EVALUATION AND MANAGEMENT

OF RENEWABLE LAND RESOURCES IN NE IRAQ

by

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THESIS SUBMITTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

SCHOOL OF ORIENTAL AND AFRICAN STUDIES
UNIVERSITY OF LONDON
January 1986

ABSTRACT

In the north-east region of Iraq, special physical and institutional conditions have governed the use of the land resources. Both the physical environment and the socio-economic structures have imposed great constraints on the management of agriculture and the land resources. The uneven terrain of the majority of the region is responsible for the generally poor soil conditions and substandard farm operations. Political instability, low management skills and depressed rural income have further inhibited enterprise and hindered improvement and conservation of the environment.

In choosing a method for evaluating the land resources for rainfed agriculture and grazing, the FAO approach was selected. Fundamental to this approach is that a value (suitability class) given to a land unit is relevant only in relation to a clearly defined use. In view of the scarcity of data, difficulties associated with field verification and lack of detailed background surveys, broad (reconnaissance) inventories of the resources have been prepared, permitting the selection of possible future areas of development and of management priorities. In this method, the land resources have been appraised on an essentially qualitative basis, and economic analysis was carried out in general terms.

Affected by erratic and sometimes insufficient rainfall, the agricultural lands of the region are largely under an extensive and traditional mode of rainfed agriculture. Driven primarily by considerations of survival, inputs in agriculture are minimised, and pressures for self-sufficiency have jeopardised chances of obtaining a high level of marketable surplus. Equally constrained are the region's grazing activities. In the absence of controls on utilisation, firm tenure and modern technology, the vegetation and soil fertility have progressively deteriorated, while farmers continue to increase their stocks to meet demand for livestock products in excess of available pasture. The study concludes with a commentary on the management options for the region, with a view to achieving a better standard of utilisation of the renewable land resources for the two major agricultural sectors in the north-east region, rainfed agriculture and grazing.

ACKNOWLEDGEMENTS

I am indebted to a great number of friends, in both Iraq and the United Kingdom, who have directly and indirectly helped in making this research possible. To my supervisor, Dr. J. A. Allan, I owe a particular debt of gratitude for his guidance and invaluable advice. Dr. K. McLachlan, of the Department of Geography at the School, was very helpful, especially at the early stages of the research, by providing valuable comments and suggestions. On two occasions, I was fortunate to meet and discuss soils with David Dent of East Anglia University; his approach and experience have greatly influenced my understanding of soils. Professor Higgins of the FAO, Rome, has responded to my letters twice, providing me with whatever information that was at his disposal on the soils of Iraq, and I am most grateful for all his assistance.

My search for information on the study area has led me to numerous libraries, where I was fortunate to be able to establish good relations with staff and management. To the staff-members of the libraries of the School of Oriental and African Studies, British Library, London School of Economics, Trinity College (Dublin) and the Hunting Technical Services, at Borehamwood, I am especially grateful. The help and encouragement from the staff of the School, especially the Department of Geography and the External Services Division, have had an enormous effect on the progress of my research, through providing an exceptionally friendly working environment.

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1.1 INTRODUCTION TO THE APPROACH AND RESOURCES

1.1.1 OUTLINE OF THE RESEARCH

The main theme of this research is the evaluation of the reneawable land resources of the north-east region of Iraq for two main purposes: rainfed agriculture and grazing. The choice of these two activities comes from the important role both sectors play in the rural economy of the region. This research is in many ways the first attempt to evaluate the land resources in this part of Iraq using a multi-disciplinary approach to the appraisal of the land.

The research is proposing to use the FAO Framework for Land Evaluation under the situation in NE Iraq, in which constraints on information and freedom of field work and to see the role experience observations made under less than ideal conditions could play in drawing suitability classes on a reconnaissance level. By and large, the NE region is a war zone the stability of which conditions has been for decades disturbed by forces of ethnic strife (the Kurdish wars) and, since 1980, by relentless military operations on the Iran-Iraq border. In this region, the local rural economy is torn between pressures of self-sufficiency and poor trading terms on the one hand; and lack of opportunities on the land (created by strong physical and financial constraints) on the other. Here, economic parameters are marred by countless adverse factors: among others, inflexible marketing and pricing systems, currency double-standards (brought about by illicit trade across the borders of Turkey and Iran) as well as a local economy in general beset by war, forced resettlement and constant political tension.

The situation, therefore, has prevented in the past a systematic assessment of the land performance, and only where such an attempt is made possible by means of personal observations that any useful measure of evaluation work can be embarked on—a case argued at this early stage and will be critically examined in the light of its findings later in the conclusion (chapter 6).

Where both qualitative and quantitative land suitability have been accepted alond detailed or/and reconnaissance levels of intensity, the Framework for Land Evaluation offers a unique opportunity for a broad investigation of the performance of the region's land resources in order to point out potential areas of development and (land) management priorities, information on which are at present very scarce at a comprehensive scale.

The thesis will look into the FAO approach to land evaluation for answers to the logistical and economic difficulties which prevented such an undertaking in the past. The findings of the current research will be critically examined in the concluding chapter of the thesis to gauge the validity of the results and the significance of the FAO system under the conditions of NE Iraq.

The thesis will give equal attention to both the institutional as well as the physical constraints on the land use in the NE region. The examination of the socio-economic factors has been intentionally placed as the opening chapter, as such factors constitute the background to the understanding of the standards of management and the degree to which human activities can influence the mode and level of the land utilisation. Chapter one, however, was not perceived as an economic analysis, which chronologically must not precede the actual process of evaluation; it is meant to serve as a background, and the relevant issues will be referred to in greater detail.

Chapters 2 and 3 will discuss the physical the physical attributes of the region's land resources. In chapters 4 and 5, the subject of the assessment of the land performance will be treated in line with the FAO approach to land evaluation. Chapter 4, which is designed to evaluate the region's land resources for rainfed agriculture, will

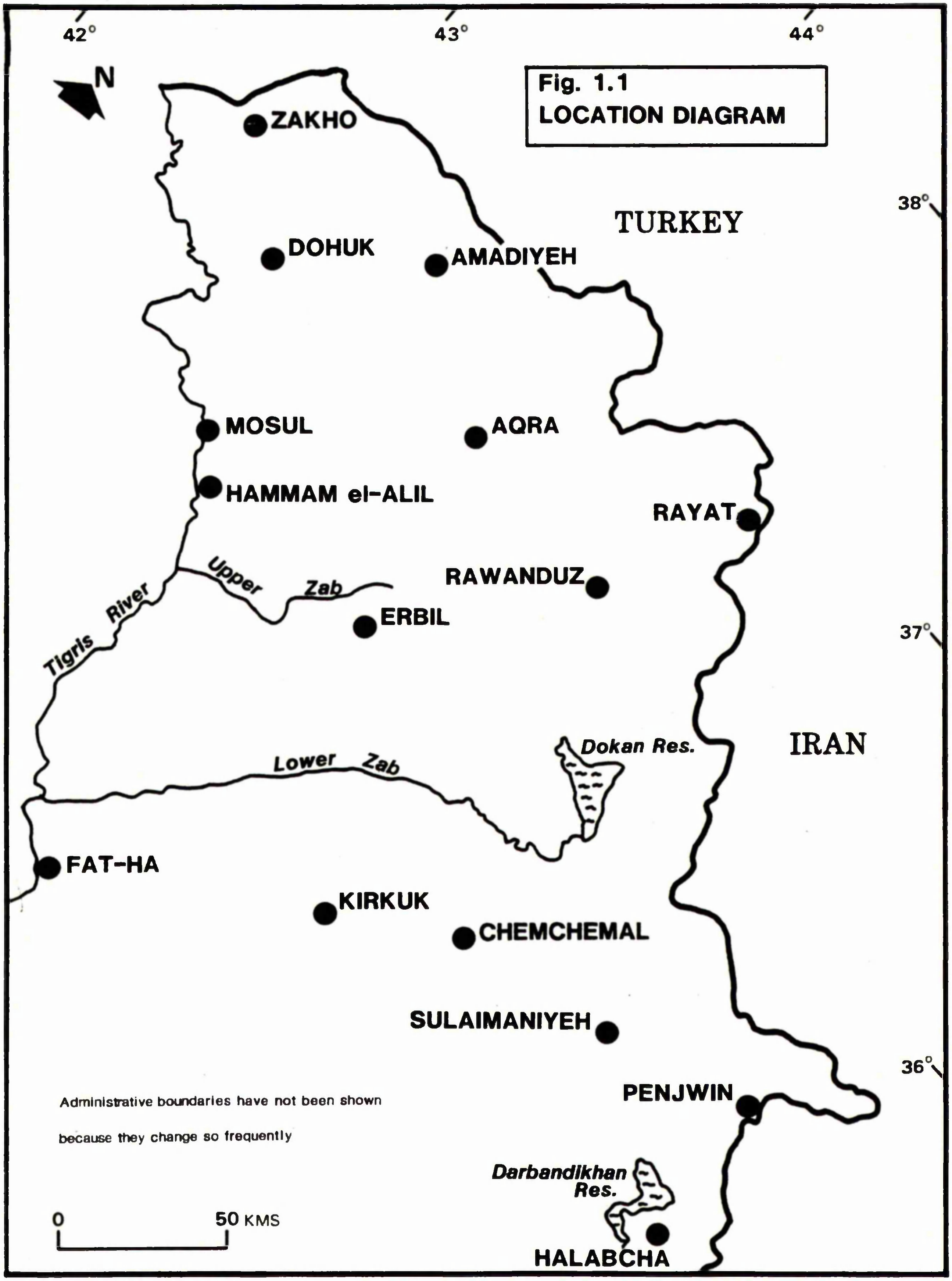


Fig. 1.1
LOCATION DIAGRAM

also serve to outline in detail the methods used by this research to conduct the evaluation.

1.1.2 OUTLINE OF GEOGRAPHY AND RESOURCES

LOCATION. The region is bordered to the east by Iran, to the north by Turkey, to the west by the Jezira plateau and to the south by the Mesopotamia alluvial plain of central Iraq. It covers approximately 20 per cent of the total area of Iraq (437,393 km^2). The region's location is illustrated by figure 1.1.

The NE of Iraq comprises five administrative provinces, all to the east of the river Tigris. Details are in table 1.1.

Table 1.1 TOTAL AREA AND LOCATION OF NE PROVINCES

Province	Capital	Location	alt.(m)	Area (km^2)
Dohuk	Dohuk	36-52N/43-00E	330	6,120
Ninevah	Mosul	26-20N/43-08E	240	38,430
Erbil	Erbil	36-11N/44-01E	1080	14,471
Ta'meem	Kirkuk	35-28N/44-24E	310	9,659
Sulaimaniyeh		35-33N/45-26E	850	15,756

TERRAIN. To the east and north-east the region rises towards the Zagros mountains, which reach altitudes of over 3000m in some places. The Kirkuk-Erbil-Mosul plain gives way farther north to a piedmont zone with alternating valleys, foothills and mountain ridges trending NW-SE. Within these uplands are incised the broad valleys of Tigris, whose tributaries cut through deep gorges. The volumes of the Tigris and its tributaries fluctuate widely from season to season, and from year to year. Farther north-east, the terrain is ragged and mountainous. The climate here is harsh, with rainfall aggregates of 700-1400mm a year, and with frequent snow and ice in winter. Together with climate, the region's terrain in general imposes great constraints on agricultural patterns and farm operations.

