-.30	.22	.03	.05	.30	-.19	-.08	.39	.34	.10	.42	-.11	.36	.09	-.12	.39	.44									
Off farm income L.D.	.22	.63	.35	-.52	-.13	.06	.37	-.10	.57	-.65	-.01	.25	-.33	.06	-.16	.05	.20	.20	.27	-.01	.27	.38	-.09	.14	-.04								
Government assistance (1/0)	.08	.17	.30	.12	-.15	.30	.08	-.34	.13	.15	.36	-.07	-.09	.17	.00	.52	.07	.10	.34	.57	.14	.30	.10	.19	.11	.13							
Sale of farm production on farm (1/0)	-.12	-.39	-.02	.14	.30	-.01	-.34	.14	-.48	.36	.43	-.62	.43	.24	.25	.01	-.23	.35	-.14	-.16	.20	.22	.19	-.20	-.14	-.20	.02						
Sale of farm production elsewhere (1/0)	.21	.25	.03	-.20	-.07	.01	.14	-.09	.43	-.27	.16	.33	-.30	-.26	-.06	.14	-.01	.35	-.37	.17	-.12	.10	-.15	.13	.30	.24	.00	.31					
Marketing problem (1/0)	-.03	-.02	.07	.24	.10	-.13	-.28	-.03	-.06	.15	.06	.18	-.17	-.16	-.13	.05	-.12	-.13	.03	-.07	.07	-.15	-.26	.04	-.30	-.10	.06	.14	-.09				
Farmer's view of further development of his land (1/0)	-.22	.26	.40	.004	.07	.36	.25	-.24	.15	.08	-.02	.34	-.39	-.31	.13	.25	.13	.24	-.14	.12	-.19	.05	-.03	.35	.32	.10	.33	-.29	.38	.14			
Heavy farm investment (machinery, etc)	-.05	.80	.50	-.03	.01	.40	.27	.15	.31	.08	.08	.02	-.02	.24	.36	-.05	.34	.13	.29	.41	.38	.24	.41	.21	.35	.18	.47	-.24	.14	-.14	.26		
Farmer's attitude to his childrens future in agriculture (1/0)	-.26	-.07	.16	.10	-.27	-.04	-.38	-.07	.14	.12	.13	.000	.02	-.14	.07	.11	.32	.13	.07	-.05	-.12	-.12	.09	.10	.23	-.18	.14	-.10	.04	-.07	.09	-.06	

explains the pattern of subsistance agriculture in the region. Farm investment has concentrated on an animal economy which enjoys better government assistance. On traditional farms investment is almost non-existent because of lack of capital and low productivity of land, small size of farm and inadequate knowledge of modern agricultural practices and high average age of farmers (53 years).

In conclusion, the aforementioned shows a great discrepancy between different types of farms in the region, where the irrigated modern farms have been expanding rapidly with the aid of favourable government assistance. In fact, what needs to be done is to channel credit to those farmers who have the least in those areas where irrigation water is available i.e., traditional farming area in Ayn Marrah and is starting to take place, i.e., El Fatayah area, where regrettably it is not finished yet, because of delays in completion of the development programme. In other words, El Marj state farming area should start receiving less subsidised government assistance, and these funds should go to the less wealthy small farmers there. This requires some serious rethinking of Libyan agricultural development projects and considerable institutional reform.

Principal Component Analysis:

The data sets were subjected to a principal component solution in order to classify farm structure in the study areas.

The technique has been carried out using (Package, SPSSX), and a number of solutions gained according to the number of factors specified. The first and second analyses were for 50 El Marj area and 40 El Fatayah area sample modern farms to explain the variation in their farm

enterprise structures. The third analysis dealt with the 30 traditional farms.

The forty variables shown in Table 11.1 for the whole sample farms were subject to a principal component analysis using a different subset of the basic 40 variable, data matrix for each area, with varimax rotation of the component solutions.

In the case of the 50 farms, 39 variables were reduced in the analysis to from 8 new independent components. The interpretation of the factors depends on the strength of the relationship between variables, which has been pointed out by Johnston, 1980. Loadings of 0.20 is significant at the 5 per cent level. According to Fruchter, 1954, loadings of 0.2 or less also are usually regarded as insignificant, loading of 0.2 to 0.3 as low, 0.3 to 0.5 as moderate, 0.5 to 0.7 as high and above 0.7 as very high (Momsen, 1969).

Three principal component analyses were undertaken and it was decided, after careful testing of alternative solutions to rotate eight factors for both 50 and 40 modern farms in the sample and rotate six factors for the 30 traditional farms.

The first eight components for 50 farms accounted for 64.8 per cent of variation in the correlation matrix of 39 variables. In the second analysis the eight components for 40 farms explained 71.7 per cent of the total variation, among 30 variables of the correlation matrix. The third analysis produced six components based on data for 33 variables for 30 farms, accounting for 67.3 per cent of the total variance. These analyses are discussed and together with the relevant factor loadings are shown in Tables 11.5, 11.6 and 11.7 respectively

Analysis 1 - 50 Farms of El Marj Area:

In the case of these farms, the first two factors accounted for just over one third of the total variation (Table 11.5). These factors are identified with the two predominant new elements in farm structure in the area: intensive irrigation and modern land tenure. The first component recognises the two major farm types of the region with high negative loadings for farm size and cereal acreage and the high positive loadings for attributes associated with intensive, small irrigated farms i.e., use of foreign workers, vegetables and irrigated area, experience or irrigated agriculture, farm investment, quantity of chemical fertilizer used on vegetables, mechanisation, water problems and gross farm income. The second component explains one-tenth of the total variation. This component is identified with the land tenure system with a negative loading for usufruct and visits by agricultural advisers and positive loadings for squatting, poultry keeping, agricultural training, number of tractors and gross income. This suggests that the farmers on the modern state farms are less prosperous and less well-trained than squatters.

The third component explains 6.5 per cent of the total variance for the 50 farms and was identified with managerial aspects of farming as identified by educational levels. The aspect is represented by a high negative loading for both off-farm income and the farmer's level of education with positive loadings for full time farmers, number of visits by technical agricultural advisers and the farmer's agriculture training.

The fourth component is identified as a motivation factor. It accounts for 6.1 per cent of total variance. It has a positive loading

TABLE 11.5: Summary of Principal Solution of 39 Variables After Rotation, Modern Farms only, Sample Size 50 Farms, All Farms Rainfed and Mixed

COMPONENT		I Intensive Irrigated Farm	II Modern Land Tenure	III Managerial	IV Motivation	V Livestock	VI Traditional Land Tenure	VII Marketing	VIII Operational
Variation	Single	24.40	9.50	6.50	6.10	5.50	4.60	4.30	3.90
Explained	Cumulative	24.40	33.80	40.40	46.50	52.00	56.60	60.90	64.80
Eigen Value		9.51	3.68	2.55	2.38	2.14	1.80	1.66	1.52
Farm size in hectares		-.90							
Cereal area per farm: ha		-.88							
Number of foreign farm workers		.85							
Vegetable area per farm: ha.		.85							
Farmer's experience in irrigated agriculture (1/0)		.84							
Irrigated Area per Farm ha.		.81							
Heavy farm investment (machinery, etc)		.75							
Quantity of chemical fertilizer input on vegetable: kg/ha		.69			-.36				
Farmer Experience at Rainfed Agriculture		-.68					-.35		
Fodder area per farm: ha		-.65							
Water problem (1/0)		.62			.34			.39	
Number of cars per farm		.58	.45						
Gross yearly income in L.D.		.52						.41	
Sell farm's production on farm (1/0)		.45		.40					
Land tenure system of squatters rights			.65				-.35		
Number of poultry per farm			.64						
Land tenure system of usufruct			-.62						
Number of tractors per farm		.35	.59						
Off farm income L.D.				-.77					
Farmer's education level				-.72					
Full time farmer (1/0)			.34	.52		.31			
Number of visits by agricultural advisor			-.30	.50	.37				.31
Agricultural training of farmer (1/0)			.43	.45			-.33		
Land tenure pattern of share cropping		.32			-.78				
Farmer's attitude to his children's future in agriculture (1/0)					.68				
Number of farm family workers		-.36		.34	.46				
Government assistance (1/0)					.43			.37	
Number of animals per farm						.78			
Fodder area per farm ha		-.34				.52			
Farmer's view of further development of his land (1/0)					.37	.50			.35
Farmer's age in years						.45			
Farmer's family size		.35				.39		-.38	
Land tenure system of inheritance							.74		
Marketing problem (1/0)							-.68		
Fodder problem (1/0)							.36		
Sell farm's production in local market in the area (1/0)								.62	-.34
Sell farm's output in other area (1/0)		.35						.61	
Quantity of chemical fertilizer input on cereal: kg/ha									-.71
Tree area per farm: ha		-.39	.35						.54

on the variable relating to the farmer's attitude to his children's future, the use of farm, family labour, government assistance, attitude to further development of the farm and the technical agricultural advisors role. The highest loading on this component is a negative loading for the share cropping system of land tenure, indicating that farmers in this category have very short-term planning horizons.

The fifth component accounts for 5.5 per cent of total variance. This indicates a new farm type linked to livestock. It has a high loading for animal husbandry, fodder area, further development of the farm, farmer's age, farm family size and full time work on the farm. This is typical of the developed, traditional, rainfed farms.

The sixth component explains 4.6 per cent of total variation. It involves a positive loading for inherited land, and a negative loading for marketing problems and squatter's rights land tenure system. It is labelled traditional land tenure.

The seventh component is identified as a marketing factor. It accounts for 4.3 per cent of total variation. It is characterised by positive loadings for the sale of farm produce in both the local market area and in other places, gross farm income, government assistance, especially in terms of subsidised prices and water problems, with the highest negative loading being associated with farm family size possibly suggesting a link between small families and high levels of commercialisation reflecting non traditional attitudes.

The last component extracted in this analysis is named operational. It explains 3.9 per cent of the variation. It has a negative loading for chemical fertilizer use on cereal crops and local sale of produce and positive loading on role of agricultural technical advisor. It also

has the highest positive loading for tree crop area, thus identifying a mixed farm type.

Analysis 2 - 40 Farms of El Fatayah Area:

The first component of the 40 farm analysis is identified with livestock farming (Table 11.6). It accounts for over one-fifth of the total variance. It has high positive loading for fodder area, animal husbandry, sale of output outside local area, number of poultry per farm, farmer's experience of dry farming, farm family labour, farm investment, government assistance, and future development with a high negative loading for cereal area. Thus this component distinguishes between arable and livestock farming in non-irrigated areas.

The second component explains 11.3 per cent of the variation, and is labelled marketing. It has high positive loadings for the sale of farm produce in the local market, fodder problems, role of agricultural advisor, and marketing problems. It also has a high negative loading on pasture area. Almost as important is the motivation component which accounts for 10.4 per cent of total variance. It shows a high positive loading on variables associated with positive long term planning for the farm such as the future of farm children and further farm development. This component is also linked to the experience of the farmer in irrigated agriculture, farm investment and farm income suggesting an identification with a group of optimistic, prosperous farmers growing irrigated vegetables.

The fourth component explains 7.3 per cent of total variance, and is labelled as a mechanization factor. The highest positive loadings are for the number of tractors and cars per farm, followed by farm

TABLE 11.6: Summary of Principal Solution of 30 Variables After Rotation Modern 40 Semi-Irrigated Farms only.

COMPONENT		I Livestock	II Marketing	III Motivation	IV Mechanization	V Managerial	VI Labour	VII Operational	VIII Farm Family Structure
Variation	Single	21.0	11.3	10.4	7.3	6.6	5.9	4.8	4.6
Explained	Cumulative	21.0	32.3	42.6	49.9	56.5	62.3	67.1	71.7
	Eigen Value	6.29	3.38	3.11	2.18	1.96	1.75	1.45	1.37
Fodder area per farm: ha		.77							
Animal Husbandry		.71				.30			
Cereal Area per farm ha.		-.69	.40						-.30
Sale of farm production elsewhere (1/0)		.60		.35	.44				
Number of poultry per farm		.52		.45	.34				
Farmer's experience in dry farming		.44			.31				
Sale of farm production in local market in the area (1/0)			.84						
Pasture area per farm ha			-.75						
Fodder problem (1/0)			.68						
Role of technical agricultural advisor			.68					.50	
Marketing problem (1/0)			.63						
Future of farm children and farmer (1/0)				.79					
Further development in Future		.38		.77					
Farmer's experience in irrigated agriculture (1/0)				.76					
Number of tractors per farm					.85				
Number of cars per farm					.74				
Heavy farm investment (machinery, etc)		.48		.38	.61				
Gross yearly income in L.D.				.49	.59				
Farmer's education level						-.82			
Farmer's age in years						.81			
Full time farmer (1/0)						.51			.53
Number of foreign farm workers					.33		.79		
Agricultural training of farmer (1/0)							.72		
Number of farm family workers		.53					-.57		
Government assistance (1/0)		.42	.39				.43		
Quantity of chemical fertilizer on cereal kg/ha								.74	
Off farm income L.D.						-.36		-.62	
Quantity chemical fertilizer input on vegetables kg/ha.						-.33		.57	
Farm family size									.67
Vegetation area per farm ha		.30		.33					.56

investment and farm income. It has a moderate positive loading on the sale of farm produce in other places, number of poultry and foreign workers. Access to the transportation mode 'car' reinforces the ability to sell produce in other places.

The managerial component of the 40 farms analysis is the fifth one. It accounts for 6.6 per cent of total variance. It has a high negative loading on education level and a high positive loading on age of farmer followed by occupation as a full-time farmer. This factor indicates that older farmers are less well educated and although most likely to farm full-time farmers lack the training necessary for such rural development in the Third World.

The sixth component is identified as a labour component. It explains 5.9 per cent of variation. It has high positive loading for non-Libyan farm workers, the farmer's agricultural training and levels of government aid, with a negative loading for farm family workers. This illustrates the clear role of foreign workers as substitutes for family labour on the farm.

The seventh component is an operational one, it accounts for 4.8 per cent of variance. It has positive loadings for both quantity of chemical fertilizer per hectare of cereal and vegetables and the role of agricultural technical advisor. It also has the highest negative loading for off-farm income suggesting that such income is not invested in increased farm inputs. It also indicates the positive role of agricultural extension in farming efficiency in this area.

The last component explains 4.6 per cent of variation. It is named farm family structure, and shows a positive loading of variables for farmer family size, full-time farming and irrigated vegetable area,

while it is loading negatively on variable of cereal area. This indicates that the roots of traditional agricultural families have vitality on modern vegetable farms.

Analysis 3 - 30 Farms of Ayn Marrah Area:

Analysis of the Ayn Marrah thirty traditional farm data is outlined on Table 11.7. The first component is a prototype of the small irrigated farm. It accounts for 19.8 per cent of variance. This component emerges with very high positive loadings on variables for irrigated area, vegetable area, and farm size, while it has a moderate positive loading on farm income, tree area usually (inter-cropped with vegetables), quantity of chemical fertilizer used on vegetables and level of farm investment. It has a negative loading for farmer's age. This component shows the main structure of a traditional irrigated garden in the region.

The second component is identified by land tenure. It accounts for 15.3 per cent of total variance, and has a high positive loading for inherited land and a negative loading on share cropped land as a first dimension of the component. The second dimension of the same component is marketing. It is indicated by the high positive loading for sale of produce outside the area and a negative loading for farmgate sales. There is a positive loading for fodder problems car ownership, use of farm family labour, and further farm development in the future. This indicates that the accessibility of farm family labour and transportation has developed agricultural marketing outside the area.