ECONOMY. The economy of the area is dependent on grazing livestock, and on tree crops in sheltered valleys. The piedmont region fringing the south-west of the mountains is made up of low mountain ridges and hills, diversifying the high plain of Kirkuk-Erbil-Mosul. The area ranges in altitude from 240m in Mosul to about 800m in the plains of Erbil (the city of Erbil itself rests on top of a high hill 1080m above the sea level). In many ways the Kirkuk-Erbil-Mosul plain is the most important part of the NE region. This region is given over to extensive (rainfed) agriculture, but it is also the area under which much of Iraq's oil resources are found, mainly in and around the city of Kirkuk and also in the vicinity of Mosul.

GEOLOGY AND SOILS. Geologically most of the NE region is underlain by rocks of Cretaceous and Eocene age, mostly limestones, with a few bands of gypsum. The region's soils are varied--brown, reddish brown and chestnut soils--and in places are merely skeletal where rock outcrops predominate. Limestone constitutes the major type of parent material, but gypsum is also present in the red and brown soils of the piedmont plains and in the foothills.

CLIMATE. Two seasons dominate the year in the NE region of Iraq: a hot dry summer, and a cold humid winter. The rainfall receipts in most parts of the region are limited and fluctuate considerably from season to season and from year to year. Rainfall often starts in late September/early October, reaches a maximum in December and February, and falls off after the end of March. Averages in the region range between the 375mm isohyetal line of Kirkuk-Mosul, and exceeds 1300mm in the mountains.

1.2 THE DEMOGRAPHY OF THE NE REGION

In 1984 the five provinces of the NE region had a population of 3.7mn (Iraq´s population in 1984 was 14.4). Approximately 46 per cent of the region´s population is rural. Data on rural/urban population distribution of the region are presented in table 1.2 (CSO 1984, pp. 11-12).

Table 1.2 RURAL/URBAN STRUCTURE OF NE POPULATION

Province	Rural	Urban	Total	% Rural
Dohuk	171,805	128,884	300,689	57.1
Mosul	608,230	718,574	1,326,804	45.8
Erbil	304,070	345,677	649,747	46.8
Kirkuk	177,586	416,924	594,510	29.9
Sulaimaniyeh	437,946	390,002	827,948	52.9
Total	1,699,637	2,000,061	3,699,698	45.9

Note: The names of the provinces and capital cities will be used interchangeably throughout the text.

ETHNICITY. There are a number of ethnic groups varying in religion, language and ethnic origion. Official data on these groups are not available. The majority of the population in the region are Muslim Kurds, but other groups also live here including Assyrians (Nestorian Christians), Yezidis (loosely dubbed devil-worshippers), Turkomans and Arabs (Nasser 1985, p. 24).

SEX AND AGE STRUCTURES. According to the 1984 statistics, males slightly outnumber females (1.06 male for one female). The age structure of the rural population in the region is characterised by a high number of young age groups, as shown in table 1.3 (calculated from CSO 1984, p. 16-18).

Table 1.3 AGE AND SEX STRUCTURE OF NE RURAL POPULATION

Age group	% Male	% Female	% Total
< 5	11.1	9.9	20.0
5 - 14	13.5	13.6	27.1
15 - 24	7.7	7.7	15.3
25 - 34	7.1	6.9	14.0
35 - 44	4.2	4.4	8.6
45 - 54	3.1	3.0	6.1
55 - 64	2.1	2.2	4.3
65 and over	2.1	2.1	4.2

DEMOGRAPHIC TRENDS. Statistics on demographic trends indicate a high fertility rate and birth per thousand of population. However, a progressive trend in migration from the countryside into urban areas has reversed the trend of population growth in the rural areas. The figures in table 1.4 give the trends on a national level which reflect the general trend in the country. There are no trend estimates available for individual NE provinces (CSO 1984, p. 10).

Table 1.4 DEMOGRAPHIC TRENDS IN POPULATION OF IRAQ

Indicators		Urban	Rural
Crude birth rate (per ´000):			
	1970	49	52
	1980	45	51
Crude death rate (per ´000):			
	1970	20	24
	1980	12	13
Total fertility rate (1980)		6.7	7.8
Average annual growth:			
	(1970-1980)	3.2	3.1
	(1980-1984)	3.4	3.3

POPULATION DENSITY. In 1984 the average population density for Iraq amounted to 33 persons per km^2, a figure which includes the desert areas which cover almost half of the total surface area of the country. In the five provinces of the NE region, population density is higher than national average, but the figures, however, still indicate a high ratio of land to labour. The highest population density in the region is in Kirkuk. This does not reflect a greater use of the land, since barely 30 per cent of the province´s population is rural. Population density data are given in table 1.5 (CSO 1984, p. 9).

Table 1.5 POPULATION DENSITY IN NE IRAQ

Province	Density (person/sq. km)
Dohuk	49
Mosul	35
Erbil	45
Kirkuk	62
Sulaimaniyeh	53
Region	44
Country	33

ECONOMICALLY ACTIVE POPULATION. In 1984, little over 30 per cent of the region's population was economically active (approximately 1.1mn). The agricultural sector employs 42 per cent of that number. Although still the major employer of the working population, the agricultural sector is gradually giving way to other sectors of the economy (the political instability in Kurdistan has also accentuated the trend). With flourishing industries in the urban areas, migration to the city is on the increase. Table 1.6 provides the data on the economically active population for 1984, as well as for 1960 and 1979 (for comparison) to demonstrate the changing trends in economic engagement by the working population of the region.

Table 1.6 LABOUR FORCE DISTRIBUTION BY SECTOR IN NE IRAQ

Sector	1960 %	1975 %	1984 %	Annual Change 1960-1984
Agriculture	64.7	49.0	43.1	- 1.7
Industry	5.5	15.6	21.1	+ 5.8
Construction	0.2	2.9	3.0	+ 11.9
Services	29.6	32.5	32.8	+ 0.4

Source: calculated from the annual statistical abstracts of 1961, 1976, 1984.

FARMERS AGE GROUPS. Data on age groups of the agricultural labour force of the region suggest that older age groups (41-64) constitute over 40 per cent of the active farmers. This is mainly due to the massive migration of the young to the city. Table 1.7 demonstrates this (CSO 1984, pp. 21-22).

Table 1.7 AGE GROUPS OF ACTIVE FARMERS (%)

Province	16-40	41-64	65 & over
Dohuk	49.5	38.7	11.8
Mosul	40.3	43.7	16.0
Erbil	49.0	40.5	10.5
Kirkuk	43.9	43.2	12.9
Sulaimaniyeh	51.0	40.9	8.1

1.3 THE SOCIO-ECONOMIC SETTING

1.3.1 EMPLOYMENT

The income of the rural community in NE Iraq is not always derived from farming. Dependence on additional income is greater in areas with strong physical constraints on agriculture--often, infertile soils or low rainfall. According to al-Najafi (1979, pp. 109 - 10), the farmers' source of income under low rainfall conditions (200-350mm) is derived from diverse activities with varying degrees of contribution to the total income. The results of his investigation are listed in table 1.8.

Table 1.8 SOURCES OF INCOME IN LOW-RAINFALL AREAS

Source of Income per Farmer	Iraqi Dinar	% Income
Cropping	53.400	9.68
Livestock farming	161.300	29.23
Off-farm employment	337.100	61.09
Total	551.800	100.00

Note: Iraqi Dinar (1979 rates)=£1.50

It is evident from above that off-farm employment, temporary or permanent, constitutes, in such areas where physical constraints are strong, the major source of income for the farmer. Livestock production, rather than cropping, is the second in importance. Nearly all the farm produce in such areas is directly consumed by the farmer´s family. little is marketed.

In areas with higher rainfall, the situation is little different. Although farmers may be less dependent on off-farm employment, the latter is still higher than income extracted from livestock farming. In areas with annual rainfall above 350 mm, farmers´ agricultural income is approximately sixty per cent of the total income receipts. The results of the investigation conducted by al-Najafi on sources of income in this area are listed in table 1.9 (al-Najafi 1979, p 110).

Table 1.9 SOURCES OF INCOME IN HIGH-RAINFALL AREAS

Source of Income per Farmer	Iraqi Dinar	% Income
Cropping	173.300	26.86
Livestock farming	211.200	32.60
Off-farm employment	261.100	40.38
Total	646.600	100.00

Off-farm income consists of all other income not related to farming. A wide range of sources may contribute to the farmers´ additional income, as it is normally called. These include trade, industry and temporary or permanent employment outside the family farm. The increased dependence on additional income may threaten farming in the region in the long run, as farming may be more and more replaced by other activities. Off-farm income, nonetheless, is often flexible enough so as not to intervene with peak labour requirements in farming. In most cases, therefore, income derived from off-farm jobs remains a welcome source of additional cash where farming fails to fulfill all family budget requirments, while farming takes care of the food supply.

LIVESTOCK COMPONENT. Goats, sheep, poultry and, in some places, cattle are the main farm animals responsible for the income derived from livestock production. Tempted by the promise of good income from livestock rearing, the farmers tend to increase the size of their herds, often at the expense of the limited rangeland resources. In peasant communities, the size of one´s herd serves as an indication of social status. As a result, palatable grass is virtually eaten out and soil is exposed to the hazards of erosion. Poultry batteries and closed livestock farms are very few in number, while herding is carried out by shepherds, often children, in exchange for cash or some commodities, normally clothes and food.

To sum up, farming is not the only economic activity in the rural NE region: plant production provides, as an average, 18 per cent of the anuual income of the farmer; livestock farming contributes 31 per cent; and the rest is provided by off-farm employment and home industries. Livestock production is a major farming activity in the region; and for the small semi-nomadic population, the sole means of livelihood.

1.3.2 ADDITIONAL SOURCES OF LABOUR: CHILDREN & WOMEN

Child labour on the farm is a widespread practice. Although the use of children in farm work is a long standing practice, the sharp increase in population has encouraged its wider use. Over 51 percent of the rural poulation in the region are under 15 (al-Leila 1979, p. 112). The increasing demand for food by the, now, larger families has encouraged the farmers to enlist the help of their children to work on the family farm. A parallel increase in off-farm employment by the adults in the family has reinforced the trend. Female labour, another long standing practice, is also on the increase. The tendency to send the adult males to the town for work has encouraged women to take men´s place on the family farm.

There are no statistics available on the size of the child labour force in the agricultural sector, but experiece has revealed that farmers enlist the help of their children (often 10-16 years) on the farm during most of the year. On the other hand, the figures available suggest that women constitute roughly 30 per cent of the rural economically active population throughout the country. Political unrest and the Iran-Iraq war may have augmented the trend.

1.3.3 LAND TENURE

The NE region of Iraq was part of the Ottoman Empire after 1534. However, not until the middle of the 19th century did the Ottomans succeed in establishing their control over the towns of the region. Even then, most of the region´s population still lived by and large independently of the central administration, in tribes which were autonomous social units with their own jurisdiction and administration. Each tribe occupied a certain area of land which it considered to be its own by customary law. The land belonged to the whole tribe, and private ownership was unknown. Cultivation and grazing was organised communally. The Aghas or Sheikhs and their agents were responsible for such functions as allotting the the lands to each household, distributing seeds and appointing dates for sowing and harvesting. Each farmer cultivated the plot of land allocated to him and gave, at the end of the season, a certain percentage of his harvest to the Agha whose income was to be used for the common defence or the maintenance of the tribe´s guest house (miwankhana).

The Land Title Settlement Law of 1932 (which coincided with Iraq´s independece from the Ottomans and then the British) provided for a cadastral survey of the whole country (including the NE region), and for the granting of ownership rights for the cultivators of the land. This was to be a major departure from the old traditional tenure system. However, most farmers being illiterate and inexperienced in dealing with government officials, did not understand the significance of private ownership. As a result, many Aghas had the land of their tribes registered as their property. In this way, large farms were created, and the farmers became mere tenants or share-croppers under a semi-feudal system. Tributes often in the form of large shares of the harvest had to be paid to the Agha landlords.

Until 1958, landed properietors also included a number of town-based landed families. During that period, eight big land owners throughout Iraq owned more than 350,000 hectares, while 286,076 farmers owned only 2.5 million hectare. Some 2.9 million peasants were landless. An agrarian reform law was enacted in 1958 (Law No. 30). A maximum limit was placed on land ownership of 250 ha on irrigated and 500 ha on rainfed lands. Previous ownerships in excess of these limits were expropriated by the state. In the first twelve years following the reform, some 2.2 million ha was distributed on landless farmers in 15 and 30 ha plots on irrigated and rainfed lands respectively, most of which were the property of previous landlords.

In compliance with Islamic and Ottoman land legislation, the Iraqi government is the supreme owner of all lands (except mulk [private] and waquf [religious endowments] lands), though the usufruct can be transferred to private persons. Today, the broad categories of land ownership in NE region are:

1) **Miri** lands (government property), constituting the largest single class of ownership. Some 97 per cent of the

total agricultural holdings in the region fall in this category. This has largely accumulated from the confiscated property of the feudal landlords affected by the land reform legislation since 1958. The government offers the estates for lease for a period of normally 3 to 6 years - renewable upon request and follwing evidence that the land has been put to good use by the farmer. During the lease period, the tenant may act as a proprietor of the land which often results in the farmer´s merciless exploitation of the land. Little effort is paid to protect the land´s performance for future use.

2) **Mulk** lands (private property), amounting to one per cent of total agricultural holdings. Only a small number of orchards and palm groves fall under this category.

3) **Waquf** lands (religious endowments) totalling two per cent of all agricultural lands in the region. The lands are donated by private landowners to mosques, churches, religious schools or the clergy in general. Normally it can neither be sold nor transferred to another person. At present, two forms of waquf exist: first, lands granted with the intention that the rent will be used to assist religious schools, maintenace of the holy shrines or the welfare of the clergy and their families. These will be the responsibility of the higher clergy **permanently.**Second, lands are sometimes placed at the disposal of a religious dignitary on the condition that after the owner´s death the ownership will be transmitted to the latter´s beneficiaries. Farmers who work on these lands are often share-croppers.

However, in addition to the three categories listed above, many peasants cultivate their lands on squatter basis. No information is available in new government statistical records on their actual size, but the the results of the agricultural census of 1971 showed that 52,021, or 8.8 per cent, of registered farmers are without land.

The tenure system is still diverse and complex. On a limited scale, a communal ownership of the land is still tolerated in some areas in the region. Although in the former case ownership is normally nominal in the form of concessions conferred by the government on certain tribes and villages without firm tenure. Grazing rights are often arranged in this manner, allowing a group of peasants to enjoy communal use of the land without necessarily having exclusive tenure or lease. Under the remnant private ownerships, the rights of cultivation are either exercised by the same person, or rented by landlords to tenants. In theory, however, land ownership in Iraq is based on a `socialist´ system: the land is owned by the state, and cultivation responsibility is given to cooperative groups or individual farmers.

FARM SIZE. Table 1.10 and 1.11 have been calculated from the results of the last agricultural census in Iraq. Although relatively old (the last census was taken in 1971), the data are believed to reflect the size groups by farms and provinces in the region today (CSO 1973). The figures have been transformed into hectares from donums (0.25ha).

Table 1.10 FARM LAND BY SIZE IN NE IRAQ

Size Group (ha)	Number of Farmers	Total area ha	%
Without land	20164	nil	nil
Under 1	44452	18,648	0.6
1 - 5	60950	223,772	7.2
6 - 25	86384	1,404,792	45.2
26 - 150	16269	935,492	30.1
151 - 250	229	87,023	2.8
251 - 500	228	127,426	4.1
over 500	458	310,794	10.0
Total	229134	3,107,947	100.0

Table 1.11 FARM LAND BY PROVINCES AND AVERAGE AREA

Province	Agricultural Area ha	Average Area of Holdings ha
Dohuk	116,541	6.6
Mosul	1,650,381	22.2
Erbil	435,970	13.1
Kirkuk	731,618	18.4
Sulaimaniyeh	173,437	3.9
Total/Average	3,107,947	13.6 (wt. 18.4)

It is obvious from the above tables that farm size cannot serve as a uniform measure in deciding levels of land utilization in the region. However, the weighted average of farm-size in the region can be estimated at 18.4 ha. This is classified as large by the standards of farming in the Third World countries (ILACO 1980, p. 644).

LAND FRAGMENTATION. Another important characteristic which has emerged from the last agricultural census of 1971 is that land holdings in the region are not kept in one parcel. The land allocated to any individual farmer (or title-holder) may come in several parcels. Inheriting the land from parents also contributes to the fragmentation of the land. Over 58 per cent of the total agricultural holdings are held in more than one parcel of land (table 1.12: calculated from results of 1971 agricultural census).

Table 1.12 FRAGMENTATION OF LAND HOLDINGS

Province	One Parcel Holdings	%	Over One Parcel	%
Dohuk	3534	16.3	18201	83.7
Mosul	48010	61.3	30313	38.7
Erbil	14044	37.6	23317	62.4
Kirkuk	14460	33.1	29270	66.9
Sulaimaniyeh	14313	29.8	33672	70.2
Total/Average	94361	41.2	134773	58.8

1.4 CONSTRAINTS ON FARMING

1.4.1 LAND REFORM

The system by which land is owned or leased offers a problem independent of physical attributes. There has been evidence that where a change in the old tenure system has permitted the peasants to cultivate their own land, some were ready to break with the old farming traditions. The task of pesuading all the rural community to adopt modern technology in farming has been, nontheless, a difficult one. Although land reform legislation has aimed at accelerating growth, the farmers have been unaware of this possibility.

Land reform may be a necessary condition for growth, but it clearly has not been sufficient to modernise the agricultural sector. Constantly changing government policies have inhibited growth; and insecurity among the new farmers hindered enterprise. Many farmers left their farms seeking employment in the town; and although there have been signs of stability in private farming during the last few years, this has not been enough to keep people on the land (McLachlan and Nasser 1985, p. 153).

Although landlords had often been unfair to their tenants, farmers were unaccustomed to independence. The landlords provided a number of services such as credit and market outlet, alternatives of which were not always available after land reform. In breaking up with the past so abrubtly, land reform was socially and economically disruptive.

Until now accounts of agrarian reform in Iraq have thrown little light on what is happening at village level. Official statistics are inadequate and often contradictory; and there is a great disparity between different partisan accounts of the effects of the measures. The agrarian reform has not sufficiently influenced the basic features of the farming system in the region. The problems of holdings irregularities and many parcels per holding still challenge the reform measures. There are well-recognised problems in quantifying the costs and benefits of agrarian reform. Changes resulting from land reform are difficult to distinguish from those resulting from improved technology. Further, accurate farm data are not easily obtained, especially in the subsistence sector. Lack of unbiased research on the issue is aggravated by reluctance of government agencies to allow foreign expert inspection. As observed by Adams (1972, p. 1), since the inception of land reform, research by outsiders has not been encouraged, and visitors to the countryside are usually accompanied by armed escorts.

The implementation of land reform throughout Iraq has been conducted by revolutionary practice, which although it had the advantage of being fast, quite often took undesirable turns because of lack of research and planning. The confiscation and division of large estates has not guaranteed a land distribution system which met actual demands. As observed in tables 1.10, 1.11 and 1.12, it has become extremely difficult throughout the NE region to draw policies which could offer a desirable solution to a region which lacks uniformity of size of holdings and where fragmentation of the land is very high.

According to the 1984 figures, number of farmers in the five provinces of the region who became beneficiaries of the land reform had reached 125,630 (CSO 1984, p. 25). This figure constitutes nearly 50 per cent of the total number of farmers in the region.

1.4.2 RURAL INCOME

Another problem facing the prospects of agricultural growth in the region is the low rural income. In a questionaire prepared by al-Najafi (1979, pp. 102 - 3, 110), the majority of the region's farmers reported an annual income of less than 300 dinars (approx. £750). This issue is demonstrated in table 1.13.

Table 1.13 AVERAGE RURAL INCOMES IN NE IRAQ (1979)

Income (Iraqi Dinar)	% Farmers
Less than 300	45.4
301 - 600	18.1
Over 600	36.5
Weighted average = 463 (£1,157)	

Against the low income shown in the above table, population growth has restricted the chance of greater investment. Over 75 per cent of the rural households in NE Iraq consist of more than six members. Families with less than five children constitute only one fifth of the household population (al-Laila 1979, p. 117).

The problem of depressed rural income is related to a number of issues. Even where farmers increased their output following land reform, there was a corresponding increase in consumption. Although such increase in consumption may account as a gain in welfare, there was little prospect of increase in amount of marketable surplus.

Rural per capita income in Iraq in general is low. The 1983 estimates put the per capita income at US$403.7, compared to $877.1 for the urban population. The annual growth in rural income in the period 1970-1983 has been 7.2 per cent, against 9.0 per cent in the urban sector, as demonstrated in table 1.14 (McLachlan and Nasser 1986).

1.14 PER CAPITA INCOME IN RURAL AND URBAN IRAQ

Sector	1970 ($)	1983 ($)	Annual Growth 1970 - 1983
Rural	163.5	403.7	7.2
Urban	286.1	877.1	9.0

1.4.3 CONSTRAINTS ON INPUTS

The task of transforming traditional agriculture is not simply a question of land reform and policies. The process is dependent on new inputs. In Iraqi agriculture capital is not always a strong constraint (FAO 1974, p. 2); the low productivity of the farm labour, however, is a serious impediment. This deficiency is also due to lack of specific factor inputs, such as research and education. Success in agriculture entails more inputs coupled with greater efficiency of application. Moreover, the enhancement of inputs must be selective; additional inputs in peasant agriculture would have limited benefit, because of the low rates of return in this system of agricultural production.

Apart from the poor efficiency of labour productivity in the region´s (peasant) agriculture, the physical constraints constitute another strong impediment. As discussed in section 1.3.1, the level of rainfall greatly influences the level and source of the farmer´s income, as well as the level of inputs required to prepare the land for cultivation. Farmers in the areas with good rainfall are less dependent on off-farm employment, relative to other groups.

MEASUREMENT OF INPUT LEVELS. Quantifying the levels of input at the village level is an especially difficult problem. The economic value of an input is the net value of production which would have been produced if it were employed elsewhere, or the same commodity produced in an alternative way. But where there are clear indications of discrepancies between market prices and economic prices, as is the case with the agricultural sector in Iraq, the task of quantifying input levels becomes formidable.