The third component is identified with labour. It accounts for 11.2 per cent of the total variance and has its highest negative loading

TABLE 11.7: Summary of Principal Solution of 33 Variables After Rotation, Traditional 30 Farms Only

COMPONENT		I Irrigated Farms	II Land Tenure	III Labour	IV Rainfed Farms	V Government Assistance	VI Managerial
Variation	Single	19.8	15.3	11.2	8.3	6.6	6.1
Explained	Cumulative	19.8	35.1	46.4	54.7	61.3	67.3
	Eigen Value	6.54	5.05	3.69	2.74	2.19	2.02
Irrigated area per farm ha		.84					
Farm size		.86			.30		
Vegetable area		.85					
Farm income in L.D.		.64				-.35	
Tree area		.56		.30			-.33
Quantity chemical fertilizer input on vegetable:		.58	-.40	.34			
Heavy farm investment (machinery, etc)		.51				.46	
Land tenure system of inheritance			.72				
Fodder problem (1/0)			.71				
Land tenure pattern of share cropping		.33	-.63	-.30			
Number of cars per farm		.47	.60				
Sale of farm production elsewhere(1/0)			.59				
Sale of farm production on farm			-.56	-.36			
Further development in Future			.54		.35		
Off farm income L.D.				-.82			
Number of foreign farm workers				-.72			
Number of farm family workers			.56	.64			
Full time farmer (1/0)				.64		.33	
Role of technical agricultural advisor		.36	-.41	-.57			
Water problems				.53			-.52
Experience in irrigated agriculture (1/0)					-.92		
Cereal Area per farm ha.					.88		
Number of tractors per farm					.73		
Government assistance (1/0)					.41	.72	
Land tenure system of squatter's rights						.71	
Number of animals per farm			.41			.61	-.32
Land fragmentation						-.49	
Farmer's education level		.42		.30			.65
Farmer experience in rainfed agriculture			.41	.30			-.63
Farmer's age in years		-.53				.39	-.57
Future of farm children and farmer (1/0)							.50
Marketing problem (1/0)							.40

off-farm income with a high negative loading for foreign workers balanced by a high positive loading for farm family workers. It also has a positive loading for full-time farming. This component shows that a relationship exists between the increase of foreign workers and decrease of farm family workers. It also emphasises the link between off-farm income and part-time farming. The number of part-time farmers in this area has increased because of water problems.

The fourth component is identified with rainfed farms. It accounts for 8.3 per cent of the total variation. It has a very high negative loading on the variables associated with experience in irrigated agriculture, and has a high positive loading on cereal area and tractors per farm and a moderate positive loading on government assistance and farm size. On the other hand, the fifth component is most clearly linked to government assistance, which has channelled credit to animal breeding farmers (Mawallah) as a commercial enterprise in traditional farming systems. This component accounts for 6.6 per cent of total variation. It has positive loadings for the variables of government aid, squatting, animal husbandry, farmer's age, full time farmer, farm investment, with negative loadings for land fragmentation and farm income.

The importance of investment in livestock is attributed to the following: Animal breeding is a way of life for farmers; the capital invested in animal breeding brings faster financial returns than arable farming. Therefore, many farmers do not apply for planting loans on a regular basis for high risk crops. Loans are secured by land and are made more often to farmers who appear best able to repay. However, large land owners have always favoured loans for planting, but small

traditional farmers do not wish to increase their debt burden and increase their level of risk.

The last component of the 30 farm analysis is a managerial component. It accounts for 6.1 per cent of total variance. It has positive loadings on the farmers' education, his future plans and marketing problems and negative loadings on experience of rainfed agriculture, the farmer's age and water problems. This component indicates that the older farmers tend to practice dry farming.

There is a basic similarity between the components for the study areas. For example, the first component for each area represents significant types of farms in each area, whilst the managerial and marketing components are very similar in all three areas. Similarity is strongest between most of the components of the 50 and 40 modern farm areas. Nevertheless, there are differences on some components, for example a modern and traditional land tenure component of 50 farms analysis has emerged because of the squatter's right land tenure system, which is related with tree area, while the number of poultry correlate negatively with the usufruct system of land tenure. This means that some farms have not developed completely, with tree plantings remaining from a previous period. At the same time the old land-lord was given priority during farm allocation. These might be called redevelopment farms. In this case the traditional land tenure component is indicated by the negative relationship between inherited land and land that is squatted on. Further, a negative relationship occurs between inherited land and market problems. It shows that private holdings enjoy easier marketing.

The motivation component in the analysis of 50 farms indicates that

the two dichotomous variables measuring the personal farming perception towards children to stay on the land, and further development in the future, related positively with the farm family worker, and government assistance, and correlated negatively with share cropper workers. This suggests that non family workers have a negative impact on farm planning for the future. Whilst the same component in the analysis of 40 farms is closely related to the variables measuring the personal quality of the farmer and his view of farm extension services. In fact, this component gives a clear separation between the modern farms in the two areas. On the 50 farms, of El Marj, the motivation variables are related to government assistance for the development of farm extension services, and to help farm workers overcome the water problems. In the case of the 40 farm analysis, the motivation attributes are closely related to the development of farm investment, extension of irrigated vegetable areas, and the number of poultry per farm.

The livestock farm component emerged quite clearly in the case of the El Marj 50 farm analysis. The rainfed farmers have concentrated on animals rather than land. This phenomenon has been repeated in the modern 40 farms also, due to the insufficient farm output up to the year of survey. In El Marj area, there were some farmers who complained of declining farm land productivity. This is a result of the continuous use of land, and misuse of chemical fertilizer and crop rotation. Further, some farmers in the south of El Marj suffered from soil erosion and flood hazards, particularly those farms adjacent to El Gharigh area (see Chapter V). These problems have limited the optimum use of land in some parts of the detailed study area, and this has encouraged farmers to invest his capital in livestock enterprises. Thus, the number of

animals per farm increased as the proportion of irrigated area decreased on irrigated farms. The same situation is repeated in dry farming, where the number of animals per farm increases as the proportion of fodder area increases and the proportion of land in trees decreases.

However, a variation exists between farm livestock enterprises in El Marj and El Fatayah sample study area. Sheep and poultry are associated with commercial farming where there are some farmers specialising in animal breeding, known as "Mawallah", as in the case of sheep in El Marj area or poultry in El Fatayah area. Cows are usually kept for the use of farmer and his family only. The livestock enterprises have been developed on modern farms because they do not demand heavy farm labour employment. The farm family can manage it, particularly as the poultry farming work can be done by the farmer's wife or the farmer's children. The government has provided credit to livestock farmers with medium and long term loans. They also have major structural improvements financed by the government either directly through bank loans or special assistance indirectly through the cooperative society which provides subsidised poultry feed.

The operational component for both modern farming areas illustrates the role of the agricultural technical advisor. In the case of the 50 farm analysis, it is related negatively to the use of chemical fertilizer for cereals and correlated positively to the tree area. This indicates the misuse of land potential for grain production. The role of the agricultural technical advisor is more positive or active in the 40 farm sample, because it correlates positively with the use of chemical fertilizer for cereals and vegetables, all of which relate negatively to the off-farm income. This means that improved

agricultural extension services have increased the farmer's reliance on his farm production. In other words, farm development has created full-time farming jobs in the country. This phenomena also arises in the component of labour in the 40 farms analysis. The farm family workers are related negatively to commercial market orientation, i.e., capital intensive farm methods which are a distinctive phenomena in intensive irrigated farms (component I in analysis of 50 farms). This type of farm is usually accompanied by increasing numbers of foreign workers, and decreasing farm family workers. This type of operation has been adapted to the new farming system. In other words, it best fits a situation of high market profit where most of the employees are share croppers and sell their production on the farm.

However, the introduction of commercial, irrigated, modern farms in the study area did cause inequality to develop in the socialist society, and also brought about the opposite of the type of labour relations which development planners would like to see arise. Manpower requirements for different types of farms differ considerably. Rainfed farming only needs seasonal workers where most of the work is concentrated in the short wet season and relatively little work is done during the long dry season. This work is done mostly by farm family workers. For irrigated operations more workers are required and, depending on the crop and type of technology utilized, they are usually employed for a longer period of time throughout the year. Certainly this needs the unpaid farm family workers, as well as remunerated foreign workers. In the case of the 30 farm analysis, a negative relationship occurs between full-time farming, off-farm income and foreign workers, while a positive relationship exist between off farm income and foreign farm workers in the labour component, because of

insufficient traditional farm output. This is due to water shortage and inadequate technical advice. This indicates that traditional agriculture has not fully benefited from agricultural development.

Having said that, the traditional farming systems have deserved more attention from the government, so as to further improve agricultural management, and to achieve equality of agricultural development targets in the region particularly, and in the country generally. However, the value of government assistance appears in the analysis of the 30 farms. This component emphasises the significance of the fragmentation in the structure of Libyan traditional agriculture. In other words, a negative relationship exists between fragmentation and farm structure attributes and deals with the negative impact of fragmentation on rational land utilisation.

Communalities:

The other set of indicators, that of communalitites, is shown in Table 11.8. These are measures of the proportion of the total variance contributed by a variable to the principal component solution. There are only three variables with communalities below 0.40. The lowest communality is found for the variable representing problems with fodder supplies on the modern farms in El Marj where because of adequate land the farmers can grow their own fodder crops. In the other two areas farms are too small to produce their own fodder and so they are dependent on imported supplies.

The next lowest communality 0.29 is associated with marketing problems. All marketing is organised by state agencies but access to

TABLE 11.8: Derived Communalities from 8, 8 and 6 components for Study Area Respectively

30 Farms	40 Farms	50 Farms	Variable Description
.84	.68	.49	Farmer's age in years
.71	.58	.53	Farm family size
.77	.76	.65	Farmer's education level
.63	.78	.65	Full time farmer (1/0)
.60	.83	.61	Gross yearly income in L.D.
.87	.*	.87	Farm size in hectares
.73	.44	.73	Farmer's experience in rainfed agricultural and animal breeding
.89	.74	.78	Farmer's experience in irrigated agriculture (1/0)
	.57	.59	Agricultural training of farmer (1/0)
.77	.88	.58	Number of farm family workers
.74	.86	.85	Number of foreign farm workers
.*	.*	.53	Land tenure of usufruct system
.55	.*	.67	Land tenure of squatter's rights
.75	.*	.63	Land tenure system of inheritance
.73	.*	.75	Land tenure pattern of share cropping
.47	.*	.*	Land fragmentation, number
.87	.69	.83	Vegetable area per farm: ha.
.88	.81	.83	Cereal area per farm: ha
.*	.70	.56	Fodder area per farm: ha
.*	.71	.51	Pasture area per farm: ha
.57	.*	.65	Tree area per farm: ha
.58	.51	.23	Fodder problem (1/0)
.71	.54	.68	Role of agricultural technical advisor
.71	.70	.67	Number of animals per farm
.*	.75	.67	Number of poultry per farm
.*	.73	.54	Quantity of chemical fertilizer input on cereal: kg/ha
.66	.50	.73	Quantity of chemical fertilizer input vegetables: kg/ha
.61	.*	.77	Water problem (1/0)
.91	.*	.77	Irrigated land per farm: ha
.68	.78	.55	Number of tractors per farm
.71	.74	.64	Number of cars per farm
.71	.74	.69	Off farm income L.D.
.77	.56	.49	Government assistance (1/0)
.*	.82	.65	Sale of farm production in local market
.50	.-	.53	Sale of farm production on farm (1/0)
.37	.84	.59	Sale of farm production elsewhere (1/0)
.29	.74	.61	Marketing problem (1/0)
.54	.81	.67	Farmer's view of further development
.65	.87	.73	Heavy farm investment (machinery, etc)
.33	.70	.54	Farmer's attitude to his childrens future in agriculture (1/0)

these agencies is easier for state farms than for the private traditional farms. The third low communality refers to the farmers attitude to his children's future on the farm. On the traditional farms families have lived on the land for generations and expect to remain there. In the two areas of new state farms there is more variation in attitude to the future of the farm and the farm family.

The managerial component (component III in the 50 farm analysis of El Marj, Component V in El Fatayh and component VI in the Ayn Marrah analysis) recognises elements which have a great effect on agricultural progress in the region especially and in the country generally. However, the managerial component has high loadings for different variables in the three analyses. In the analysis of 50 farms in El Marj the highest loadings in this component are the variables for education level and all farm income.

In the analysis of 40 farms in El Fatayah the highest loadings are for the farmers age and education which are negatively associated while full-time farming is linked negatively to education. Thus it can be seen that in these two areas of modern state farms education is clearly linked to part-time farming and interest in non-farm occupations. The better educated farmers do not appear to use their training to improve their farm management skills. On the other hand, for the private traditional farms of Ayn Marrah education is negatively linked to age and experience in farming and positively linked to a desire for children to seek non-farm employment. Thus in all three study areas education is seen as the key to movement out of agriculture.

The variables describing farm labour are only clearly identified as a basic component of farm structure in two analyses. In the case of the

40 semi-irrigated farms of El Fatayah the employment of foreign farm labour is positively linked to the agricultural training of the farmer and to the level of government assistance and negatively associated with the number of family workers employed. This indicates that on the more progressive farms agriculture depends heavily on foreign workers. Labour is the third most important component in the analysis of the traditional farms with highest loadings for foreign workers positively associated with off-farm income an negatively linked with family workers full-time farming, agricultural extension and water problems. This means that on traditional farms, off farm income allows the farmer to afford to employ foreign workers to compensate for loss of family labour. Therefore, in any planning of agricultural development attention should be given to the farmer's characteristics of age, education, interest in agriculture and availability of family labour as well as to land reclamation and farm infrastructure. It would appear important to note the differences between those farmers who have an interest in agriculture per se and those who are mainly interested in the farm as a source of new accommodation when considering agricultural modernisation. The differences between the various types of farms in terms of crop livestock mix and use of irrigation is also an important criterion. This latter is illustrated in the following sections using discriminant and cluster analysis techniques.

DISCRIMINANT ANALYSIS:

A discriminant analysis was applied to the farm level data collected in order to identify the major types of agriculture in the study area. The power of discriminant analysis as a classification and

analytic and predictive techniques is discussed by Johnston, (1980).

This study was employed to discrimate between farm structures on the basis of their farming methods or systems. Therefore, the choice of variables for the discriminant analysis was identified for this purpose. Of forty variables selected only twelve were found to be significant when discriminating between farm systems in the three case study areas using a stepwise method (Table 11.9).

Discriminate analysis has been used in the social sciences many times. For example King (1969); Adelman and Morris (1968); Cooley and Lohnes (1971); Klecka (1980); and Johnston (1980), provide some useful contextual comments and the explanation of the mechanics of the discriminant analysis. Recently it has been applied in analyses of the differential characteristics of adopters (agricultural cooperatives) and non-adopters (non-agricultural cooperatives) with a view to comparing their efficiency and their tendency towards adopting farm innovations, (Oyeleye 1982). It has also been used to distinguish the institutional and structural factors in facilitating traditional farmers to adopt new technology for high-yielding varieties of rice in the Essequibo Coast region of Guyana, (Shaw 1985).

The statistical procedures used in this study come from the Statistical Package for Social Science (SPSS). A step wise selection of variables is used based on Wilks Lambda. On the other hand, the group classification is distinguished as clearly as possible, by maximising the F-ratio of the between groups to the within group variance estimate (Shaw 1985). Thus the discriminant function provides the best analysis of variance (Norman et al, 1975).

TABLE 11.9: Mean and Standard Deviation Values of Significant Variables Used in Discriminant Analysis for 120 Farms

	MEAN				STANDARD DEVIATION			
	Total Farms	Rainfed Farms	Irrigated Farms	Mixed Farms	Total Farms	Rainfed Farms	Irrigated Farms	Mixed Farms
Gross yearly income	2719.00	3651.00	1668.00	2830.00	2237.00	1436.00	1438.00	2666.00
Farm size	19.05	51.03	3.20	11.89	20.85	5.57	9.21	11.14
Usufruct land tenure	0.53	0.51	0.00	0.83	0.50	0.50	0.00	0.37
Squatter's rights land tenure	0.17	0.37	0.12	0.10	0.38	0.49	0.33	0.30
Land fragmentation	0.80	1.00	0.25	1.00	0.40	0.00	0.43	0.00
Irrigated vegetables	1.39	0.00	1.09	2.25	2.76	0.00	2.39	3.29
Cereal area	9.37	30.34	0.95	3.64	13.11	5.68	4.94	5.62
Tree area	4.68	9.72	0.73	4.34	4.25	3.02	1.91	3.06
Role of agricultural technical advisor	0.56	0.65	0.03	0.81	0.49	0.48	0.17	0.39
Water problem	0.72	0.00	0.58	1.15	0.73	0.00	0.55	0.69
Irrigated area per farm	2.66	0.00	1.14	4.80	3.41	0.00	2.40	3.36
Number of tractors per farm	0.83	1.06	0.12	1.10	0.53	0.25	0.33	0.35

DATA ANALYSIS:

As a crude approach to distinguish between socio-economic characteristics of farm structure in the detailed study area, the mean values of each of the twelve variables were examined for each group of farms. A measure of significance exists if the mean for each group's variable is larger than the mean of that variable for all groups combined (Table 11.9). The rainfed farms' group is distinguished by farm income, squatter's rights as land tenure system, farm size, fragmentation, cereal and tree areas, the role of technical agricultural advisors and level of mechanisation. The mean of these attributes is larger than the mean of all groups combined.

Irrigated farms are characterised by irrigated vegetables only. Mixed farms shared in most of the characteristics of the other farm patterns. The new mixed state farms have the advantages of a larger farm family, higher farm income, usufruct land tenure, no fragmentation, more irrigated vegetable area, more attention from the agricultural technical advisor, and greater mechanisation but they are more of water problems.