At macroeconomic level, the agricultural sector in Iraq in general suffers from very low levels of inputs. The value of inputs in the Iraqi agricultural GDP constitutes less than one-quarter of the gross value of agricultural products; a low rate in comparison to advanced standards of agriculture, as shown in table 1.15 (McLachlan and Nasser 1986, **estimates**).

Table 1.15 COMPOSITION OF AGRICULTURAL GDP IN IRAQ (1985)

Sector	ID `000,000	% GVP*
Crops	984.2	59.5
Livestock products	640.1	38.7
Forestry & Fishery	29.8	1.8
GVP*	1654.1	100.0
Total Inputs	385.4	23.3
Agricultural GDP	1268.7	76.6

* gross value product.

Given an improvement in efficiency, rates of return on agriculture are directly proportional to increase in levels of inputs. In an experimental investigation in three different areas in north Iraq, al-Najafi (1979, pp. 98-110) has established the relationship between higher levels of input and increased value-added. The three zones were selected on rainfall basis: the first zone with annual rainfall below 350mm; the second with 350-500mm; and the third with over 500mm annual rainfall. The figures in table 1.16 have been calculated per hectare from his findings.

Table 1.16 INPUT/OUTPUT LEVELS PER HECTARE IN THREE RAINFALL ZONES IN NORTH IRAQ*

Item	1st Area		2nd Area		3rd Area	
	ID	%Output	ID	%Output	ID	%Output
1) Inputs:						
Machinery	4.9	9.0	7.6	12.8	8.5	10.7
Labour	0.8	1.5	0.4	0.7	3.9	4.9
Seeds	4.1	7.5	4.4	7.4	5.4	6.8
Rates**	0.0	0.0	0.1	0.2	0.4	0.5
Total	9.8	18.0	12.5	21.0	18.2	23.0
2) Output	54.4	100.0	59.5	100.0	79.1	100.0
3) Net	44.6	82.0	47.0	79.0	60.9	77.0

* The investigation selected mechanised farms of 50ha average area. Mixed farming (livestock husbandry) and off-farm employment have been reported in all cases.

** Rates include interests paid to service loans.

Although al-Najafi has concentrated on individual areas in the north of Iraq, his findings can be interpreted in broad terms as indication of the general trends in inputs, outputs and value-added of the agricultural sector in the region. It is not clear, however, whether he deducted from his figures the amount of product consumed by the farming community itself. In any event, it would appear that his assessment is close to the macroeconomic parametrs of the agricultural sector.

Figures 1.1 and 1.2 have been prepared to demonstrate the composition of the GDP of the agricultural sector. In the case of figure 1.2, the graph has been drawn on figures provided in several early reports on the progress of the agricultural GDP. A projection trend has also been drawn to describe the possible trend until 1990. McLachlan and Nasser (1985;1986) have provided some estimates of the agricultural sector GDP. These have also been incorporated in both figures.

1.4.4 AGRICULTURAL PRICES AND MARKETING

The prices of agricultural commodities are government controlled. In an attempt to protect the prices of basic food products from fluctuation, the prices of most agricultural products have been separated from the market mechanism, by setting rigid pricing policies based on national targets.

Figure 1.2 THE DISTRIBUTION OF COSTS AND RETURNS IN FARMING IN NE IRAQ

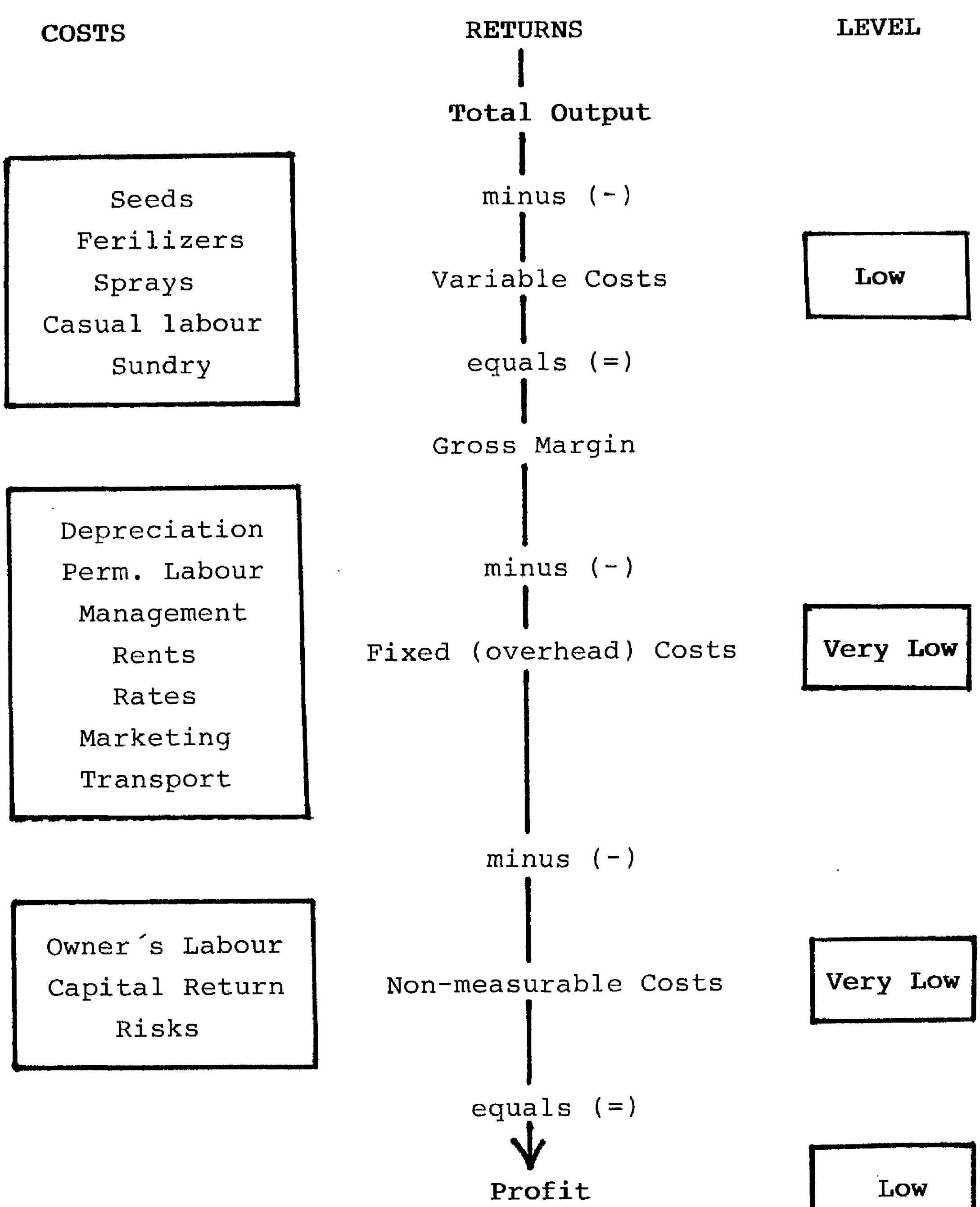
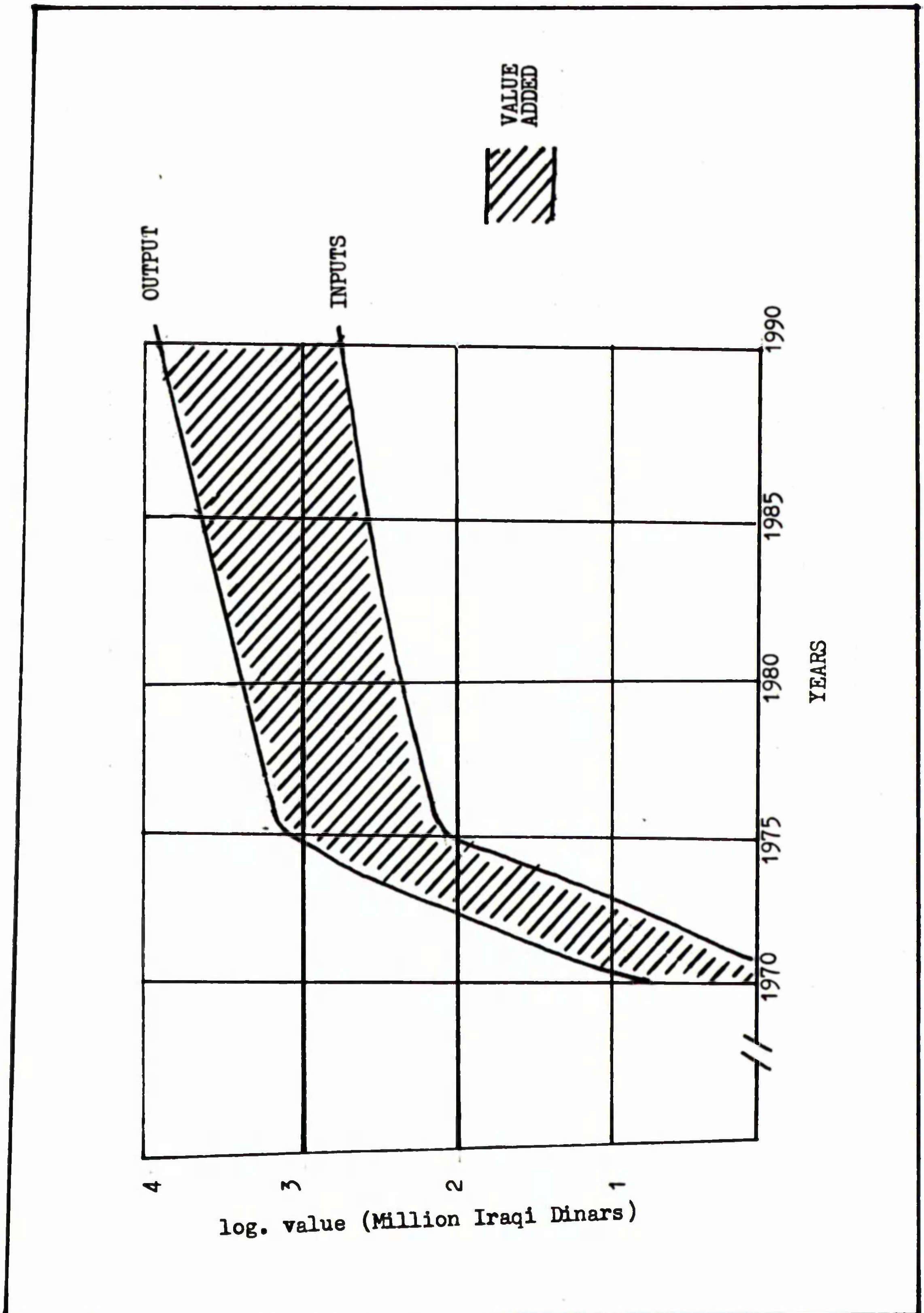


Figure 1.3 INPUTS, OUTPUT AND VALUE-ADDED PROJECTIONS OF IRAQI AGRICULTURAL SECTOR



The agricultural commodities produced in NE Iraq, especially, are less capable of competing with commodities produced elsewhwere in the country. This situation has been caused by the relative isolation of the region from the rest of the country, and as a result of the political unrest.

The weak bargaining position of the region´s farmers, coupled with infrastructural deficiencies and lack of information have diminished prospects of marketing. The marketing and pricing system of the agricultural products is so rigid that farmers do not have an effective choice of market oulets, and are obliged to accept any price that the government has set. As a result, farmers lose interest in increasing marketable surplus in favour of self sufficiency at the village level.

The rural community in NE Iraq is characterised by a high degree of self-sufficiency at the village level and even at the level of individual households. The incentive for producing greater marketable surplus and increasing investment in marketing is very limited, because the farmers consider these as involving unacceptable risk.

Progress in agricultural marketing is constrained by low standards of infrastructural provision. Adequate transport is especially difficult, as the cost of long distance journeys to the market becomes prohibitive. The development of agricultural marketing is further constrained by lack of specialised infrastructure, such as cold stores, slaughter houses and market areas.

The problem of agricultural prices deserves special attention. Market price and economic value would be identical if supply and demand corresponded on an open market, where there is free competition between suppliers and bidders, a complete mobility of production factors, and where there is full engagement in agricultural employment on the part of the farming community. In Iraq and the NE region in particular, a free market is virtually non-existent. There are nearly always distorting influences such as price controls and state monopolistic tendencies which cause the market price of labour, machinery and other inputs to deviate from their real utility and productivty.

Also, many of the agricultural products of the NE region never reach the national market. They are produced and consumed locally; sometimes through the intermediary of local merchants. The individual farmers can do virtually nothing to influence prices of their products. Cooperatives and government marketing organisations generally do not operate efficiently or economically.

The prices of almost all agricultural inputs are subsidised, but in return the farmer is obliged to sell his products to government agencies at artificial prices, often too cheap to give enough incentive to increase production. A farmer may risk the confiscation of his harvest if he chose to breach agricultural marketing regulations. During the last few years, however, there have been signs of encouraging the private marketing of some commodities, but staple-food prices are still strictly controlled.

1.4.5 ORGANISATION AND GOVERNMENT ASSISTANCE

COOPERATIVES. Village agriculture in the NE region exhibits a combination of individuals, cooperatives and collective enterprises. Former sharecroppers have successfully taken over from Agha landlords, and the management gap has been filled by the cultivators themselves. Cooperatives, however, have not been prominent in this regard, and their role is still limited to selling fertilizers and seeds on credit. The agrarian reform legislation has not greatly influenced the basic features of the farming system. Today, organising the farming community into self-organised units (cooperatives) is still a major problem. The record of the agricultural cooperative movement in Iraq is poor.

Although cooperative farming was intended as an area of rural activity to encourage the spread of the scarce factors of management skills and capital, the cooperative movement in Iraq has been highly politicised and many farmers resisted membership on political, religious or ethnic grounds. Due to lack of distribution of individual rewards on merit, there has been loss of incentive to greater enterprise. After the failure of several experiments with collective farms in the 1970s (al-Dahiri 1982, pp. 255-261), the agricultural cooperatives in the region and throughout Iraq have been designed to act as rural service cooperatives. The services include the supply of agricultural inputs, such as seeds and fertilizers, the provision of technical equipment (hire of agricultural machinery) and the arrangement of credit supply.

Table 1.17 lists the agricultural cooperatives in NE Iraq in 1982 according to their functions and membership (calculated from al-Dahiri 1982, pp. 247-262).

Table 1.17 THE AGRICULTURAL COOPERATIVES IN NE IRAQ

Type	Number	Membership	% Farmers
Rural services*	617	137,935	60.2
Collective farms	5	104	-
Specialised**	11	978	0.4

* Officially called local cooperative associations.

** Specialisation includes poultry, bee-keeping and livestock husbandry.

The above table clearly demonstrates the predominant type of the the agricultural cooperatives in the region. With increased incentive as well as government pressure, over 60 per cent of the farming community in the region were members in cooperatives by 1982. Experience obtained with the introduction of cooperatives in the region has usually been disappointing. The main reasons are:

- the absense of sufficient qualified management staff;
- insufficient cooperation of the members, together with unrealistic expectaions as to the advantages of a cooperative system;
- different views among the members, often due to different tribal or ethnic affiliations.

The functioning of the agricultural cooperatives in the region proves to be hampered by a lack of sufficient motivation and the dependent, passive attitude of the members. Most cooperative farmers are usually only too willing to accept support, but are prepared to give little in return, for instance in terms of an increased production on their own farm and active participation in the cooperative. In a questionaire taken by al-Laila (1979, pp. 120), it was found that the farmers interviewed were not all equally enthusiastic about cooperative farming. A third of the cooperative members **considered membership to be very useful.** The results of the questionaire are listed in table 1.18.

Table 1.18 PARAMETERS OF COOPERATIVE RECOGNITION

Parameter	N=238	%
Attendence of coop. meetings:		
Regularly	88	37.0
Occasionally	87	36.5
Seldom	48	20.2
Never	15	6.3
Level of benefitability:		
High	79	33.2
Medium	106	44.5
Low	37	15.6
Very low	16	6.7

CREDIT. One of the essential supplementary functions of the agricultural cooperatives in Iraq has been the arrangement, and sometimes the direct supply, of credit. The introduction of government credit agencies (through the Agricultural Cooperative Bank) has been an important change in the life of the region´s farmers. The results of this measure, however, have been mixed.

The political instability in the region has meant that government assistance to the agricultural sector has been late to arrive. The role of the private lenders has not totally diminished (build-up of debts has occasionally cost farmers their land). However, government assistance has been disturbed by frequent political unrest, and the ACB has been often reluctant to extend credit to farming communities considered risk groups. Credit also is not always accompanied by supervision from an agricultural extension authority aimed at assisting the farmer in preparing a sound production and credit plan.

There are no official data available on the provincial distribution of the recipients of government credit. However, it is clear from the declared purposes of the loans of the ACB that credit distribution has targeted two major investment areas: poultry and farm machinery (the NE region has a modest share of both). Important areas of investment such as infrastructure and land reclamation have attracted little or no attention in the allocation of credit. The distribution of loans over sectors and years are also extremely irregular, as listed in table 1.19 (CSO 1982,p.24).

Table 1.19 ACB CREDIT RELEASE BY SECTOR (1981-1982)
ID`000

Purpose	1981	%	1982	%	% 81-82
Farm supply*	13,204	7.1	7,049	7.2	- 46.6
Marketing	6,442	3.4	2,671	2.7	- 58.5
Maintenance	1,636	0.9	1,321	1.3	- 19.3
Poultry	66,720	35.9	34,709	35.3	- 48.0
Livestock	4,213	2.3	6,990	7.1	+ 65.9
Machinery	74,116	39.9	32,101	32.7	- 56.7
Fruit orchards	17,685	9.5	11,180	11.4	- 36.8
Structures	14	0.0	0	0.0	-100.0
Land reclamation	48	-	71	0.1	+ 47.9
Unspecified	1,878	1.0	2,159	2.2	+ 15.0
Total	185,956	100.0	98,251	100.0	- 52.5

* Often taken to mean seeds, fertilizers and insectcides.

PUBLIC HEALTH AND EDUCATION. Assessing such areas of social development as agricultural extension, public health and education are extremely difficult. While impressive improvements in the standards of social services are apparent, especially since the oil boom of 1970s, official information on these subjects are grounded in strong rhetoric and insufficient data. Public health and education are free for all citizens; and at least on official level, both urban and rural sectors receive equal attention.

Since the inception of agricultural extension service in Iraq in early 1950s, the results have been mixed. Agricultural extension alone has seldom been sufficient to bring about substantially higher output. Extension services alone have been meaningful only where other measures were taken as well, including local availability of supplies and equipment, sound marketing and price policies, good infrastructure and credit supply. On the side of the extension service, in as far as agricultural cadre personnel are considered, its activities are often not adequate enough. The reasons for this have been varied: little motivation; the absence of identification with the interests of the farmers (most cadre personnel do not come from a farmer´s family); and the extreme bureaucratisation of the agricultural services. The situation in the north has been even more difficult. Lack of in-service training and ethnic sensitivities have marginalised the role of the extension officer in the region (Singh and Mohammed 1979, pp. 37-46). Al-Laila 1979 (p. 119), in his investigation of a number of socio-economic problems of the farming community, reported that over 25 per cent of the northern farmers had not had received any advice from an extension officer.

Signs of improvement in education of the rural community are promising (Literacy classes are compulsory for all under 60-years citizens in Iraq). By 1979, however, over 70 per cent of the region´s rural community were illiterate (al-Laila 1979, p. 119) (the 1979 Statistical Abstract put the figure for Iraq´s rural community at 74.8 (93.1 per cent of females, and 56 per cent of males(CSO 1979, p. 34)).

Data on public health services in Iraq lack specific indicators on a provincial basis (for instance, number of doctors or hospital beds per 1000 persons, per province). The 1982 data indicate a low rate 0.6 hospital-bed per 1000 person, and 2.2 doctor per 1000 of Iraq´s population (calculated from CSO 1982, pp. 67-68). The World Development Report of 1981 has listed other health-related indicators: food production, calorie intake and water supply, as well as life expectancy and infant mortality. The figures in table 1.20 are for the United Kingdom and Iraq, for comparison.

Table 1.20 HEALTH-REALTED INDICATORS FOR IRAQ AND UK

Indicator	Iraq	UK
Index of food production (1969-1971 = 100)	86	115
Daily per capita calorie supply:		
Total	2134	3336
As percentage of requirement	89	132
Access to safe water (% population)	62	100
Life expectancy	56	73
Infant mortality ('000)	92	14

Medical attention in the region´s rural areas is still in short supply. In a questionaire prepared by al-Laila (1979, p. 122), the majority of the population reported shortage of medical centres in their areas as a major problem (table 1.21). As a result, resort to folk medicine is still common (table 1.22).

Table 1.21 PROBLEMS REPORTED BY FARMERS

Problem	Cases	% N=238	% (669)*
Crop failures	207	87.0	30.9
Livestock management	184	77.3	27.5
Domestic problems	67	28.2	10.0
Shortage of health centres	184	77.3	27.5
Shortage of schools	27	11.3	4.0

Table 1.22 METHODS OF MEDICAL TREATMENT

Method	Cases	% N=238	% (307)*
Clergy	96	40.3	31.3
Folk medicine	22	9.2	7.2
Elderly advice	33	13.9	10.7
Qualified practitioner	156	65.5	50.8

* Multiple choice.

1.4.6 THE STATE OF IRAQI AGRICULTURE

GDP CONTRIBUTION. Before the outbreak of the Gulf War in 1980, Iraq was the world´s third major oil-exporting country after Saudi Arabia and Iran. Especially since the oil boom of 1970s, the country has been undergoing a rapid process of modernisation and development. Agriculture, however, has suffered from the shift in government emphsis towards non-agricultural sectors of the conomy. In 1960, agriculture was an important sector of the national economy, accounting for no less than 20 per cent of the Gross Domestic Product ($1,320.1mn). By 1976, which marked the beginning of a giant climb in oil revenues (GDP rose dramatically from $5,120mn in 1973 to $17,317mn in 1976), the contribution of agriculture to the GDP fell to 8.4 per cent; but by 1983, oil exports had suffered from a drastic drop caused by the war with Iran, elevating the contribution of agriculture to 11.2 per cent. Today, the agricultural GDP-share holds its ground by virtue of the continuation of the war (all figures calculated from Annual Abstracts at 1980 exchange rates).