Analysis of these variables showed that they were effective in distinguishing the three groups of cultivators in the study areas. Thus, the predominance of a traditional land tenure system in a modern dry farm area indicated that the allocation of newly developed farms gave priority to old settlers on the land of those who had a title to land, in order to avoid tribal disputes, which had existed in the area in the past. On the other hand, the new system of land tenure would appear as usufruct in mixed farming in the areas of both El Marj and El Fatayah. This is a result of changes in farm structure in the region

and is combined with the arrival of new settlers in the areas. They have different agricultural backgrounds, which are reflected in agricultural management. Irrigated farms are mainly in a traditional farming area, Ayn Marrah, with a predominant system of inherited private holdings associated with a share cropping system of land utilisation. This system is also characterised by part-time farmers, non-Libyan workers, and high off-farm income.

Overwhelmingly, it indicates the increasing number of foreign labourers in irrigated agriculture as share-croppers who intensively use the land in order to earn their share. These might be considered the essential elements in the impact on land utilisation. Therefore, agricultural training and the role of the agricultural technical advisors in the irrigated traditional farms are not significant. If these farmers received more advice and assistance it might discourage the land owner from migrating to off-farm work, and using foreign workers to cultivate the land.

Discriminant Function:

Two functions are produced by the analysis. Table 11.10 provides some statistics, which indicate the important discriminant characteristics of farm enterprises in the sample detailed study areas. Altogether, 97.50 per cent of the cases have been correctly classified (Table 11.12). There were five significant attributes that could be linked with the modern rainfed and mixed farm enterprises in the first function. These were identified as farm size, gross yearly income, usufruct land tenure system, water problems irrigated area per farm. These were linked to the institutional and structural nature of new farm

Table 11.10: Summary of F Values and Standardised Canonical Discriminant Function Coefficients

Variables	F. Value	Discriminant Function I.	II.
Gross yearly income	6.70	0.56	0.09
Farm size ha.	214.00	-1.07	0.18
Usufruct land tenure system	53.89	0.51	0.69
Squatter's right land tenure system	5.98	0.43	0.24
Land fragmentation	128.70	0.18	0.38
Irrigated vegetables ha.	7.43	-0.19	-0.98
Cereal area ha.	283.5	-0.29	0.02
Tree area ha.	79.67	0.13	0.37
Role of agriculture technical advisor	46.17	0.11	0.37
Water problem	41.63	0.53	0.11
Irrigated area per farm ha.	38.40	0.78	0.75
Number of tractors per farm	100.5	-0.03	0.51

enterprises in the modern farming area, and it explains the important role of agricultural development in the farm structure of modern farms.

This grouping of the modern farms is significant, despite a remarkable variation in the size of holding, farm labour, and farm output and it reflects changes in development programmes. Extension services were concentrated where change was thought to be most promising but regional planners focussed on the development of the farm infrastructure. This means that during the development programme of the 1970s, the government took the view that the medium mixed and large rainfed property holders were in the best position to implement modern farming methods. After 1975, the policy was reversed and changed to reduce the scale of this farm enterprise. Therefore, it has had to give preference to assisting small farmers. The effect of the new policy was implemented to achieve equality in the standard of farm life in socialist society and to resettle semi-nomadic people.

Consequently, function II has a high positive value on the variables irrigated land and vegetables per farm, and moderate positive loadings on attributes of the land tenure system and number of tractors per farm. Indeed, this function identified the dynamics of irrigated farms in the region. It is guided by the two dimensions of this function. The first concerns the traditional irrigated farm, and the second one is mainly modern mixed or irrigated state farms.

The aforementioned analysis divided farming systems on the basis of commercial versus subsistence, type of management and enterprise class i.e., one crop, two or more crops and livestock (see Morgan 1977). Therefore, the agricultural development strategy can be seen to have mainly concentrated on developing new agricultural land particularly in the most favourable part of the region. It has neglected traditional small farms, which basically require development, in order to raise the farmer's standard of living. In fact, traditional farmers, are those in small irrigated or rainfed farms (shifting cultivation). Most traditional farmers surveyed receive agricultural technical advisor visits only once a year or have never been visited at all, and have very little access to credit. Therefore, farm output on small traditional irrigated farms is very low.

The statistics shown in Table 11.11 deal with the importance of the discriminant functions. Thus as a discriminant, the first function is more powerful than the second, and the statistics indicate the canonical correlation and its square which is the proportion of the variance in the discriminant function explained in the three groups of farms in the detailed study areas.

Further tests which are used to test the power of the function to

TABLE 11.11: Canonical Discriminant Functions

Function	Eigen Value	Percent of Variance	Canonical Correlation	Squared	Wilks Lambda	Chi Square	Significance
I	10.06	52.91	0.95	0.90	0.009	524.27	0.0
II	8.95	47.09	0.94	0.88	0.10	256.27	0.0

discriminate between the structure of farms are the eigen value, Wilk's lambda and chi-square (Table 11.11). They indicate that functions I and II have significance at an incalculable level, which is shown by Wilk's lambda and chi-square. They indicate that considerable discriminating power exists in the variable being used, i.e., the larger lambda is, the less discriminating power is present, (Klecka, 1975).

The territorial map of canonical discriminant function plots the three groups of farms by type, (Figure 11.1), which shows the characteristics of irrigated farm patterns being associated with the two other farm types. Thus, the pattern of irrigated farms is the focus of agricultural structure in the region being the traditional farm system. On the other hand, both rainfed and mixed farming systems share the same socio-cultural characteristics but differ in the general layout of the farms. This indicates an increased separation between the two groups with modernisation, whilst the farmer on traditional farms is very similar in his attitudes and characteristics to farmers in the new rainfed farms. Thus agricultural structure in the region shows more variety than the farmer's way of life in both modern and traditional farming systems. In addition, Fig. 11.2 illustrates the separation score of each case on the variable under consideration. The location of points within the axis frame is the same as that in Fig.11.1. These indeed give a better view of differentiation in farming systems in the study area.

Classification Results from the Discriminant Function:

Table 11.12 shows the classification results computed from the questionnaire data. There is an almost perfect separation of classes

Fig 11.1 TERRITORIAL MAP OF THREE GROUPS OF FARMS IDENTIFIED BY CANONICAL DISCRIMINANT ANALYSIS

SYMBOLS USED IN TERRITORIAL MAP

SYMBOL	GROUP	LABEL
1	1	DRYFARM
2	2	IRRIGATED FARM
3	3	MIXED
*		GROUP CENTROIDS

TERRITORIAL MAP * INDICATES A GROUP CENTROID

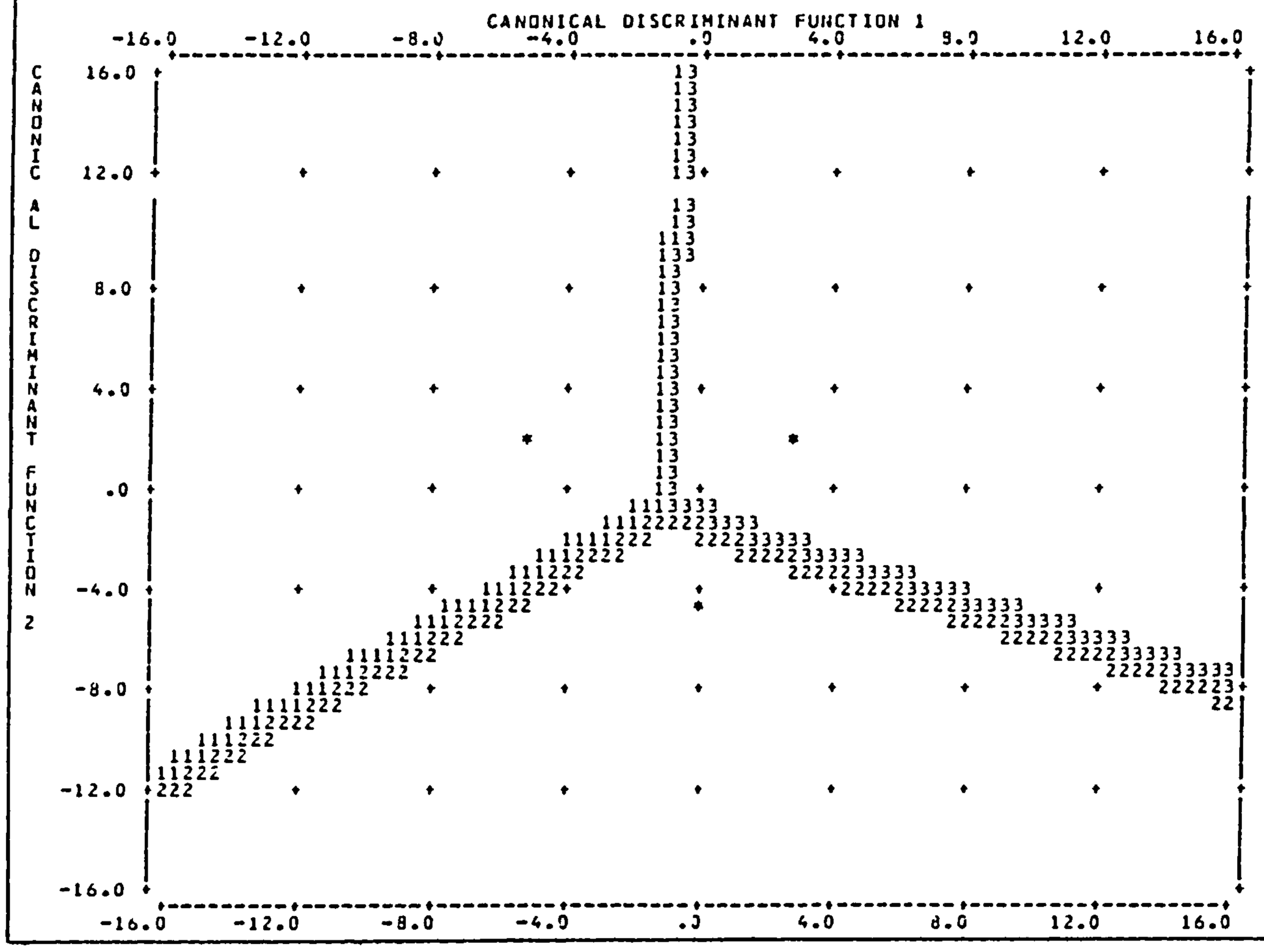
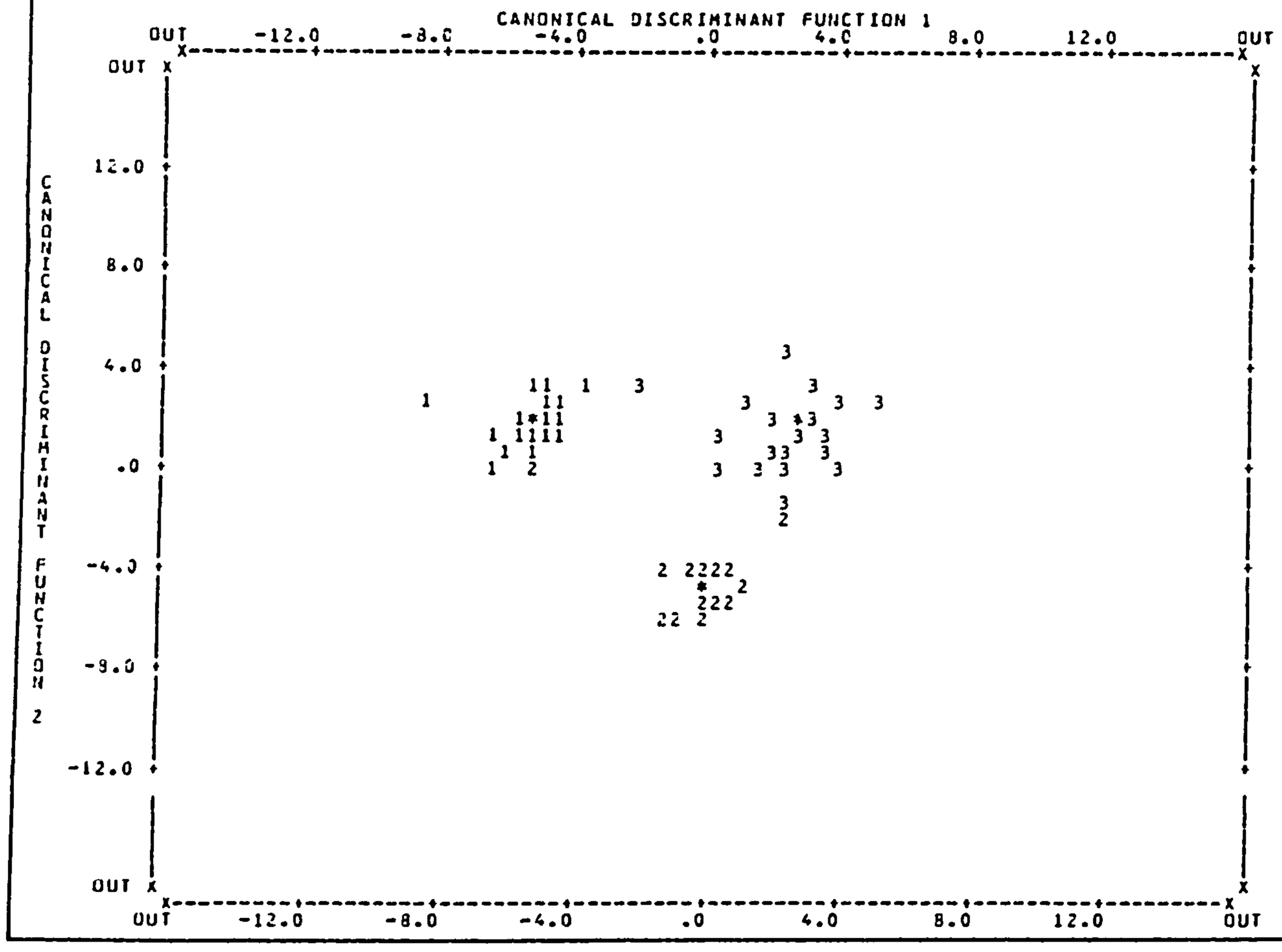


Fig. 11.2 PLOT OF DISCRIMINANT SCORES

SYMBOLS USED IN PLOTS

SYMBOL	GROUP	LABEL
1	1	DRYFARM
2	2	IRRIGATED FARM
3	3	MIXED
*		GROUP CENTROIDS

ALL-GROUPS SCATTERPLOT - * INDICATES A GROUP CENTROID



with 97.50 per cent of the total number of cases correctly classified at the level the 12 step, as performed by the discriminant analysis. This

Table 11.12 Classification Results

Group Type		No. of Cases	Predicted Group Membership I	II	III
Group I	dry farms	29	29	0	0
			100%		
Group II	irrigated farms	32	1	30	1
			3.1%	93.8%	3.1%
Group III	mixed farms	59	1	0	5.8
			1.7%		98.3%

Per cent of grouped cases correctly classified = 97.50%.

classification indicates that north east Libyan farming systems can be divided into modern rainfed and modern mixed farms and traditional irrigated farms.

This classification is based on the differences between farms revealed by 12 variables for crops, farm size, fragmentation, water control, land tenure, farm mechanization and gross yearly income.

The farms in the first group are distinguished by their large size, production of cereal and lack of irrigation with adequate use of modern inputs. Their gross yearly farm income is higher than that of other farms on average, but risk factors are great because of dependence of rainfall, which is characterised by a great variability (see Chapter III).

The group of farms identified as number three are mixed farms characterised by a high degree of commercial aptitude, with heavy investment in modern farm inputs. They practice farm management measured in terms of economic return. This group of farms has developed

cultivation of food for urban consumption.

The second group made up of small irrigated forms, is characterised by subsistence farming by farmers with a traditional way of life. It appears that this group of farmers were reluctant to undertake changes in their farm methods even if government assistance was made available to them. Because the prototype of farming culture exists among them, the old people posess the economic power in the society. Their conservation is thought to be a barrier to progress.

In these circumstances, it is clear that simple dichotomies of rainfed and irrigated and traditional and modern are not adequate for a classification of farm types as indicated in the third hypothesis in Chapter I.

CLUSTER ANALYSIS:

Clustering techniques seek to form 'clusters', 'groups' or classes of individuals, such that individuals within a cluster are more 'similar' in some sense than individuals from different clusters (Everitt, 1978 and 1980). Therefore, sets of data are used to explore the potential of cluster analysis. The original data set of 120 cases by 40 variables has been employed.

The range of clustering algorithms and measures of association that are currently available are numerous, but a standard first approach is gradually emerging in the form of minimum-variance procedure based algorithms, (Ward, 1963) using Euclidean Distance as a measure of dissimilarity (Everitt, 1980). It is an agglomerative method, bringing out those clusters or individuals which tend to a minimum increase in variance. It seeks 'tight' clusters that are well separated. It has

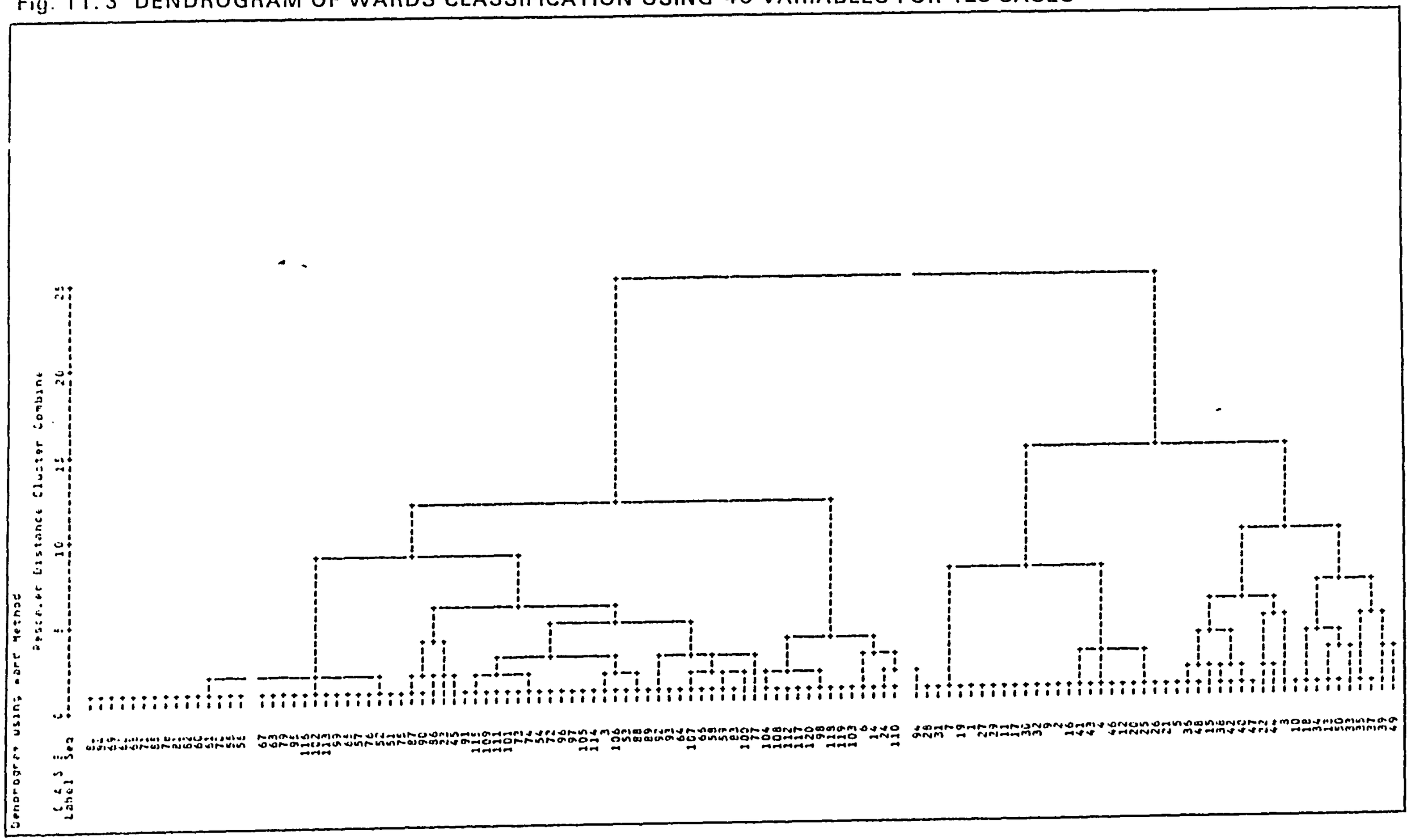
been widely used in a variety of natural science fields (Bradley, 1983), and social sciences (Openshaw, 1973), and favoured as a technique that yields a clear-cut dismemberment of a set of individuals, with a corresponding case of interpretation. Thus, the actual value depends on the clustering methods and the distance measure used.

However, Ward's method gives a dendrogram which shows several changes in levels and indicates the presence in this case of perhaps two to four groups.

The dendrogram, Fig.11.3, contains the complete 120 farms. Since many of the distances at the beginning stages are similar in magnitude, one cannot tell the sequence in which some of the early clusters are formed. However, at the last three stages the distance at which clusters are being combined is fairly large. It appears that the four cluster solution, identified as small settler modern farms, small traditional farms, large rainfed modern farms and large irrigated modern farms, may be appropriate, since it is easily interpretable and occurs before the distance at which clusters are combined becomes too large.

The dendrogram divides the 120 farms into two major groups. The criteria of separation in the first stage would seem to relate well to variables of low farm income, small farm size, irrigated vegetables per farm, experience of farmer in irrigated agriculture and off-farm income. Thus, the first group of 62 farms, comprising small settler farms and traditional irrigated farms, is distinguished by low farm income and some off-farm income. This is because it includes farm number 3 which has the lowest farm income of modern rainfed farms of a large size and the farmer receives off-farm income. The second group of 14 farms (including the traditional farms of Ayn Marrah area and modern rainfed

Fig. 11.3 DENDROGRAM OF WARDS CLASSIFICATION USING 40 VARIABLES FOR 120 CASES



farms of El Marj area) have a higher farm income and more efficient farm management.

The third group has 24 cases or farms. It comprises both large rainfed and irrigated modern farms. These are distinguished by average farm income, dual way of life, i.e., livestock raising integrated with intensive agriculture. The intensive livestock raising is indicated by the increased range of and emphasis on fodder crops. In effect, the new land tenure system of usufruct permits the new landlords to invest heavily in such estates, and the role of the agricultural technical advisor is clearer in terms of cropping systems, organisation and market access. Thus, the development agrosystem is sophisticated and highly effective on the modern farm.

The fourth group includes 20 cases. They are mainly the commercial farms on the best lands of the region, and this group of farms are the main food producers. A characteristic of this intensive agrosystem is related to cropping practices such as (1) selection or plant species or varieties best suited to the season, area, soil and climate, (2) inter-cropping of vegetables among fruit orchards complementing field agriculture, (3) more advanced techniques in agricultural management, (4) following agricultural calender for soil preparation, plant, watering, and harvesting, (5) using chemical fertilizer, animal manures, compost, and 'green' manure, as well as wood ash (from stubble), and follow in the agricultural rotation, (6) advanced technology for water lifting or collecting, although not necessarily applied on a large scale, and an increased use of farm machinery on both irrigated and rainfed modern farms.

At this stage, there are four groups in the analysis. The dendrogram goes from four groups to two groups; this would infer the presence of two groups whose important characteristics are as follows.

The first group includes 76 cases 'farms'. The most common characteristic among them is low farm income, ageing farmers and traditional farming methods revealed in these farms. These farms are mainly in the Ayn Marrah traditional farming area and El Fatayah area. They could be labelled as traditional farms, although they include new farms in El Fatayah area, where the traditional farming methods still exist side by side with modern farms.

The second group includes the remaining 46 farms. These are modern farms. They include rainfed and mixed large farms, the common features that occur between them are, farm size, farm input and farm output.

In summary, the numerical classification based on the 40 variables has resulted in a four-group pattern which is interpretable in terms of the farming system. The importance of individual and groups of associated farms is evident. In general, their identification corresponds to previous discussions using a principal component and discriminant analysis. Cluster analysis shows the adherence of individual farms to different farming systems, and it divides the farming system to two main groups. These are traditional and modern farming systems. Thus, the farming pattern has been identified on the basis of farm management and farmer characteristics rather than farm layout and farm structure.

The traditional farms include the modern settlement farms in El Fatayah area and some rainfed farms of El Marj area, which are less efficient in farm management. This means that the traditional farming

system still exists within modern farm systems. Therefore, modern agriculture has to face challenges from traditional systems, in that modern agriculture should provide a standard of living not below that of traditional agriculture, otherwise the new farmers will migrate from the land. To make farming efficient to this degree, Libyan agricultural planners should make extensive use of land resources in order to be able to utilize fully the limited and rather special natural resources of the country. This can be done through the use of high capital investment well trained manpower and often unconventional non-traditional farming methods.

CONCLUSION:

The statistical approach in this section, in light of the preceeding ones has led up to the conclusion that traditional agriculture in the region particularly, and in the country generally, should have its share in agricultural development. This may be achieved through cooperative agricultural organisations, and the secretariat of agricultural offices in each agricultural area. Further, the agrarian conferences should provide traditional agriculture with essential needs. The encouragement of the role of technical agricultural advisors in traditional farm management is essential to orientate the farmer to modern farming practices, such as the restoration of soil productivity through rotation with fallow land, and how and when to use proper chemical fertilizers, pesticides and modern farm inputs generally.

Production should be optimised with respect to composition and variety of species, and in an area with long and intensive dry seasons, with regard to availability of water when required. Therefore, besides

aiming to achieve sustained improvement of productivity of farms, they should pursue the following goals:

i. Diversification of production for example in Ayn Marrah a traditional farm should specialize in one or two crops for each season.

ii. Management of natural resources by rational use, mainly depending on the availability of sub-surface water and its quantity and quality. This could be achieved by the development of the irrigation system of the area.

iii. To make farming attractive to highly educated people so that they will remain as full-time farmers and practice improved farm management techniques.

In rural development theory education is frequently considered to be vital for promoting rural transformation, (see Haswell, 1972 ; Arnon 1981; Hardman, et al, 1982). The Schooling is certainly important in this respect, although the general changes occurring in society, and government propaganda on the radio and television are probably more important sources at the present time. There should be an encouragement of adult education, which should mainly concentrate on agricultural curriculum and training. It would seem that there is a need for rural development programmes to raise the standard of women's productive capabilities and this should take the form of training programmes for the wives and daughters of farmers as they have come to play an increasingly important role in the agricultural economy.

The government efforts to fuel the process of technical change in the public modern sector by providing credit and extension services usually worsen the inequalities present within the private traditional system. Once again, many of these distortions arise because of the

development model pursued by national and regional planners.

If traditional sectors and modern sectors in agriculture are to develop in a way that is in accordance with the social reality of the region or country overall, government policy must be changed to give an opportunity to the traditional agricultural sector.

This might increase the degree of competition between different type of farms, but there is no doubt of the effect, directly or indirectly, on agricultural production systems in the country.

The modern development farms badly need an evaluative study, mainly concentrating on farm management. In fact, the heavy investment in certain agricultural schemes has had a negative response. The reason for that could be the lack of cooperation between the farmer and the headquarters of the project, and added to that, the farmer has not been given the full responsibility for farming practices. Another factor which affects farmer's attitude to new agricultural technology is a psychological reason. How does a semi-nomadic farmer who originally came from a herding society adapt to a sedentary life. Some of these obstacles are expected in an under-developed country, particularly a semi-arid country. How to demolish them is a big task which burdens the planners and the administrator's committee in the projects which are inadequate in the study area.

In general, there are other factors which are represented by the discovery of substitutes for scarce products, which thus provide a way to diminish the dependence on farm inputs from external sources. For examples, substitution of capital to buy equipment to compensate for shortage of labour, concentration on petrochemical industries to produce chemical fertilizer locally instead of importing it, and also encourage

production of animal feed locally. The government should provide incentives to the best farm management regularly and try to give the farmer his freedom in marketing, stressing a commercial agricultural orientation. By this path and others agricultural development in Libya might find its way to productive success.

CHAPTER TWELVE

CONCLUSION

Agricultural potential in these case study areas does exist. However, physical factors with their severe restrictions and their specific characteristics leave no room for manoeuver, and in combination they create a unique situation in each area. Land development or land reclamation in such regions involves the creation of farms in a critically sensitive ecological environment, placing the responsibility for the exploitation of a hazardous environment on the human factor which thus becomes the key.

On the other hand failure to resolve priorities amongst agricultural policy objectives such as resource exploitation, maximisation of agricultural production and regional improvement in socio-economic and cultural life has led to problems. Each of these objectives could have been met in isolation but when assembled without any stated priority given, inevitably, they produced conflicts of interest. For example, the development of small family farms in El Fatayah area made it difficult to maximise agricultural production, even to gain much production at all. In addition the most effective use of water resources has been severely and adversely affected by the survival of the traditional farm on the Wadi Dernah terraces and in Dernah city gardens, as shown by Benkhail's detailed study in 1985.

This has resulted from the relative neglect of resource development in the country generally and in the case study areas in particular, in relation to their specific regional variations. The use of the concept

of land systems in relation to agro-ecological potential, as developed in this thesis has highlighted this regional variation in the study region. It is significant to direct attention to this approach in the evaluation of resources in the country. An integrated view in terms of agricultural potential, especially on a micro-scale using land facets, can be used for the assessment of actual and potential farming systems in a specific area. A deeper knowledge of ecosystem analysis and related fields will increase the capacity of the nation to cope more effectively with environmental management.

However, overstressing the environmental aspects in a marginal semi-arid region such as North Libya, and ignoring the socio-economic and managerial problems that accompany rural development might produce some negative impacts on the new settlers and the region as a whole.

The method of analysis used in this study provides a framework by which an evaluation of the constraints imposed by land on farming practice can be assessed. The major value to land use planning of such a study is that it assists the development of an agricultural land classification which provides a basis for an objective comparison, in terms of the agricultural quality of a number of farming areas.

The findings of this study suggest that there are some important structural and regional variations in the study area which warrant consideration in any policy decisions. For example, dry land farmers should diversify more in order to achieve a higher level of subsistence. This should be interpreted differently for the various farming types and areas. A particularly useful policy might be to divert resources away from tree crop growing into food crop raising. At the other extreme, the farm type which seems to be characteristic of traditional gardens is

apparently a type of subsistence agriculture. Some encouragement and orientation toward modern farming methods for these traditional farmers might well be promoted by agricultural technical advisors or agricultural extension workers.

However, agricultural development policy faces the challenge of rising demand for a wider variety of food crops as a result of an increase in disposable incomes, cutbacks in imports of some food items such as fruit (bananas) and change in consumption patterns in favour of the products of intensive irrigated agriculture. A shift took place, as indicated by changes in farm structure, by which land resources were diverted away from traditional agricultural production of subsistence crops in favour of orchards and fruit trees, as has been shown in study. This has led to economic and social dangers which the state has been slow to recognise.

In some areas farming production has reached the point at which the state has had to intervene, for economic as well as social reasons, as in tribal disputes about land. Agricultural development policies have created income differentials, favouring the large and medium sized farmers capable of diversification, leaving the small traditional farmers out of the scope of development. Policies aimed at national economic efficiency, stabilization of agricultural systems and modernisation of the rural economy are vitally important elements in the new strategy. Land reform has contributed considerably to the social awakening of the rural population and succeeded in developing a strong sense of resistance to exploitation by landlords or any anonymous landlord as in the case of tribal property. The government is both able and willing to support the small traditional farmer, even at the cost of

breaking down the barriers which the revolutionary government erected between private and settlement farms.

Government finance should be deployed in agriculture in the interests of internal accumulation. That is small traditional farms should be viewed not so much as a means of increasing net production per hectare or per person, or absolute level of output, but rather as a means of enabling an agricultural livelihood to maintain itself in harmony with the environment. While there may be no doubt that productivity on traditional farms will not be as high as on the modern farms, they are more similar than has previously been thought, as has been proved by the use of cluster analysis in this study. As in the past, traditional farming does not only continue to contribute to the urban economy but its productivity could be increased considerably by modern techniques of land use and marketing.

Significant findings concerning the economic and social characteristics of the farmers have emerged in the principal component analysis of the survey data. For example, the third component in the analysis of 50 farms in El Marj and the fifth component in the 40 farms in El Fatayah solution, and the sixth component in the analysis of the 30 traditional farms was identified as a managerial component which was clearly more important in El Marj than in the other sample areas. A marketing component was identified in both analyses of modern farms, while this element was not identified in the analysis of the 30 traditional farms. All in all, the use of principal component analysis allowed the recognition of elements which have a great effect on agricultural progress.