RURAL URBAN MIGRATION. The growth in the oil revenues has increased the non-agricultural demand for labour, which has been met by increased rural urban migration. In 1961, over 74 per cent of the total population of about 2 million were classified as rural; but two decades later, the 1984 official figures recorded only 5.5 million people (38.4 per cent) living outside urban areas. The buoyant industrial and construction sectors, in particular, have attracted an increasing movement of rural people into the big cities.

AGRICULTURAL PRODUCTION. Food production has generally risen in terms of most agricultural commodities since 1970. This trend, however, has not kept pace with the increase in population and the climb in demand brought about by the oil wealth. There has been nevertheless a significant decline in domestic agricultural production in wheat, rice and dates--the three major staple diets of the population. Lack of price incentives and the over-exploitation of the country's agricultural acreage has encouraged the farmers to increase production of more profitable crops and commodities such as fruits, vegetables and livestock products. There has also been a great increase in fodder-crops production to meet the demand of the expanding livestock sector. Table 1.23 lists the production parameters of the major agricultural commodities for 1970 and 1984 (McLachlan and Nasser 1986). The figures reflect a major change in the pattern of expenditure on food, due to the high income elasticity of demand, particularly for livestock products, and also for fruits and vegetables. The self-sufficiency figures demonstrate the underlying trends.

AGRICULTURAL IMPORTS. As a result of the climb in domestic demand on food products, import of agricultural commodities has sharply risen in the period 1970-1984 by an annual increase estimated at 20.7 per cent, while increase in exports of agricultural products has only witnessed a 9.1 per cent annual growth. In 1984, Iraq imported over $1,408mn of food products and exported less than $118mn, mainly dairy products, vegetables, skins and hides to the Gulf market (McLachlan and Nasser 1986).

Table 1.23 **PARAMETERS OF AGRICULTURAL PODUCTION IN IRAQ**

Parameter	1970	1984	Annual Growth %	Self-suff. %
1) Population (mn):				
Sheep	8.3	12.6	3.8	
Goats	1.6	4.4	7.5	
Cattle	1.5	3.5	6.2	
Buffaloes	0.1	0.2	5.9	
Layers (poultry)	5.3	17.5	8.9	
2) Livestock products: (`000 ton)				
Red meats	164	303.7	4.5	91.6
Poultry	9	70.2	15.8	143.6
Eggs	7	30.9	11.2	92.5
Milk	423	1,711.6	10.5	134.3
3) Crops (`000 ton):				
Wheat	1,080	910	- 1.2	53.3
Barley	692	902	1.9	n.a.*
Rice	268	151	- 4.0	46.0
Fruits	481	490	0.1	
Vegetables	1,800	2,291	1.7	> 107.4
Fodder crops	67	679.9	18.0	n.a.
Dates	330	956	7.9	n.a.

* Not available.

1.5 LAND USE SITUATION

1.5.1 LAND USE IN ANCIENT HISTORY

In 1948, Robert Braidwood, an American archaelogist, began an investigation to explore the possibilities of discovering evidence of pre-historic patterns of land use and domestication of plants and animals in regions east of the Nile valley in Egypt. In choosing a site, NE Iraq was selected. The findings of the mission were to change the previous convictions about the beginning of agriculture in the Middle East. The excavations, phased over three seasons, led to the discovery of cultivated two-row barley and wheat (almost certainly emmer and einkorn) in sites dated about 6500 B.C. Evidence was also found of domesticated sheep, goat and pig (Braidwood and Howe 1960, pp. 2-13).

The historical accounts available (Whyte 1961; Flannery 1973; Leonard 1973) indicate that the earliest farmlands in the region were open forests in which wild wheat and barley were sown among widely spaced trees. A history of physical constraints in the forms of erratic rainfall and progressive infertility of soil was evident, leading to a change from shifting cultivation to the basic cereal-fallow system known to-date. Excavations have also indicated that densities of agricultural sites in the late Neolithic age in NE Iraq were greatest in intermountain plains with a high sub-surface water table, showing that farmers sought lands of high water retension where soil moisture could help plants survive fluctuations in rainfall.

1.5.2 STANDARDS OF USE

INTRODUCTION. Land-use categories in Iraq are difficult to define with high precision. Agricultural censuses have only covered the agricultural acreage on holdings. Little attention has been paid to land use patterns. The data available on rangelands, marshlands and forests, therefore, are generally inadequate. Large areas of land are left fallow by the farmers for one or several years after being used extensively; while open ranges, not registered as agricultural land, are used to a certain extent for grazing. The greater part of the cultivable land (over 50 per cent) is sown with cereals--often wheat and barley.

SOURCES OF WATER FOR AGRICULTURE. With respect to method of irrigation, it is possible to state simply that northern Iraq has adequate rainfall for cultivation; central and southern Iraq, inadequate. In this fashion, the agricultural area of the country is divisible into a rainfall zone in the north and irrigation zone in the south. The latest available data on the distribution of the agricultural acreage according to sources of water are those released after the agricultural census of 1971. As listed in table 1.24, over 97 per cent of the total cultivable area in the NE region is rainfed. On a provincial basis, Mosul is almost completely dependent on rainfall for its agriculture. Only in areas near irrigation schemes, and where pumping facilities are available, that a measure of irrigation is practised to support land cultivated with fruits, vegetables as well as sugar-beet crops for the local sugar refining industry.

Table 1.24 ACREAGE OF RAINFED AGRICULTRE IN NE IRAQ

Province	Total (ha)	Rainfed (ha)	%
Dohuk	116,541	110,789	95.1
Mosul	1,650,387	1,634,398	99.0
Erbil	453,970	425,311	97.6
Kirkuk	731,612	719,241	98.3
Sulaimaniyeh	173,437	142,390	82.1
Total/Average	3,107,947	3,032,129	97.6

FALLOWING. Each year only about half of the total arable land in the region is cultivated, the remainder is left fallow. As in most other Middle Eastern regions, fallow is a common feature of traditional farming customs. The fallow periods allow the replenishment of the soil by natural processes, and also conserve the limited rain water reserves in the rainfed areas while lowering the water table in the flooded or irrigated areas. The practice of fallow is less common in the irrigated plains of central and southern Iraq where farming is affected by many factors: flooding, progressive silting of the land, a rising water table, and soil salinity. In these southern areas, fallowing, in the sense of a rotation of cropping and fallowing, is combined with shifting agriculture. Clearly, the advantages of fallowing in the NE egion are exaggerated. Soil exposure in the fallow season allows erosion to impair soil fertility.

FARMING PRACTICES. As in most other parts of Iraq, extensive agriculture is the main mode of cultivation. The arable acreage is far from completely utilised. Of the total agricultural area in the region, only half is under cultivation every year. Fertilizers are scarcely used and farming operations are generally poor; as a result, crop yield is low. Al-Najafi 1979 (pp. 104) has calculated yield parameters of wheat grown in three rainfall zones in the region. These are listed in table 1.25.

Table 1.25 WHEAT YIELD PARAMETERS IN THREE RAINFALL ZONES

Diagnostic Criteria	Low Rainfall (200 - 350 mm)	Medium Rainfall (350 - 500 mm)	High Rainfall (Over 500 mm)
Grains (kg/ha)	168	428	604
Hay (kg/ha)	228	720	1136

The methods of cultivation are generally simple and primitive. In many places, the land is still tilled by means of wooden plough with an iron share, drawn by draught animals. Seeds are broadcast by hands, and little attention is paid to the fields after sowing. Weed and pest control are still unknown in many places. Spraying of insecticides by planes has not been attempted. Fertlizers are scarcely used. In vegetable farms, however, manure is applied sparingly by the farmers to enhance growth.

1.5.3 LAND USE GROUPS

LAND USE CATEGORIES. No information on land use categories are available on a regional basis. Table 1.26 has been calculated from several independent reports. Although nearly 37 per cent of the total area of the five provinces of NE Iraq is classified as arable, agricultural use of the land is inconsistent. About half of the total acreage is left fallow every year, and the last agricultural census declared over 37 per cent of it as marginally exploited.

The fruit orchards which constitute 0.6 per cent of the total agricultural acreage in the region are chiefly apples, figs and grapes. Vegetables are grown all over the region in small farms. Main species are onion, potatoes and tomatoes. Fodder crops occupy only a very small part of the cultivated area, and green fodder cultivation in the European sense has only recently been introduced into the region. Much of the rough grazing area included in the estimate of this category of land use ocur in steppe areas which at other times, in different climatic conditions, might be classified as non-agricultural land. Woods and forests are found chiefly in the mountainous areas in the region. In sheltered valleys, some forest trees are cultivated, mainly poplar trees, which can be sold in local timber markets for the use of their poles in the construction industry. Most forests consist of oak trees. Riverine forests along the Tigris and its tributaries consist mainly of poplar, plain-tree, and willow. In artificial forests around the cities of Mosul, Erbil, and Kirkuk Eucalyptus trees are raised in green-belts.

Table 1.26 LAND USE CATEGORIES IN NE IRAQ*

Land Use	Area (ha)		%
Arable:	3,160,212	(100.0)	37.4
cereals	1,808,460	(57.2)	21.4
vegetables	29,315	(0.9)	0.3
fruit orchards	18,513	(0.6)	0.2
industrial crops	47,910	(1.5)	0.6
fodder crops	56,000	(1.8)	0.7
forest crops**	8,500	(0.3)	0.1
marginal***	1,191,514	(37.7)	14.1
Medows, permanent grassland and rough grazing	186,448		2.2
Woods and forests	1,725,900		20.4
Non-agricultural land	3,371,040		39.9
Total surface area	8,443,600		[99.9]

* Arable land estimates from the 1971 agricultural census; figures on pastures from Radhwan (1975); forest estimates from Nasser (1984).

** Mainly poplar and plane-tree plantations in sheltered valleys. Also include olive and almond trees.

*** Includes lands left fallow for over three years.

In NE Iraq the mountainous terrain both limits soil depth and quality. Only in the extensive plains, and on the mountain-basin floors, that adequate farming can be practised on a large scale. In the steeply folded mountains with their narrow valleys, gorges and uneven floor basins, land use categories are found as fractionated patterns of croplands, open rangelands, and low (coppice) oak forests. The original form of vegetation in the mountainous areas was undoubtedly woodland, completing a clearly defined altitudinal zoning of vegetation. The present situation of these forests, however, is extremely poor. The region's woodlands are in a very bad shape. Most have been overexploited; cut down for fuel or overgrazed by goats, with stumps in the ground to ensure regrowth for future requirements. At lower altitudes, cultivation has pushed the lower limits of the region's forest range upwards.

LAND USE ZONES. In his Provisional Map of Land Use in Iraq, Davis (1957?) has recognised four major patterns of land use in NE Iraq. These zones consist of:

I. high forests;
II. open rangelands;
III. low woodlands (mainly scrub oak);
IV. rainfed agricultural tracts.

With the exception of a number of dams and barrages constructed later, the land-use categories recognised by Davis have not undergone a substantial change. The units are demonstrated in the land use map in appendix II.

CHAPTER 2 :

CLIMATE,HYDROLOGY,VEGETATION & LANDFORMS

2.1 CLIMATE

The climate of the NE region is generally semi-arid, characterised by a hot summer and a severe winter. According to the FAO `agroecological zones project´, four climatic zones can be recognised in NE Iraq. In order of **intensity,** these are (SW-NE):

- Subtropical semi-arid Mediterannean;
- Subtropical Mediterranean;
- Cold temperate Mediterranean; and
- Continental Mediterranean.