This study has shown that the main problems of farm management are related closely to the farmer's age and his education level. This finding suggests that a solution is either to concentrate agricultural educational opportunities upon children who can be carried through post-primary education, or to adopt new approaches to adult education that are within the means of these farmers. This latter approach could be launched through programmes aimed at conscripts for military service. The agricultural college student should be more prominent in teaching work in the field, especially during summer vacations. Teaching should be concerned not only with securing the adoption of a particular improved practice, but also with changing the outlook of the farmer to a point where he will be receptive to new ideas and use his own initiative continuously to improve his farm methods. At the same time the government should give priority to agricultural graduates in the allocation of new farms for development. This is one of the alternative solutions for improving farm skills, added to the adoption of concepts and technology by the farmer, and the training of traditional farmers in technology.

Exemption is given to the farmer from military service, but the government should use soldiers in farm work at peak periods of labour demand. School children could also be employed on farms during summer term. Nevertheless, a long term strategy would suggest that closer economic cooperation with neighbouring Arab countries, such as Egypt, Sudan and Tunisia, appears to be beneficial to both Libya and the cooperating partners.

The study also emphasised the problem of government assistance being unevenly distributed among farmers. Government needs to channel

scarce capital to those farmers who have the least and those areas where agricultural development is starting to take hold. Favourable areas where more capital has already been amassed such as El Marj should start receiving fewer subsidised loans and these funds should go to less wealthy medium and small farmers there.

The state's agricultural policy, attempts to tackle the two fundamental issues of equity and efficiency. Socialist agrarian policy gives more weight to equity, while assuming that this does not jeopardise efficiency considerations. Efficiency in farming management and the availability of farm workers are acute problems in farming development in the study area, which have come out clearly in the principal component analysis in this study. Above all, agricultural marketing must be used to attempt to direct agricultural resources in the direction required by the goverment's overall development plan. The state perceives a minor role for marketing in influencing output. Production is seen by the administration as being controlled by the state directive, since allocation of resources has already been set by the state's agencies. Therefore, the outline of the new development model is clear. Libyan agricultural development will be increasingly orientated to the internal market, a market characterised by growing inequalities of income.

The market solution could suggest a relatively free market for domestic production. At the same time state intervention in setting prices in order to realise social justice in a socialist society, should be preserved and the state should not cut subsidies for farm inputs in subsistence agriculture. A rural development strategy based not so much on maximising economic growth, but on optimizing economic and social

benefits has a great number of advantages; it lessens the psychological stress and the social implications for all the rural population involved; it diminishes the push-factors for rural-urban migration and it encourages the development of a genuine rural economy which could, after a certain time at least, initiate a change in the dependency of the rural areas on the urban economy.

On the other hand, traditional farm production can be market-orientated and may develop effective forms of rural productivity. Small traditional irrigated farms can be extremely efficient. Careful improvement of traditional practices, especially through the development of effective cooperatives, could serve both aims, namely an increase in production and a reduction of harsh social consequences.

The findings of the detailed surveys have shown that a new farming model is urgently needed. Cluster analysis has revealed that modern farming systems face challenges from traditional ones. In other words, they have many similarities, in terms of both institutional and managerial variables. This finding could suggest that modernization has not improved the efficiency of farm management. It appears that an improvement in traditional farms could generate social response. The emphasis in modern farming should be on improving rural services and providing a standing of living not less than that based on traditional agriculture, thereby reducing rural-urban movement.

In order to achieve this, the planners should make extensive use of land resources, to be able to utilise fully the limited and rather special natural resources. Libyan agriculture needs capital-intensive land utilisation, highly trained workers and non-traditional farming practices.

A similar conclusion has been indicated by a discriminant analysis of farming systems based on farming methods. Again a great deal of similarity is found between types of farms on the basis of level of commercialisation, type of management and enterprise class, water use and crop-livestock mix. Variables which distinguish more clearly between farm types are the operational variables of farm size, fragmentation, and water control, land tenure, and farm mechanisation. These should be taken into account by the planners in developing a new farming model. However, the major challenge for agricultural research is to design a new farming system adopted to the various combinations of environment, production factors and technological levels under which small farmers operate. The emphasis will be on using local inputs of labour and materials in order to provide improved economic conditions for the majority of the rural population.

It is natural to look to a more intensive farming system with the integration of crops and livestock for a solution to the problem of the declining productive capacity of intensive irrigated farms as a result of over-utilisation of resources and shortage of labour. It may also be seen as a solution to the problem of inadequate output from small dry land farming related to high rainfall variability and an expanding population of subsistence cultivators.

Often, in a localised situation, this over-exploitation can be attributed to the commercial motives of the farmers on farms characterised by employment of foreign workers, capital intensive inputs and a share cropping system of land tenure. For example, such a farmer frequently ignores the potential environmental damage in computing his

short-term profit, and is usually oblivious of the costs that this action imposes on others.

This study has shown that the solution for these environmental problems lies in the proper use of chemical fertilizers, efficiency in water use, crop rotation, mechanization and adaption of the existing technology to local physical and cultural variations and the introduction of modern farming methods. This type of farm is isolated in the fourth group identified by the cluster analysis Figure 10.4a Chapter ten. This type of farm is strongly linked with the private profit motive which is not adaptable or acceptable the ideology of a socialist society.

An alternative proposal is for a combination of different types of agriculture in order to achieve optimum results from rural development under the umbrella of socialist strategy. The mixed farming system is revealed by a discriminant analysis as being most efficient. It seems this farm is more favourable for the study areas. Nevertheless it has been planned, but it has not been applied properly. The dual structure of small intensive irrigated farms and dry farming permits either an accentuation of progress emphasising either production growth for a limited number of modern capital intensive units or permits a shift to a wider participation in national agricultural production by a greater number of less well situated smaller farmers.

Broadly speaking, the continuing weakening in the oil markets during 1985 and the dramatic decline in early 1986 affected the development efforts of Libya. For example, the great man-made river project is expected to be delayed, and further projects will not be completed. In order to tackle this problem the General People's

Congress has adopted programme adjustment, by forcing the significant retrenchment of public expenditure, rationalising investment programmes and introducing greater efficiency in various operations. This retrenchment, in turn, seriously affected the level of economic activity in the various sectors, notably in construction services and development planning as has been shown in the first draft of the development plan, 1986-90. Development has slowed down and the need for foreign technical assistance has fallen. Foreign workers began to leave the country in late 1985 as the Libyan government reduced expenditure. Further cost cutting was carried out by reducing imports by up to 20 percent in 1985. In 1986 the oil market was at its lowest point for the last fifteen years and this implies a serious deterioration in the current accounts balance, with a deficit of up to $4 bn in prospect, despite further attempts to make cutbacks, E.I.U. (1986). Ultimately, the current account deficit has reduced spending capacity which has also helped to delay or cancel major projects of questionable value.

Dependence on oil as the only resource to generate dynamism in the Libyan economy has led to vulnerability. The development of alternative renewable energy resources is essential. Solar energy has great possibilities as Libya is the richest among desert countries in terms of average insulation. This would enable the economy of the country to be more broadly based with increased investment in the development of productive sectors such as agriculture and industry.

The decentralisation approach has also been introduced in early 1986, in order to reduce the effect of the bureaucracy with its painstaking and highly centralised process of decision-making particularly in rural development institutions. Projects of

agricultural development have to beat the bureaucracy if they are to maintain their schedules of implementation. This problem gives rise to efforts to by-pass existing agencies and to create new ones. This can be done by giving responsibility to local people's committees for each area, where political-administrative inputs in various forms such as agrarian conferences, agrarian cooperatives, agricultural extension, agricultural establishments and companies and agricultural loans and aids provide a most important mechanism offering new opportunities for farmers. Such strategy should imply a greater degree of social and spatial equity in the distribution of economic benefits.

The Libyan rural development or farming development model of diffusion together with trickle-down policies has been held responsible for rising inequality in places where little had previously been present and worsening it where it was found traditionally, as occurs in the study area. But increased knowledge of alternative technology may speed up a new approach "from below to above" or "development from within". Although it is difficult to envision this as being of great importance in the absence of other stimuli, there are undoubtedly contributions to be made. However, a substantial effort on the part of those concerned with facilitating change through biotechnical research, and education must be directed towards understanding the political socio-economic and cultural aspects of the existing situation if realistic expectations and relevant programmes are to result.

Traditionally, planning consultants and some agency planners have tended to simply make plans with a series of alternatives based on either ecological suitability or economic probability, leaving local

society to try to implement the plan using the alternative that holds the most appeal, as best they can, in the light of current problems. This approach is not sufficient.

Agricultural development planning should use the views of local inhabitants and take into account adaptive strategies when drawing up plans. These plans should be implemented through the existing social organisations and include local groups as just mentioned. In this way the local administration becomes responsible for monitoring farm management

. Thus, the farming system is improved by the adaptation of the farm to the farmer; by the maintenance of farm resources, such as soil fertility by training the farmer to operate his land efficiently, and by encouraging cooperation between farmer and agricultural technical advisors or the agricultural service.

Implicit in all, this is the possibility of relative changes in farm structure with potential political implications. Clearly, therefore, an indispensible requirement for success for such new approaches to development is a great social consciousness on the part of governments and national planning agencies, and a national determination to improve the quality of life of the rural population.

In conclusion, a very interesting finding of the rural development evaluation in a study of the farm family programmes is the need for improved research methodology in analysing the impact of investments at the level of the ultimate beneficiary. It is argued that the fundamental unit in the agricultural sector is not the farm enterprise, which strictly forms an economic unit of production, but is rather the

farm household which represents both a unit of production and a unit consumption.

There is the need to know about how the household decision-making process operates with regard to production and consumption issues. How do these influences, for example, affect changes in cropping patterns and farming systems? This knowledge can only be gained through a close consultation with the farm population.

This research represents a first step in establishing baseline data for an evaluation of the impact of Libyan rural development.

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APPENDIX 1: MEAN ANNUAL RAINFALL:

Year	Beninah	El Marj	Jardis El Ahra	Maran	Messah	Shahat	Safsat	Dernah	Tobruk
1921	*	361.0	*	*	*	*	*	*	*
22	*	594.0	*	*	*	*	*	*	*
23	*	496.0	*	*	*	*	*	*	*
24	*	583.0	*	*	*	*	*	*	*
25	*	535.0	*	*	*	*	*	*	*
26	*	448.0	*	*	*	*	*	*	*
27	*	399.0	*	*	*	*	*	*	*
28	*	721.0	*	*	*	*	*	*	*
29	*	783.0	*	*	*	*	*	*	*
1930	*	471.0	*	*	*	*	*	*	*
31	*	333.0	*	*	*	*	*	*	*
32	*	359.0	*	*	*	*	332.0	*	*
33	*	280.0	*	*	*	*	183.3	*	*
34	*	565.0	373.0	*	710.0	*	380.0	*	*
35	*	388.0	304.0	*	602.0	*	413.0	*	*
36	*	537.0	253.0	*	599.0	*	579.0	*	*
37	*	440.0	*	*	592.0	*	306.0	*	*
38	*	619.0	*	*	920.0	*	705.0	*	*
39	*	370.0	258.0	*	837.0	*	454.0	*	*
1940	*	443.0	267.0	*	710.0	*	407.0	*	*
41	*	*	*	*	146.0	*	*	*	*
42	*	*	*	*	*	*	*	*	*
43	*	*	*	*	*	*	*	*	*
44	*	*	*	*	*	*	*	*	*
1945	457.4	*	*	*	*	361.0	*	237.7	177.9
46	426.3	*	*	*	*	528.9	*	266.8	33.9
47	315.5	*	*	*	*	664.0	*	237.2	137.8
48	338.7	*	*	*	*	529.6	*	358.3	308.6
49	232.3	*	*	*	*	584.1	*	262.4	139.5
1950	197.3	*	*	*	*	554.3	*	190.1	127.5
51	292.2	*	*	*	*	459.4	*	124.4	71.3
52	337.6	*	*	*	*	492.0	*	239.8	55.0
53	262.3	*	*	*	*	535.1	*	311.5	98.8
54	343.3	*	*	*	*	963.4	*	356.5	64.8
55	127.8	*	*	*	*	357.1	*	155.1	30.3
56	159.3	254.0	*	*	564.0	411.6	*	233.9	147.2
57	351.1	570.0	*	*	550.0	699.1	*	379.4	135.2
58	105.2	172.0	*	*	361.0	283.7	*	167.0	46.8
59	207.1	291.0	*	293.0	535.0	559.9	*	436.9	86.6
1960	245.0	252.0	*	151.0	323.0	491.8	*	179.3	104.6
61	281.3	352.0	*	407.0	389.0	801.4	*	353.3	166.3
62	323.4	243.0	*	320.0	621.0	761.2	*	331.5	109.9
63	159.7	325.0	*	219.0	485.0	467.6	*	260.9	40.6
64	166.6	269.3	208.0	141.0	500.9	490.5	185.0	264.8	158.7
65	366.8	315.4	211.0	208.0	741.0	585.4	434.0	257.2	52.1
66	316.8	494.5	397.0	307.0	785.0	699.6	462.0	179.8	53.3
67	197.6	271.5	133.0	156.0	127.0	686.2	402.0	277.6	124.4
68	324.5	396.5	272.0	252.0	315.0	717.4	548.0	275.4	69.3
69	369.0	363.5	257.0	295.0	439.0	877.2	437.0	300.7	145.3
1970	140.7	290.5	169.0	58.0	*	502.3	461.0	174.7	45.9
71	323.2	335.1	315.0	276.0	417.0	486.2	337.0	224.9	89.5
72	191.4	338.0	246.0	239.0	435.0	453.0	403.0	238.5	126.8
73	216.5	299.7	202.0	160.0	422.0	441.4	327.0	220.2	127.5
74	347.6	360.9	237.0	304.0	384.0	460.0	407.0	232.2	90.1
75	184.3	215.0	249.0	135.0	601.0	431.9	201.0	236.9	163.0
76	250.5	226.5	*	*	*	606.6	*	260.8	98.9
77	299.5	*	*	*	*	660.2	*	181.5	82.9
Mean	267.5	399.8	255.9	241.7	545.9	562.8	415.6	254.7	105.5
Std.Dev.	87.9	139.0	66.2	85.3	191.4	153.4	142.3	70.3	55.3

* No data available

Source: Ministry of Communications Meteorological Department, Tripoli, (Undated).

APPENDIX 2:

Basic expressions are outlined by Veihmeyer as Evaporation Section II in Hand book of Applied Hydrology, edited by V.T. Chow, 1964.

The Penman expression combines two values of evaporation, one by the net radiation and one by the drying power of the air (i.e. humidity and wind speed). In the former, the short wave radiation at the outer atmosphere tabulated for date and latitude as in the Smithsonian Meteorological Table (1949), is reduced by the atmosphere and by clouds:

$Ry = Rs\ (0.18 + 0.55\ {}^{n}/_{N})$; where

Ry = Radiation received at the ground

Rs = Radiation at outer atmosphere

${}^{n}/_{N}$ = Ratio of hours of clear sky to total daylight hours

This expression has been widely used and here checked quite satisfactorily with the Smithsonian tables for radiation received at the ground at 32° through an atmosphere with turbidity coefficient near to 0.6. The higher the latitude, the larger the path length of the radiation ray i.e. the greater the air mass with latitude 0 and alternative radiation expression is;

$Ry = Rs\ (0.29 \cos \phi + 0.52\ {}^{n}/_{N})$.

This gives greater values of radiation received at 32°N so in view of figure 4.5 was not preferred here. The reflected radiation is subtracted from the short wave radiation received to give the radiation absorbed at the ground (Rg).

$Rg = Ry\ (1- x)$ where x is the albedo or coefficient of reflection (R reflected / R incoming).

For net radiation, the outgoing long wave radiation Rb is modified from the Stephen Bolzman blackbody radiation (coefficient O) as a function of the fourth power of th surfact eemperature T in degrees absolute, reduced by cloud amount (N-n) and by water vapour pressure e in millibars. The expression is;

$$Rb = OT^4 \quad (0.56 - 0.09\sqrt{e}) \quad (0.1 + 0.9 \ {}^{n}/_{N})$$

The aero dynamic term of evaporation Eo is;

$$Eo = 0.262 \quad (e_s - e_a) \quad (0.5 + 0.0062 \ U_2)$$

where e_s = saturation vapour pressure in millibars at air temperature

e_a = air vapour pressure in millibars, as measured

U_2 = run of the wind in Km per day at 2m height.

The 0.5 in the above expression was adopted in place of the earlier constant unity after Penman's experience of the international team observing evaporation at Lake Meffen. It is used here also because values of wind run U_2 are probably at heights above 2m.