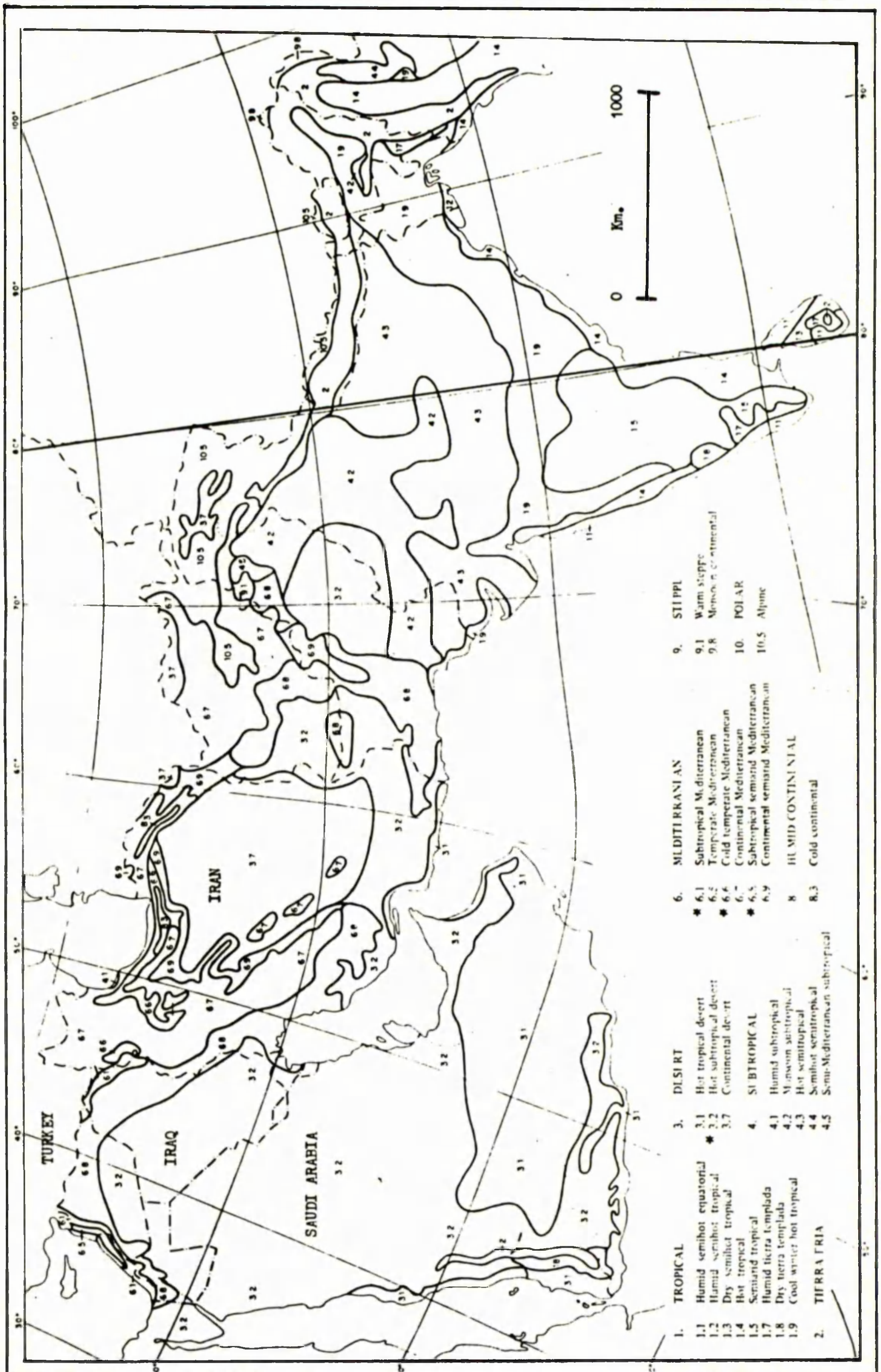
Mediterranean climate therefore dominates most of the region. This is demonstrated in figure 2.1 (FAO 1978).

The subtropical element in the region´s climate, although of minor presence, stems from the latitude position of NE Iraq (between 37-10^{O} and 34-50^{O}). The regions between 23.5^{O} and 35^{O} are generally regarded as subtropical (ILACO 1981, p. 469). Outside the NE region, the rest of Iraq is therefore normally classified as hot subtropical desert (figure 2.1).

2.1.1 TEMPERATURE

Temperature is dependent on a number of factors: altitude, day length, and geographical location. It is known that the average temperature decreases by about 0.6^{O}C with every 100m increase in altitude. Differences of course exist over geographical location, the season of the year and length of the day. What is clear is that the NE region,

Figure 2.1 THE AGROECOLOGICAL ZONES OF THE MIDDLE EAST



Source: FAO/UNESCO 1974

being predminantly hilly and mountainous, enjoys mild temperatures. Mean temperatures in the region are above 20 degree centigrade only 6 months of the year. In order to understand the pattern of temperature distribution throughout the year, table 2.1 provides detailed examination of the temperature parametrs. The data are taken from the records of Mosul meteorological station (36-20N/43-08E). The figures are representative for most other parts of the region (IMO 1982, pp. 115-117).

Table 2.1 TEMPERATURES DISTRIBUTION
(32 Year averages)

Temperature category	Monthly averages J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	06	08	12	17	24	30	32	32	27	21	14	08	19
Maximum	12	14	19	24	33	39	43	43	39	33	22	14	28
Absolute max.	19	26	31	40	42	48	51	48	47	40	35	24	51
Minimum	02	03	06	09	14	18	22	21	16	11	08	03	11
Absolute min.	-9	-6	-4	00	06	10	15	13	07	00	-3	-7	-9

Soil tempratures in the region show in general a systematic monthly fluctuation. Temperatures decrease with increasing depth and drop in air temperatures during the hot months of the year (April to August), while in colder months the soil profile tends to become warmer with increasing soil depth. IMO (1982, p. 121) reported the following data for soil temperatures in the Mosul meteorolgical station (table 2.2):

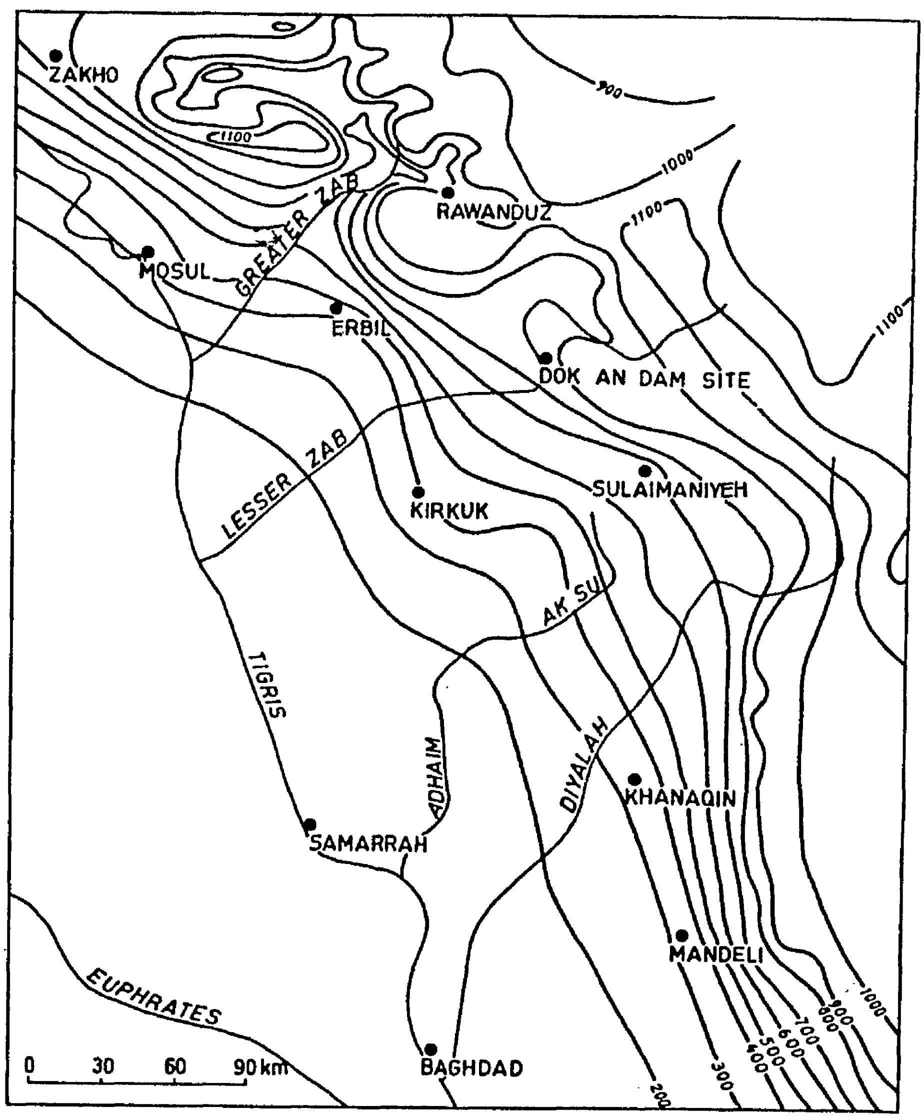
Table 2.2 SOIL TEMPERATURES DISTRIBUTION
(6 year averages)
°C

Depth (cm)	J	F	M	A	M	J	J	A	S	O	N	D	Annual
10	09	10	16	23	29	33	34	34	31	26	18	10	20
50	13	12	12	22	27	31	33	34	32	28	22	15	23
100	16	16	18	21	25	28	31	32	32	29	24	19	24

2.1.2 PRECIPITATION

Rainfall is the most important climatic factor as far as plant growth is concerned. The region´s farmers are dependent on rainfall for water supply as the majority of NE Iraq´s agricultural acreage is rainfed. Unlike temperature, rainfall vary from one year to another; and it is generally observed that the region´s isohyetal lines are more or less parallel to the physiographic-structural trends (Al Ansari 1981, p. 36). The region´s levels of precipitation vary between 200mm to over 1000 as indicated in figure 2.2 (Buringh 1960).