Modification of the Penman expression are generally small, e.g. the McCulloch modification 1965 in West Africa reduced each of the expressions (radiation incoming / back radiation outgoing and wind speed with humidity) by the ratio of the slopes of the saturation vapour pressure cure to that same slope plus a psychrometric constant that included a barometric pressure to cater for altitude and the efficiency of conversion of incoming heat energy into vaporition of water. Such modifications were not tried in this work because altitudes and humidities are low.

The separate component expressions above are combined in the Penman expression for total evaporation Et as;

$$Et = \frac{\frac{R\ net}{L} \Delta + Eo\ \gamma}{\Delta + \gamma}$$

(b) Evaporation values by Hassan (SDWR, 1976) are calculated on the basis of radiation indicated by sunshine hours and also on the basis of drying power indicated by wind speed and air humidity.

$$Eg = \frac{50.1 \times 5 \times \cos Z}{L} + (4.63 \times 10^{-3} \frac{U\Delta e)}{T})$$

where

Eg = Potential Evaporation from a wet short grass covered area or from a lake or sunken tank in cm/day

S = n + 0.22 (N -n)

= Mean daily weighted sunshine hours

n = Observed sunshine hours

N = Length of the day

Z = Mean Zenithal angle of the sun during the day

L = Latent heat of evaporation

U = Mean daily run of the wind in Km at 2 meters above ground

Δ e = Saturation deficit of air passing over the surface in mbs

T = Air Temperature in degree absolute

Note: information on the albedo of the wet and short grass has been taken = 0.36.

The Piche evaporation comprises a graduated glass tube filled with water and invented to evaporate from a 5 cm disc of stiff papter held by a brass dip over the end of the tube. It gives a simple direct measure of evaporation, though in a selected environment such as inside a growing crop or, more usually, inside a meteorolgical screen. The SDWR report (1976) uses the Piche values x 0.7 to compare with empirical calculations of evaporation.

Thornthwaite measured the evapotranspiration of maize seedling through central and eastern U.S.A. and found those values were not a simple function of temperature but related to it via a heat index I which is the sum of 12 monthly values i.

$$i = \frac{(Tc°)}{5}^{a} 1.514 \qquad I = \sum 12_i$$

PE = 1.6 $\frac{(10Tc°)}{I}^{a}$ in which a is an awkward polynomial function of I. Between 10 and 80°C the power a can be written;

a = 0.016 I + 0.5.

Thornthwaite catered for the effect of radiation by calculating evaporation for a month of 30 days, each 12 hours and then multiplying by a correction factor to cater for change in month and day length, at the latitude of observation.

The use of Thornthwaite monogram and table is very simple, but it should be remembered that they were designed for climatology and can only be a rough indication in hydrology.

The Blaney-Criddle method correlates the consumptive use in inches per month with the product of mean monthly fahrenheit temperature (iT) the monthly percentage of day time hours for the year (D), an empirical coefficient for the crop (Ke) and month and, in a later version, the cosine of the mean monthly zenith angle of the sun (cos O). The k value ranges from 0.6 for when soil moisture is more abundant, to 0.8 for more arid conditions. These last two variables increased the seasonal range, which at Shahut seemed essential, bringing more agreement to the different approaches that were made.

$$\text{Consumptive Use} = Cu = TDK_c \cos \Theta$$

The empirical expression by Turc requires precipitation and factors for the soil and the crop. Hence it is little used in recent years.

$$\text{Evaporation mm} = \frac{P + a + b}{\left[1 + \left(\frac{P + a}{L} + \frac{b}{2L}\right)^2\right]^{\frac{1}{2}}}$$

P = precipitation in mm
a = soil factor
b = crop factor
L = latest heat of evaporation

Olivier (1961) tabulates for each 5 of latitude the deviation from unity of the ratio of the monthly radiation function to the radiation

function emerged over the year. This radiation function is $^{RV}/_{R}$ which is the vertical radiation Rv to the incoming radiation R. The wet bulb depression Td - Tw for the month correlates directly with evaporation, E measured by pan.

$$E = \frac{Td - Tw}{\left(\frac{R}{Rv}\right) mth \Big/ \frac{1}{12} \sum_{1}^{12} \left(\frac{R}{Rv}\right)}.$$

APPENDIX 3: WATER BALANCE FOR SELECTED STATION BASED ON PENMAN FORMULA:

	Shahat						El Marj					
Month	P. total mm	PET total mm	Effect P mm	Actual Evap. mm	Storage	Runoff or Deficit	P. total mm	PET total mm	Effect P mm	Actual Evap. mm	Storage	Runoff or Deficit
Jan	127.4	28.4	99.0	28.4	80.0	+ 99.0	112.4	45.0	67.4	45.0	80.0	36.0
Feb	79.6	44.2	35.4	44.2	80.0	+ 55.4	68.4	36.0	32.4	36.0	80.0	32.4
Mar	64.5	74.2	- 9.7	64.5	70.03	0.0	38.2	67.5	- 29.3	67.5	3.1	0.0
Apr	24.1	87.2	- 63.4	24.1	6.9	0.0	16.8	99.0	- 88.2	67.5	0.0	- 31.5
May	9.0	148.4	-139.4	9.0	0.0	-132.5	4.8	148.0	0.0	0.0	0.0	-143.2
Jun	2.2	165.8	0.0	2.2		-163.6	1.1	157.0	0.0	0.0	0.0	-155.9
Jul	0.0	173.9	0.0	0.0	0.0	-173.9	0.0	186.0	0.0	0.0	0.0	-186.0
Aug	2.3	166.4	0.0	2.3	0.0	-144.1	0.0	181.0	0.0	0.0	0.0	-181.0
Sep	10.8	117.1	0.0	10.3	0.0	-106.3	7.5	137.0	0.0	7.5	0.0	-129.5
Oct	59.9	60.8	0.0	59.9	0.0	-11.9	35.4	104.1	0.0	35.4	0.0	- 68.7
Nov	67.5	51.6	15.9	15.6	15.9	0.0	40.4	63.8	0.0	40.4	0.0	- 23.4
Dec	112.5	35.8	76.7	35.8	80.0	+ 12.6	94.2	45.3	48.9	45.3	48.9	0.0
Ave.	562.0	1154.0				+147.0 -731.4	399.0	1269.0				+ 68.4 -919.2

	Beninah						Bernah					
Month	P. total mm	PET total mm	Effect P mm	Actual Evap. mm	Storage	Runoff or Deficit	P. total mm	PET total mm	Effect P mm	Actual Evap. mm	Storage	Runoff or Deficit
Jan	54.7	94.9	0.0	54.7	0.0	- 40.2	69.8	74.4	0.0	69.8	0.0	- 4.6
Feb	35.8	87.9	0.0	35.8	0.0	- 52.1	33.0	81.2	0.0	33.0	0.0	- 48.2
Mar	24.1	105.4	0.0	24.1	0.0	- 81.3	24.0	127.1	0.0	24.0	0.0	-103.0
Apr	9.2	195.3	0.0	9.2	0.0	-186.1	5.4	225.0	0.0	5.4	0.0	-220.0
May	6.5	193.8	0.0	6.5	0.0	-187.3	7.0	235.6	0.0	7.0	0.0	-238.0
Jun	0.0	194.4	0.0	0.0	0.0	-194.4	0.5	258.0	0.0	0.5	0.0	-257.0
Jul	0.0	201.0	0.0	0.0	0.0	-201.0	0.0	238.0	0.0	0.0	0.0	-238.0
Aug	0.0	191.0	0.0	0.0	0.0	-191.0	0.0	192.0	0.0	0.0	0.0	-192.0
Sep	7.4	187.5	0.0	7.4	0.0	-180.1	3.8	186.0	0.0	3.8	0.0	-182.0
Oct	41.2	115.0	0.0	41.2	0.0	-113.8	22.0	156.0	0.0	22.0	0.0	-134.0
Nov	30.6	110.0	0.0	30.6	0.0	-79.4	31.5	97.6	0.0	31.5	0.0	-66.1
Dec	48.2	95.1	0.0	48.2	0.0	-46.9	66.0	70.0	0.0	66.0	0.0	-16.0
Ave.						-1553.6						-1696.0

APPENDIX 4: POTENTIAL EVAPOTRANSPIRATION VALUES AT SHAHAT (in mm.)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
Hassan	72.0	96.0	135.0	183.0	250.0	282.0	295.0	257.0	169.0	123.0	97.0	80.0	SWDR
Piche	81.0	101.0	130.0	195.0	254.0	243.0	167.0	170.0	144.0	105.0	105.0	99.0	GEFLI
Penman	28.4	44.2	74.2	87.2	148.4	165.8	173.9	166.4	117.1	60.8	51.6	35.8	
Turc	39.2	48.6	73.2	104.3	135.0	165.0	166.1	153.4	120.4	88.6	60.4	41.7	GEFLI
Blaney-Griddle	33.0	36.0	64.0	83.0	122.0	134.0	139.0	130.0	102.0	72.0	47.0	32.0	
Olivier	67.0	71.0	71.0	90.0	126.0	134.0	114.0	105.0	95.0	73.0	98.0	83.0	
Thornthwaite after El Aghel	21.0	23.0	34.0	52.0	86.0	117.0	131.0	128.0	93.0	71.0	45.0	29.0	
Thornthwaite	2.3	3.3	6.8	17.3	41.3	69.6	84.7	82.8	59.7	35.3	15.8	5.8	

APPENDIX 5: WATER LEVEL MEASUREMENT AT EL MARJ PLAIN, NORTH HIGHWAY ROAD:

Well No.	Total Depth m.	Initial W.L.	Date	Reading W.L.	Date	Variation	Average decline per year in m.	Aquifer	Remarks
84902- C2	63.3	50.48	07.06.76	50.88	21.03.83	- 0.14	0.02	Quartan	
C6	260.0	80.85	01.02.77	93.21	21.03.83	-12.88	1.84	Eocen	
C9	260.0	82.25	01.02.77	92.94	21.03.83	-10.69	1.52	Eocen	
C26	243.0	82.18	03.02.77	85.25	01.04.80	- 3.07	0.77	Eocen	
C58	260.0	82.53	10.06.76	85.22	08.04.79	- 3.39	0.85	Eocen	
C59	250.0	83.10	01.06.76	85.98	09.01.79	- 2.88	0.72	Eocen	
C68	77.0	41.70	04.11.75	41.26	10.01.72	- 0.46	0.08	Quartan	
B14	36.2	27.86	28.07.76	28.37	02.04.80	- 0.51	0.10	Quartan	
B15	200.0	87.95	05.76	78.32	21.02.77	+ 9.63		Eocen	
B38	175.0	80.72	04.11.79	77.38	15.12.79	- 3.34	3.34	Eocen	
B48	157.0	97.05	01.02.77	98.81	22.03.83	- 1.76	0.25	Eocen	
B73		77.35	01.02.77	87.39	01.11.83	-10.04	1.43	Eocen	Irregular
B74	293.0	148.30	25.08.76	149.21	24.03.80	- 0.91	0.18	Eocen	Obstruct
B106	210.0	121.35	27.06.77	125.95	22.03.83	- 4.60	0.65	Eocen	Irregular
F4	-	89.19	28.07.76	89.18	08.04.79	- 0.01	0.0025	Eocen	Equipped
A7	-	144.38	08.76	150.77	21.03.83	- 6.39	0.79	Eocen	Equipped
C5	-	78.85	01.02.77	81.80	26.02.77	- 2.95	-	-	

Source: S.W.D.R. (1984) Plesometry in El Marj Plain, Benghazi (Unpublished)

- Data not available

APPENDIX 6: WATER ANALYSIS FROM WELLS IN JEBEL EL AKHDAR

Area	P.H.	E.C. m.mhos/ cm	T.D.s ppm	Meg / Litre								S.A.R.	R.S.C.
				Ca	Mg	Na	K	CO_3	HCOs	Cl	SO_4		
Batte	7.40	1.18	755	1.75	2.43	8.40	0.20	Nil	3.84	5.70	3.24	5.73	Nil
El Habban	7.22	1.87	1196	3.75	2.40	14.60	0.12	traces	5.40	12.70	2.77	8.32	Nil
El Qubbah	8.10	0.55	3.52	1.47	1.72	0.78	0.04	Nil	3.09	1.05		0.61	Nil
El Mehhella	7.30	3.90	2496	16.51	11.33	28.70	0.56	Nil	4.80	38.20	14.10	7.40	Nil
Benghazi	7.20	5.95	3616	6.60	2.70	45.20	0.40	Nil	4.36	47.84	1.40	19.15	Nil
Talmeitha	7.10	3.90	2496	12.00	9.12	20.60	0.20	Nil	5.80	36.00	0.08	6.20	Nil
Farzugh	7.85	1.95	1248	1.50	1.00	20.00	0.20	Nil	7.38	13.20	2.12	17.89	Nil
El Marj	-	1.00	640	-	-	-	-	-	-	-	-	-	

Source: Mohamul Shanf, 1974, A short account on Jebel El Akhdar Development project, El Marj.

- Data not available

APPENDIX 7:

Table A: Degree of Farm Fragmentation in El Marj Baladiyah:

Farm Size in ha.	Total No. of farms	Number of Plots Per Farm					
		One	Two	Three	Four	Five	Six
< 1	27	25	2	-	-	-	-
1	20	20	-	-	-	-	-
2	48	45	2	1	-	-	-
3	50	43	5	2	-	-	-
4	96	72	22	2	-	-	-
5	416	354	101	28	2	1	-
10	516	325	114	51	13	4	9
15	307	173	75	46	9	3	1
20	675	364	171	84	35	13	8
30	491	239	122	72	31	19	8
40	291	127	78	48	24	10	4
50	259	129	62	35	10	9	8
60	161	72	49	19	13	5	3
70	65	29	10	11	9	3	3
80	55	30	8	6	6	2	3
90	27	8	10	4	2	3	-
100	60	19	13	9	10	4	5
150	15	4	4	5	1	1	-
200	16	7	5	1	2	-	-
300	1	-	1	-	-	-	-
400	3	2	-	-	1	-	-
500	2	-	1	-	-	-	1
>5001	-	1	-	-	-	-	-
Total	3672	2087	856	424	174	77	54
% of total	100	58.2	23.3	11.0	4.7	2.0	1.6

Source: Ministry of Planning (1979), Agricultural Census, 1974, Jebel El Akhdar, Table 12, Tripoli (in Arabic)

Table B: Degree of Farm Fragmentation in El Gubbah Baladiyah:

Farm Size in ha.	Total No. of farms	Number of Plots Per Farm					
		One	Two	Three	Four	Five	Six
< 1	89	85	4	-	-	-	-
1	62	58	2	2	-	-	-
2	88	81	6	1	-	-	-
3	109	93	15	1	-	-	-
4	191	148	36	6	-	1	-
5	484	321	103	30	16	2	2
10	282	173	79	17	11	1	1
15	149	91	39	12	3	2	2
20	163	102	39	13	3	4	2
30	54	38	8	4	3	1	-
40	8	5	1	-	1	-	1
50	1	-	1	-	-	-	-
60	1	-	-	-	1	-	-
70	1	1	-	-	-	-	-
80	1	-	-	-	1	-	-
90	-	-	-	-	-	-	-
100	1	-	1	-	-	-	-
150	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-
400	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-
>500	-	-	-	-	-	-	-
Total	1684	1206	334	86	39	11	8
% of total	100	71.6	11.8	5.0	2.3	0.6	0.4

Source: Ministry of Planning (1979), Agricultural Census, 1974, Dernah, Table 12, Tripoli (in Arabic)

Table C: Degree of Farm Fragmentation in Dernah Baladiyah:

Farm Size in ha.	Total No. of farms	Number of Plots Per Farm					
		One	Two	Three	Four	Five	Six
< 1	173	124	32	13	4	-	1
1	27	22	3	1	-	1	-
2	35	27	7	-	1	-	-
3	39	28	11	-	-	-	-
4	66	52	11	3	-	-	-
5	254	174	72	6	2	-	-
10	152	80	54	12	2	1	3
15	79	40	37	15	2	1	-
20	109	57	14	11	3	1	-
30	61	30	6	9	3	1	4
40	29	13	4	4	3	1	2
50	13	4	2	3	1	1	-
60	12	8	3	1	-	-	1
70	10	3	1	3	1	-	-
80	4	1	-	1	1	-	-
90	4	4	3	-	-	-	-
100	7	2	-	1	-	1	-
150	1	-	-	-	-	-	-
200	2	2	-	-	-	-	-
300	-	-	-	-	-	-	-
400	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-
>500	-	-	-	-	-	-	-
Total	1078	671	281	83	23	8	11
% of total	100	62.2	26.1	7.7	2.3	0.7	1

Source: Ministry of Planning (1979), Agricultural Census, 1974, Dernah, Table 12, Tripoli (in Arabic)

APPENDIX 8:

GROSS DOMESTIC PRODUCT AND NATIONAL INCOME OF LIBYA, BY SECTOR, 1970-1983
at current prices (in million LD.)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983 *
Agriculture, forestry	33.1	33.0	43.6	60.0	64.7	82.9	99.7	90.0	122.1	140.4	164.9	174.0	193.0	214.5
Petroleum mining	812.6	922.7	920.6	1131.8	2385.3	1961.1	2750.0	3275.9	2808.7	4545.3	6571.9	4756.5	4194.0	3649.0
Other mining and quarrying	1.7	7.6	9.3	12.0	15.5	20.7	24.2	28.5	33.3	41.5	48.8	55.0	56.5	52.1
Manufacturing	22.5	24.5	32.0	43.8	55.0	65.5	90.6	124.7	148.7	185.8	213.9	243.9	348.9	355.6
Electricity and gas	6.2	7.3	9.4	10.8	12.4	17.6	22.4	26.1	31.0	40.0	49.7	58.5	67.9	77.3
Transportation and telecomm	43.2	87.2	100.5	129.3	155.0	175.8	193.3	220.1	250.9	291.2	335.3	420.0	440.7	459.0
Wholesale and retail trade	47.0	75.6	95.8	124.8	184.2	224.6	263.1	292.0	338.9	383.2	481.7	535.0	533.4	526.0
Banking and insurance	13.0	29.4	37.2	51.6	72.8	98.9	121.4	144.1	177.5	194.6	230.9	260.0	285.9	310.5
Public administration	98.1	135.0	147.8	158.0	209.5	258.3	295.5	362.2	410.8	512.5	611.1	707.0	791.1	868.6
Education services	39.7	46.6	60.7	71.8	95.4	122.3	150.8	172.8	188.2	206.6	220.8	245.0	262.2	278.6
Health services	15.8	22.0	26.9	31.7	38.5	51.6	65.1	79.6	94.8	104.2	114.7	127.3	140.2	151.0
Ownership of dwellings	59.6	69.0	76.1	84.0	111.3	121.0	144.9	157.3	170.7	188.8	210.4	223.8	235.2	246.1
Other services	8.5	9.4	10.2	11.2	19.5	29.3	32.8	37.4	37.7	42.2	47.4	50.3	56.8	64.5
Total of GDP	1288.3	1586.5	1703.0	2182.7	3795.7	3674.3	4768.1	5612.7	5496.1	7603.0	102372.2	9003.3	851.0	8185.5
Non oil sectors	375.7	663.8	832.4	1050.9	1410.4	1713.2	2018.1	2336.8	2678.4	3057.7	3665.3	4246.8	4458.0	4509.5

Source : Secretariate of Planning (1984) Economic and Social Indicators in Libya & Tripoli (in Arabic)

* provisional

(LD.) = Libyan Dinar =

DAMAGED TEXT IN ORIGINAL

APPENDIX 9: ECONOMIC ACTIVITY AS PERCENTAGE OF G.D.P.
1958, 1962 - 83

	1958	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980*	1981*	1982*	1983*
Agriculture, forestry and fishing	26.1	9.8	6.9	4.5	4.9	3.7	3.7	2.6	2.4	2.6	2.1	2.4	2.7	1.6	2.3	2.1	1.6	1.7	1.9	1.6	1.9	2.2	2.6
Petroleum mining	6.9	26.4	41.6	53.7	55.1	56.9	55.4	61.9	75.7	63.1	58.8	54.1	51.8	62.9	53.4	57.7	58.3	51.10	59.8	64.1	52.8	48.5	44.7
Other mining and quarrying		0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.1	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.6
Manufacturing	11.5	5.6	4.2	3.2	2.6	2.5	2.6	2.3	2.0	2.1	2.4	2.1	2.3	1.8	1.8	2.0	2.5	2.8	2.5	2.1	2.7	4.0	4.4
Construction	3.4	7.2	5.4	6.0	7.1	6.5	7.7	6.5	4.8	4.2	4.7	10.2	12.0	9.9	11.8	11.8	10.7	12.4	9.6	9.1	12.7	12.1	11.1
Electricity and gas	1.5	0.5	0.4	0.4	0.3	0.3	0.4	0.3	0.4	0.5	0.7	0.5	0.5	0.3	0.5	0.5	0.5	0.6	0.7	0.5	0.7	0.8	0.9
Transportation & telecommunications	5.6	5.5	4.9	4.1	3.8	4.0	4.4	4.0	3.7	3.7	5.8	5.6	5.7	4.7	4.8	4.2	4.1	4.5	3.8	3.3	4.7	5.1	5.6
Wholesale and retail trade	14.0	8.7	7.0	5.5	5.1	5.4	5.0	4.6	4.1	3.8	4.8	5.5	5.7	5.9	6.1	5.5	5.2	6.2	5.0	4.7	5.9	6.2	6.5
Banking and insurance		1.1	0.9	0.7	0.7	0.7	0.8	0.6	0.6	1.6	1.8	2.1	2.4	1.9	2.7	2.5	2.6	3.2	3.6	2.3	2.9	3.3	3.8
Public administration & defense	12.8	9.7	8.2	7.1	7.5	7.8	8.5	7.5	6.9	7.6	8.5	8.5	7.2	5.5	7.0	6.5	6.4	6.5	6.7	6.0	7.9	9.1	10.7
Education services		3.2	3.0	2.6	2.6	2.5	2.7	2.5	2.8	3.1	2.9	3.5	3.3	2.5	3.3	3.1	3.1	3.4	2.7	2.1	2.7	3.0	3.4
Health services		1.3	1.1	0.9	0.9	1.0	1.1	1.1	1.1	1.2	1.4	1.5	1.5	1.0	1.4	1.4	1.4	1.4	1.3	1.1	1.4	1.6	1.9
Ownership of dwellings		17.3	12.5	9.2	7.5	6.7	6.1	4.8	4.5	4.6	4.7	4.4	3.9	2.9	3.6	3.0	2.8	3.1	2.5	2.1	2.5	2.7	3.0
Other services	18.2	3.3	2.6	1.9	1.7	1.6	1.4	1.2	0.7	0.6	0.6	0.6	0.5	0.5	0.8	0.7	0.7	0.7	0.6	0.4	0.6	0.7	0.8
Total % of GDP	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total GDP - million LD at factor cost	52.2	177.2	250.3	364.2	468.0	557.2	619.1	835.3	947.2	1288.3	1586.5	1753.0	2182.7	3745.7	3674.3	4506.0	4905.8	5038.0	5447.7	10237.2	9003.3	8651.0	8158.5

Source: Ministry of Planning (1981), National Account 1962-71, 1975-80, Tripoli, Tables 21 and 28

* Provisional

APPENDIX 9: ECONOMIC ACTIVITY AS PERCENTAGE OF G.D.P.
1958, 1962 - 83

	1958	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980*	1981*	1982*	1983*
Agriculture, forestry and fishing	26.1	9.8	6.9	4.5	4.9	3.7	3.7	2.6	2.4	2.6	2.1	2.4	2.7	1.6	2.3	2.1	1.6	1.7	1.9	1.6	1.9	2.2	2.6
Petroleum mining	6.9	26.4	41.6	53.7	55.1	56.9	55.4	61.9	75.7	63.1	58.8	54.1	51.8	62.9	53.4	57.7	58.3	51.10	59.8	64.1	52.8	48.5	44.7
Other mining and quarrying		0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.1	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.6
Manufacturing	11.5	5.6	4.2	3.2	2.6	2.5	2.6	2.3	2.0	2.1	2.4	2.1	2.3	1.8	1.8	2.0	2.5	2.8	2.5	2.1	2.7	4.0	4.4
Construction	3.4	7.2	5.4	6.0	7.1	6.5	7.7	6.5	4.8	4.2	4.7	10.2	12.0	9.9	11.8	11.8	10.7	12.4	9.6	9.1	12.7	12.1	11.1
Electricity and gas	1.5	0.5	0.4	0.4	0.3	0.3	0.4	0.3	0.4	0.5	0.7	0.5	0.5	0.3	0.5	0.5	0.5	0.6	0.7	0.5	0.7	0.8	0.9
Transportation & telecommunications	5.6	5.5	4.9	4.1	3.8	4.0	4.4	4.0	3.7	3.7	5.8	5.6	5.7	4.7	4.8	4.2	4.1	4.5	3.8	3.3	4.7	5.1	5.6
Wholesale and retail trade	14.0	8.7	7.0	5.5	5.1	5.4	5.0	4.6	4.1	3.8	4.8	5.5	5.7	5.9	6.1	5.5	5.2	6.2	5.0	4.7	5.9	6.2	6.5
Banking and insurance		1.1	0.9	0.7	0.7	0.7	0.8	0.6	0.6	1.6	1.8	2.1	2.4	1.9	2.7	2.5	2.6	3.2	3.6	2.3	2.9	3.3	3.8
Public administration & defense	12.8	9.7	8.2	7.1	7.5	7.8	8.5	7.5	6.9	7.6	8.5	8.5	7.2	5.5	7.0	6.5	6.4	6.5	6.7	6.0	7.9	9.1	10.7
Education services		3.2	3.0	2.6	2.6	2.5	2.7	2.5	2.8	3.1	2.9	3.5	3.3	2.5	3.3	3.1	3.1	3.4	2.7	2.1	2.7	3.0	3.4
Health services		1.3	1.1	0.9	0.9	1.0	1.1	1.1	1.1	1.2	1.4	1.5	1.5	1.0	1.4	1.4	1.4	1.4	1.3	1.1	1.4	1.6	1.9
Ownership of dwellings		17.3	12.5	9.2	7.5	6.7	6.1	4.8	4.5	4.6	4.7	4.4	3.9	2.9	3.6	3.0	2.8	3.1	2.5	2.1	2.5	2.7	3.0
Other services	18.2	3.3	2.6	1.9	1.7	1.6	1.4	1.2	0.7	0.6	0.6	0.6	0.5	0.5	0.8	0.7	0.7	0.7	0.6	0.4	0.6	0.7	0.8
Total % of GDP	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total GDP - million LD at factor cost	52.2	177.2	250.3	364.2	468.0	557.2	619.1	835.3	947.2	1288.3	1586.5	1753.0	2182.7	3745.7	3674.3	4506.0	4905.8	5038.0	5447.7	10237.2	9003.3	8651.0	8158.5

Source: Ministry of Planning (1981), National Account 1962-71, 1975-80, Tripoli, Tables 21 and 28

* Provisional

APPENDIX 10: ACTUAL DEVELOPMENT EXPENDITURES BETWEEN 1970 - 1983:
(in million L.D.)

Development Sector	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983 *	Total	Percentage of Total
Agriculture/agrarian reform	23.4	47.8	63.8	35.9	91.8	109.6	102.2	100.3	107.8	120.6)						
Land reclamation	0.0	0.0	0.0	53.0	132.1	132.6	182.8	158.6	162.0	238.7)	489.9	487.5	308.6	207.6	3396.9	18.4
Dams & water resources	0.0	0.0	0.0	0.0	0.0	0.0	3.1	4.8	12.0	20.4)						
Nutrition & maritime wealth	0.2	0.2	0.5	1.1	1.0	3.7	8.6	13.9	7.3	6.2	0.0	0.0	0.0	0.0	42.7	0.2
Light industry	15.0	29.0	65.1	62.5	107.0	100.0	165.5	160.7	157.1	210.2	173.2	128.5	113.2	70.8	1557.8	8.4
Heavy industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	410.0	402.4	296.5	350.2	1459.1	7.9
Oil & gas exploration	1.5	15.3	27.8	28.5	56.8	52.9	67.3	67.6	80.0	93.4	55.3	57.6	25.2	19.3	648.5	3.5
Electricity	14.9	27.1	38.3	42.3	86.5	83.4	129.2	146.8	159.9	288.8	328.5	195.4	198.2	220.9	1960.2	10.6
Education	6.6	16.1	31.6	36.8	56.5	81.5	80.9	79.9	72.0	112.0	137.1	191.7	182.5	135.0	1220.2	6.6
Information & culture	1.5	1.0	2.0	4.2	5.4	4.5	13.0	16.0	24.2	28.5	31.6	22.5	23.8	19.1	197.3	1.1
Manpower	1.0	1.8	3.5	3.4	7.5	4.8	5.7	7.5	9.8	9.6	10.8	15.9	11.8	8.5	101.6	0.5
Public Health	4.9	3.7	15.4	9.8	15.9	20.9	28.3	36.3	53.5	69.8	69.1	115.6	84.0	68.0	595.2	3.2
Social affairs / security	0.0	0.0	0.0	3.7	8.8	3.8	2.5	1.9	3.9	0.9	6.7	16.1	11.6	6.5	66.4	0.4
Youth & sports	0.0	0.0	0.0	0.0	0.0	0.0	1.6	8.5	6.0	18.7	16.7	16.0	24.8	18.2	110.5	0.6
Housing	37.5	39.4	72.2	60.9	146.9	128.3	138.3	175.1	152.7	167.8	224.0	296.3	230.1	197.4	2066.9	11.2
Security services	0.0	0.0	0.0	0.0	0.0	0.0	5.6	6.3	6.6	5.6	6.4	0.0	0.0	0.0	30.5	0.2
Municipalities	26.5	31.4	34.0	34.3	55.7	87.2	109.9	126.3	149.7	231.6	113.4	343.4	258.9	254.0	1856.3	10.0
Transport & communication	11.3	23.7	37.4	25.8	63.1	49.7	78.5	118.2	130.8	201.6)						
Maritime transport	1.0	1.5	2.9	8.0	26.7	52.9	56.9	47.1	67.4	35.0)	390.1	405.0	511.4	377.8	2723.8	14.7
Economics	0.4	8.9	2.2	2.3	2.6	2.6	1.1	2.5	5.8	6.4	85.0	170.6	80.4	51.1	422.7	2.3
Planning	0.3	0.7	0.7	1.3	1.7	4.8	5.4	2.0	2.8	3.0	3.8	8.3	4.9	5.1	44.8	0.2
Total	146.0	247.6	397.4	413.8	866.0	923.2	1187.2	1280.3	1371.3	1868.8	2551.6	2872.8	2365.9	2009.5	18501.4	100.0

Source: Secretariate of Planning (1984): Economic and Social Indicators in Libya, Tripoli (in Arabic)

APPENDIX 11:

Evaluation of per capita income during 1970-1983

Year	GDP LD million	Population	Per capita income LD	Per capita income in £
1970	1228.3	2,006,000	642	1,798
1971	1586.5	1,100,000	755	2,129
1972	1753.0	2,203,000	796	2,420
1973	2182.7	2,348,800	929	3,112
1074	3795.7	2,513,100	1,510	5,100
1975	3674.3	2,683,100	1,369	4,624
1976	4768.1	2,839.600	1,679	5,671
1977	5612.7	2,939,200	1,910	6,452
1978	5496.1	3,014,100	1,824	6,102
1979	7603.0	3,127,100	2,431	8,157
1980	10237.2	3,245,800	3,154	10,687
1981	9003.3	3,495,200	2,576	8,728
1982	8651.0	3,728,300	2,320	7,861
1983	8158.0	3,910,700	2,086	7,068
Annual growth between 1970/81 %	21.5	4.9	15.7	15.7
Annual growth between 1970/83 %	15.2	5.3	9.5	9.5

Source : Secretariat of Planning (1984) Economic and Social Indicators in Libya, Tripoli (in Arabic)

APPENDIX 12:

Table - Libya's Imports of Agricultural Commodities 1963-1983

Year	Total imports in (LD Millions)	Food imports in (LD millions)
1963	85.3	10.2
1964	104.5	13.4
1965	114.4	16.2
1966	144.7	19.7
1967	170.0	26.3
1968	231.3	27.6
1969	241.4	30.7
1970	198.0	39.3
1971	250.4	47.6
1972	343.2	53.0
1973	539.9	85.1
1974	817.8	129.8
1975	1048.7	87.8
1976	950.8	66.6
1977	1117.1	190.2
1978	1362.6	205.3
1979	1572.4	238.1
1980	2006.2	338.6
1981	2481.4	404.6
1982	2124.3	301.4
1983	2040.0	286.0*

* Provisional

Source: Ghanam, S. (1985) "Changing Planning Policies in Libya" in Planning and Development in Modern Libya, (eds) Buru, M.M. et al, MENAS, London. Table 15.2: 222
Secretariate of Planning (1984), Economic and Social Indicators in Libya, Tripoli, Table 8.2 : 35

APPENDIX 13: AGRICULTURAL BANK: Loans Approved and Loans Paid Out:

During Year	SHORT-TERM LOANS				MEDIUM-TERM LOANS				LONG-TERM LOANS				TOTAL			
	Loans approved		Loans paid out		Loans approved		Loans paid out		Loans approved		Loans paid out		Loans approved		Loans paid out	
	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount
1967	9,224	1,117	9,845	1,109	2,457	809	2,119	954	839	783	N.A.	1,031	12,520	2,709	11,964	3,094
1968	10,350	1,357	9,605	1,304	2,054	767	1,923	600	1,883	1,790	N.A.	1,412	14,287	3,914	11,528	3,406
1969	8,625	1,409	7,521	1,068	2,079	794	1,590	581	1,237	1,50	N.A.	1,420	11,941	3,709	9,111	3,069
1970	13,800	2,318	13,635	2,210	3,282	1,366	3,156	1,258	2,458	2,705	N.A.	1,660	19,540	6,389	16,791	5,128
1971	15,867	2,933	16,788	2,847	5,510	3,421	5,144	3,107	5,621	3,945	N.A.	2,877	26,998	10,299	21,932	8,831
1972	26,322	5,037	24,710	4,510	6,339	3,772	6,361	3,793	2,831	3,479	N.A.	4,633	35,492	1,288	31,071	12,936
1973	18,346	3,698	18,116	3,661	6,183	4,306	6,093	3,935	2,049	2,470	N.A.	2,176	26,578	10,474	24,209	9,772
1974	19,479	4,667	19,815	4,570	5,722	5,048	5,768	4,704	1,559	2,443	N.A.	1,925	26,901	12,793	25,997	11,399
1975	16,885	4,371	14,021	3,811	4,230	3,806	3,790	3,485	563	1,017	N.A.	1,637	21,678	9,194	17,811	8,933
1976	12,447	3,490	14,975	3,812	2,082	1,954	2,043	1,927	737	1,281	N.A.	1,076	15,266	6,725	17,018	6,815
1977	14,681	10,026	12,395	5,570	1,32	1,905	1,375	1,852	1,156	3,293	N.A.	2,792	17,160	15,224	13,770	10,214
1978	8,005	5,140	7,570	6,342	4,766	10,374	3,450	6,727	782	2,060	N.A.	2,210	13,533	17,574	11,020	15,279
1979	6,348	8,335	6,294	8,037	1,482	1,965	2,071	4,049	220	1,237	N.A.	2,009	8,050	11,537	8,365	13,095
1980	4,047	2,531	4,222	2,706	1,360	1,647	1,292	1,628	213	1,246	N.A.	578	5,620	5,424	5,514	4,912
1981	6,392	19,623	4,989	9,745	3,230	3,380	2,912	2,925	209	2,552	N.A.	1,180	9,841	255,555	7,901	13,830
1982	389	8,430	372	6,602	2,696	6,130	2,137	4,515	609	2,541	N.A.	1,539	3,694	17,102	2,509	12,656
1983 (Mar)	285	714	261	626	636	1,585	588	1,523	33	143	N.A.	814	954	2,442	849	2,963
1983 (June)	72	1,155	78	1,170	483	1,750	624	2,090	38	183	N.A.	496	593	3,088	702	3,776

Source: Central Bank of Libya (June-March 1984) Economic Bulletin, Vol., XXIV, N1.3, Table 26:

APPENDIX 14: VARIABLE SELECTION

The selection of the 40 variables for analysis in Table 12.1 from the 147 collected in the survey was focussed on economic, physical and management characteristics of farms. They are named and coded with serial numbers e.g. V1, V2, etc. Final selection was decided by an examination of the 40 x 40 correlation matrix discarding those variables with very high intercorrelation and those with very weak correlations. These variables are:

(1) Variable 1 (V1) is a farmer's age in years, to measure the farmer's capabilities for his farm operation.

(2) The farm family size is indicated by variable 6, in order to define pattern of farm family.

(3) The education level of farmer was classified according to whether, he was illiterate, had completed primary school or had had a secondary education or agricultural college and higher education (University). This is coded by variable 8.

(4) Variable 9 measured the farmer's occupation to explain the variation between full time and part time farmer at different type of farms.

(5) Gross yearly income in Libyan Dinar was indicated by variable 11.

(6) Variable 13 farm area (in hectare). The total area of all parcels which could be identified as a management unit was recorded. The plot or plots might be owned, let or managed by the respondent.

(7) Variables 15 and 16 described the farmer's previous agricultural experience in rain fed agricultural and animal breeding, and irrigated agricultural or lack of experience as a new farmer,

respectively. Variable 18 explained the farmer's agricultural training in relation to this efficiency.

(8) Land tenure, patterns have been discussed by variables 26, 27, 28 and 30. These are related to the traditional land tenure system in the country, such as squatter's rights, inheritance and share cropper systems. Variable 26 measures settlement farms, which form a new pattern of land tenure in the region, because the farmer has not yet been officially granted ownership.

(9) Variables 145 and 146 explained farmer's attitude towards agriculture. Variable 145 was looking at the farmer's view of the extension services, in the same time variable 146 asked, whether the farmer wished his children to work on land. These variables explored the farmer's opinion on agriculture.

(10) Land use attributers have been shown by variables 34, 36, 38, 40 and 42. The variables were measured by absolute figures per farm. The total area cultivated in 1983/84, included both dry and irrigated plots. Therefore, variable 34 measures total area cultivated with vegetables. The area under vegetables was recorded in the field for the summer 1984, and the respondents recollection of the preceding winter's vegetables.

Vegetables include the following: Broad beans, Peas, Turnip, Raddish, Cabbage, Cauliflower, Artichoke, Tomato, Cucumber, Lettuce, Parsley, Onion, Melons, etc.

Variables 36 and 38 were also the total area planted in cereals and fodder crops. Variable 40 is the total fallow land per farm. This was used as a pasture or was part of the farm that has not been reclaimed yet. Total fruit tree area per farm is included with variable 42.

Therefore, the land use variables were required to describe the acreage, yield and fertilizer input (where relevant) of the most important enterprise on the farms studied.

(11) Variable 74 was the irrigated land per farm in absolute numbers with respect to the water resources and irrigation methods. In addition variable 72 was identifying water problems both qualitative and quantitative.

(12) Livestock have been indicated by total number of animals per farm. Variable 170 included Cattle, Sheep and Goats. Poultry was measured separately by variable 49. This was a form of insurance on which cash can be realised a new farming system, follow the development of commercial poultry as small family farms. In addition variable 52 is asking about fodder problems.

(13) Family farm labourers were explained by variable 173, which included family worker full time, part time and seasonal. In addition variable 20 measured non-Libyan workers on the farm, if they existed.

(14) Variable 165 measured off farm income, where many farmers supplemented their income by working off the farm. This included certain answers to various questions, such as family income, private business and grant to the farm.

(15) Mechanisation was measured by the number of tractors per farm (variable 88). Further to the availability of private transport to the farmer, often a car made the marketing of crops and the purchase of farm input, and the integration of distant plots into the farm system much easier.

(16) Fertilizer use was applied mainly to irrigated vegetables and rain fed cereals. This was dealt with in variables 56 and 60. Variable 56 is the quantity of chemical fertilizer in kilogram per hectare for cereals and variable 60 is the quantity of chemical fertilizer in kilogram per hectare for vegetables.

(17) Government assistance to the farmer was expressed by variable 161. This variable includes subsidies for agricultural equipment, farm input loans, and other assistance.

(18) Variable 169 measured farm input investment. This variable contains the recent activity of the farmer in his land, which includes buying new agricultural machinery, tending new farm buildings, increasing farm labour, developing an irrigation system, introducing new crops and increasing animal husbandary.

(19) Agricultural marketing was indicated by variables 139, 140, 141 and 142. The first three variables deal with the sale of farm produce in the local market in the area, on the farm in other places respectively. But variable 142 is measuring market problems.

(20) Variable 31 is investigating one of the main characteristics of traditional agriculture, which is fragmentation.

(21) Overwhelmingly, variables of 52 declare the role of technical agricultural advisors on farming practices, the nature of the relationship between him and the farmer.

APPENDIX 15: QUESTIONNAIRE

1. PERSONAL FORMATION :Could you please write information clearly, sometimes put ( ), and others write numbers and its exponent

	District
	Farm Number
Type of Holding	Private State Owned
	Age of Farmer
Member of your Family	M. F. T.
Marital Status	Single Married Divorced Widowed
Level of Education	None Pre-secondary school Secondary & High school University
Status of Health	Good Poor
Work on the Farm	Full-time Farmer Part-time Farmer
	Nationality
	Place of Birth
	Income
Type of Farm	New Old Redevelopment
	Size of Farm

2. Where do you live?

Farm ..... ____
The nearest village ..... ____
Other, please specify ..... ____

3. How long have you been involved in the following?

Dry farming and animal breeding ... ____
Irrigated farming ..... ____
No previous experience ..... ____

4. Do you practice any agricultural training?

Yes ..... ____
No ..... ____

5. Do you encourage your children to become

Farmers ..... ____
Other ..... ____

6. How many people do you employ on your farm?

	Family	Foreign	Remarks
Full time	____	____	____
Part time	____	____	____
Seasonal	____	____	____
No-one	____	____	____

7. How did you obtain this farm?

		Squatter's Rights	Inheritance	Purchase	Share Cropping	Other
Total	Area ha					
C	Wheat					
R	Barley					
O	Fodder					
P	Vegetable					
T	Type					
R	Number					
E	Area ha					
E	Productive					
S	Non Productive					
	Fallow					

8. Is your farm

One Unit ..... ____
Two parcels or more ..... ____

9. If more than one parcel - where are they situated?

Within a major farming area ..... ____
Outside a major farming area ..... ____

10. What is the main production of your farm?

Type	Area ha.	Remarks
Vegetables	_____	_____
Cereals	_____	_____
Fodder	_____	_____
Pastures	_____	_____
Trees	_____	_____
Others	_____	_____

11. What are the animals that you have?

Type	Number	Remarks
Cattle	_____	_____
Sheep	_____	_____
Goats	_____	_____
Poultry	_____	_____
Other	_____	_____

12. Do you have any fodder problems?

Yes ..... _____
No ..... _____

13. How frequently have had the chance to have technical advisor visit you on your farm in the past year, or in this year?

Once ..... _____
More than once ..... _____
Never ..... _____

14. How many times have you had the chance to visit the project headquarters at your unit, in the past year or in this year?

Once ..... _____
More than once ..... _____
Never ..... _____

15. Do you consider your land is

Good for agriculture ..... _____
Fair for agriculture ..... _____
Poor for agriculture ..... _____
Without agricultural capability ... _____

16. Do you practice rotation of cultivation in any part of the farm?

Yes ..... _____
No ..... _____

17. What type of fertilizer do you use?

Chemical ..... _____
Organic ..... _____
Both ..... _____
None ..... _____

If you do not use chemical fertilizer go to question number 21.

19. How much chemical fertilizer do you use?

Type of Production	Kg./ha.	How many times per year	Remarks
Cereals			
Fodders			
Vegetables			
Trees			

20. How long have you used chemical fertilizer?
    - Less than 5 years ..... ____
    - Between 6 and 10 years ..... ____
    - More than 10 years ..... ____

21. Is your farm
    - Dry farm ..... ____
    - Irrigated farm ..... ____

    If your farm is a dry farm, go to question no.30

22. From where do you obtain irrigation water?
    - Well ..... ____
    - Cisterns ..... ____
    - Tank or container ..... ____
    - Other resources (specify) ..... ____

23. Do you own the well which you are using?
    - Yes ..... ____
    - No ..... ____

24. If so, what is the depth of the well?
    - Less than 25m (specify) ..... ____
    - 26 to 50m ..... ____
    - 51 to 100m ..... ____
    - 101 to 200m ..... ____
    - More than 200m ..... ____

25. What are the major problems with water?
    - Nothing ..... ____
    - Water quality ..... ____
    - Water quantity ..... ____
    - Both ..... ____

26. What source(s) of power do you use for water lifting?
    - Small fuel pump ..... ____
    - Electric water pump ..... ____
    - Other sources of power ..... ____

27. How many hectares do you irrigate on your farm?
    - Specify ..... ____

28. What methods of irrigation are used on your farm?
    - Ditching and furrows ..... ____
    - Sprinkler ..... ____
    - Drop irrigation ..... ____
    - Sub irrigation ..... ____
    - Other method (specify) ..... ____

29. How many times do you irrigate your farm products?

	Summer	Autumn	Winter	Spring	Remarks
	No.days	No.days	No.days	No.days	
Vegetables					
Trees					
Cereals					
Other					

30. Do you have any observations about how to use the water?

_____ .....

_____ .....

_____ .....

31. What type of mechanisation do you have?

Tractor ..... _____
Harvester ..... _____
Hay baler ..... _____
Plough ..... _____
Seeding machine ..... _____
Pumps ..... _____
Other (specify) ..... _____

32. Do you have -

Small car ..... _____
Lorry ..... _____
Pickup ..... _____
Nothing ..... _____

If nothing go to question no. 34.

33. Do you use it for -

Work ..... _____
Visiting ..... _____
Other ..... _____

34. What kind of assistance do you obtain?

Agricultural equipment & machinery. _____
Interest free loan ..... _____
Subsidized farm input ..... _____
Other assistance ..... _____
None ..... _____

35. Can you tell me the use of this property in

1961 - use ..... _____
don't know ..... _____
1971 - use ..... _____
don't know ..... _____
1981 - use ..... _____
don't know ..... _____

36. Please indicate if any of the following changes have been made on your land, and when did they occur?

Type of change	1961	1971	1981	No Change
Splitting up of land				
Consolidation of land				
New farm building				
Fencing of unfenced area				
Fencing removed				
Scrub clearance				
Tree planting				
Drainage (field product)				
Gravel extraction				
Other (please specify)				

37. Has the use of this land intensified, reduced or remained the same since 1969?

Intensified ..... ____
How ..... ____
Reduced ..... ____
How ..... ____
Remained the same ..... ____

38. What major changes in your land use have been made since 1970?

Farm size ___Intensified ___Reduced ___Remained the same
Farm production ___ " ___ " ___ ---- " ---
Farm type ___Irrigated ___Dry farm ___Fallow
Other (specify)

39. What is the most recent activity added to your farm?

New crops ..... ____
Infrastructure ..... ____
Labour requirement ..... ____
Mechanisation ..... ____
Sprinkler irrigation ..... ____
Drop irrigation ..... ____
Sub irrigation ..... ____
Greenhouses ..... ____
More stock ..... ____
Other (please specify) ..... ____

40. What has caused you to change the use of land or your activity in the past ten years?

.....
.....
.....

41. Has there been any major changes in farm cost prices which has caused you to alter your farm activity in the past ten years?

Yes ..... ____
No ..... ____

42. If yes; what changes in your activities were caused?

.....
.....

43. Are you aware of any government policies or other changes which have affected you or your land use in recent years?

Yes ..... ____

No ..... ____

44. If so, please specify

.....

.....

44. Could you please specify crop and yields on your farm this year

Land use	Production	Remarks
Vegetables		
Trees		
Cereals		
Fodder		
Pasture		
Other (specify)		

45. How much do you earn per year approximately?

Less than 500 L.D. ..... ____

Between 501 and 1000 L.D. ..... ____

From 1001 to 1500 L.D. ..... ____

From 1501 to 2000 L.D. ..... ____

From 2001 to 2500 L.D. ..... ____

From 2501 to 3000 L.D. ..... ____

More than 3000 L.D. ..... ____

46. Do you have any income outside your farm?

Yes ..... ____

No ..... ____

If so specify -

Type of business ..... ____

Income from sons and relatives .... ____

Private business ..... ____

Grants on the farm ..... ____

Other (specify) ..... ____

47. Do you sell your agricultural products?

Local market or agricultural market. ____

In Farm ..... ____

Other places (please specify) ..... ____

48. Do you have any problem in marketing your production?

Yes ..... ____

No ..... ____

49. If so, what are they?

.....

.....

50. What are the major difficulties facing agricultural development in this area?

.....

.....

51. What are your suggestions for solving this problem?

.....

.....

52. Within the next five years, do you anticipate making any major changes or improvements in the use of your land?

Yes ..... ____

No ..... ____

If yes; what changes or improvements?

.....

.....

53. Do you feel that the pattern of farming has been reserved or protected for future agriculture?

Yes ..... ____

No ..... ____

or

Remain as it is ..... ____

Change in the future ..... ____

Specify ..... ____

54. If you were the headquarters of the secretary of agriculture in this area, what would you do?

.....

.....

Thank you.