Figure 2.2 ISOHYETAL LINES OF NE IRAQ



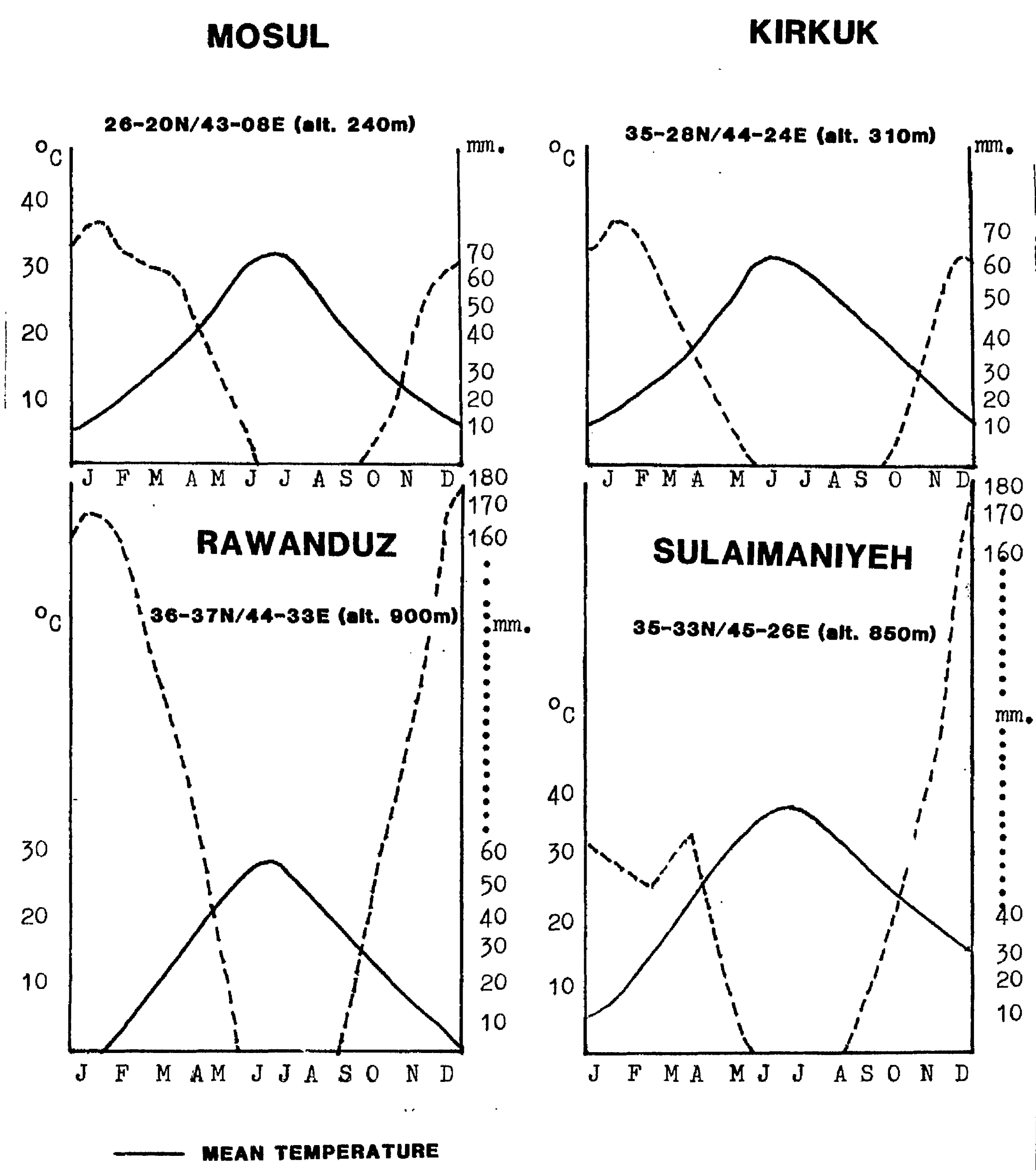
Source: Buringh 1960

Wernstedt (1972, p. 236) has reported the rainfall data of a number of meteorological stations in NE Iraq. The data clearly reveal the strong correlation between the level of precipitation and the geographical location in relation to altitude, as shown in table 2.3.

Although for perennial crops annual rainfall levels serve as suitable indicators of water supply, annual crops require suitable seasonal rainfall. Rainfall, however, may vary considerably from year to year and also from season to season. In the case of annual crops, particularly for those with short growing periods like wheat and barley, it is important to know during which months the required amount of rainfall falls. Unpredictable rainfall has often lead to a widespred practice of delaying sowing in the region until the farmers make sure that sufficient rainfall will be available for their crops. Heavy rainfall on the other hand is perceived by the region´s farmers as a sign of unsuccessful cropping season. Heavy rains may cause erosion particularly on sloping terrain, and seeds or plants are often washed away following a long shower.

Rain scarcely fall in the NE region during the months of summer. The months June, July, August and September are often dry, and no rainfed cultivation is possible during this period. Four climadiagrams are given in figure 2.3 for the areas of Mosul, Kirkuk, Rawanduz (in Erbil province) and Sulaimaniyeh. The figures clearly show a strong rise in temperatures during the middle months of the year, coinciding with a sharp drop in rainfall(Guest 1966; Majed 1982).

Figure 2.3 CLIMADIAGRAMS OF FOUR AREAS IN NE IRAQ



Source: Calculated from IMO 1982.

Table 2.3 **RAINFALL OF NINE METEOROLOGICAL STATIONS IN NE IRAQ (mm)**

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1	108	154	138	133	069	0	0	0	0	043	114	108	870
2	208	216	170	127	020	0	0	0	0	023	118	123	1005
3	135	098	107	156	029	0	0	0	0	005	042	085	557
4	112	092	078	064	033	0	0	0	0	012	051	076	702
5	070	078	053	047	018	0	0	0	1	005	048	062	382
6	066	070	081	043	007	0	0	0	0	004	036	063	371
7	311	245	239	105	054	0	0	0	0	051	130	204	1339
8	119	116	122	117	041	0	0	0	0	009	079	117	0720
9	157	134	126	110	042	0	0	0	0	031	090	127	0817

	Area	Location	Altitude (m)
1	Amadiyeh	37-06N/43-54E	1200
2	Aqra	36-45N/43-54E	750
3	Chemchemal	35-30N/44-50E	700
4	Erbil	36-11N/44-01E	1080
5	Mosul	26-20N/43-08E	240
6	Kirkuk	35-28N/44-24E	310
7	Penjwin	35-36N/45-58E	1300
8	Sulaimaniyeh	35-33N/45-26E	850
9	Zakho	37-08N/42-40E	450

Source: Calculated from IMO 1982.

2.1.3 ATMOSPHERIC HUMIDITY

The relative humidity of the air closely depends on the amount of rainfall. Relative humidity may serve as a suitable indicator for incidence of plant disease (especially fungal diseases). Dent and Young (1981, p. 166) have also proposed the relative humidity factor (RH %) as a land characteristic which may be used to measure or estimate air humidity as an atmospheric factor affecting plant growth, especially in the case of rainfed agriculture.

Relative humidity (RH) is a measure of the moisture in the atmosphere: the degree of saturation from the total vapour pressure divided by saturation vapour pressure. RH percentages in the NE region, as compared to the other regions, do not drop below 25 per cent. The highest values (over 75 per cent) are observed during the winter months (December to February). During the summer, however, relative humidity is often below 40 per cent (the lowest level is normally during July, where RH reaches almost 25 per cent). Annual mean relative humidity, nevertheless, is usually over 50 per cent. Details are shown in table 2.4 (Thalen 1979, p. 64).

Table 2.4 reveals that the annual relative humidity in the region is 20 per cent higher than RH mean annual level of the central region of Iraq, and 11 per cent lower than the level of RH in south Iraq. If compared, the seasonal RH trend is clearly of negative correlation to the temperatures and roughly, but directly, proportional with rainfall.

Table 2.4 RELATIVE HUMIDITY (%) FIGURES FOR THREE REGIONS IN IRAQ (29 years)

Rgion	J	F	M	A	M	J	J	A	S	O	N	D	Annual
North (Mosul)	82	76	70	62	44	30	26	29	34	49	67	83	54
Central (Baghdad)	71	62	52	44	31	23	23	24	27	36	56	71	43
South (Basra)	78	70	64	58	53	49	49	48	50	56	69	78	60

Source: Thalen 1979, p. 64.

2.1.4 EVAPORATION

Data on evapotranspiration are scarce in Iraq. UNESCO (1975) emabarked on scheme in the early 1970s to contribute on natural resources research in the country. One striking result emerging from the UNESCO investigations on the levels of evapotranspiration in Iraq is the disproportionally high levels of evaporation (responsible for moisture stress) compared to the amount of rainfall. Evaporation is greatest in the central parts of Iraq, and in all cases the highest during the summer months (table 2.5). In the northern region (figures available for Mosul), the winter months´ daily mean evaporation ranges between 2 to 21 mm. There is a rapid increase in spring; and during the summer months, evaporation is several times higher than the winter months´ levels. Autumn levels are roughly similar to those of early spring months: between 4 and 6mm per day. The annual total evaporation is over 3 metres.

Table 2.5 **MEAN DAILY (per season) EVAPORATION (mm) FOR THREE REGIONS IN IRAQ**
(class A pan figures)*

Reg.	Winter D J F	Spring M A M	Summer J J A	Autumn S O N	Annual mean	Annual total
1	2.5	6.8	16.3	4.8	8.6	3139
2	5.0	8.9	15.5	5.9	9.1	3322
3	2.3	6.3	8.5	3.9	5.6	2044

	Area	Location	Mean annual temp. (^{o}C)	Rain (mm)	RH %
1	Mosul	36-20N/43-04E	19	382	54
2	Baghdad	33-20N/44-25E	23	147	43
3	Basra	30-33N/47-48E	25	171	60

Source: UNESCO 1975.

2.1.5 SEASONS AND CLIMATIC VARIATIONS

There is a strong element of seasonality in the climate of Iraq. This has a great impact on all climatic parameters including those discussed above. In lower Iraq, the year is divided into two well-marked seasons with short transitional periods between: the long hot rainless summer (May to October) and the comparatively short cool winter (December to February). The transitional seasons in the north and NE are more pronounced (Guest 1960, p. 18).

* Clearly the figures provided in table 2.5 above are very high, and should therefore be treated with discretion.

Four seasons can be distinguished in the north and NE region:

Winter (December-February). Winter is invariably cold and, relatively, wet. Snow and frost are common. 43 to 57 per cent of the annual rainfall in the NE region fall during this season (table 2.3). Relative humidity is also the highest during winter (often over 75 per cent). Average minimum temperatures are often below 3°C, while mean temperatures are 6-8°C.

Spring (March-May). This season is characterised by a gradual increase in temperatures and evaporation, as well as a drop in relative humidity. Mean temperatures during spring range between 12-24°C. Rainfall often falls in strong showers, and at least one quarter of the annual rainfall is accounted for by spring rains. Sowing of annual crops often takes place during end of February to early March. In years with late rains, however, sowing is delayed until sufficient rainfall is secured. These years are not uncommon.

Summer (June-August). Summer is the driest and hottest part of the year. Rainfall is scarce; potential evaporation is the highest (over 16mm/day in Mosul). July and August witness the highest daily temperatures in the year (mean daily temperatures registeded are in the region of 30°C, but maximums above 40°C are not uncommon).

Autumn (September-November). Autumn in north Iraq is characterised by a sharp change in rainfall and relative humidity patterns which witness a rise greater than the opposite spring trends. Daily rise in relative humidity, for instance, climbs twice as rapidly as the opposite trends in the spring season. Air and soil temperatures as well as evaporation, however, do not change so emphatically, and the transition is often smoother than those during the spring.

Seasonal variations are best understood in terms of seasonal trends in temperature and other climatic parameters, calculated in average daily variations for the transitional seasons (spring and autumn). The figures for the Mosul area of north Iraq are calculated from the UNESCO report (1975, passim), as shown in table 2.6.

Table 2.6 SEASONAL VARIATION TRENDS IN CLIMATE

	Average Daily Variations (%)	
Climatic Factor	Spring M A M	Autumn S O N
Air Temp.	+ 0.8	- 0.7
Topsoil Temp.	+ 0.7	- 0.6
Rainfall	- 1.2	+ 4.4
Relative Humidity	- 0.5	+ 1.0
Evaporation	+ 2.1	- 1.3

Source: Calculated from UNESCO 1975.

2.1.6 DAY LENGTH AND RADIATION REGIME

Photoperiodism and solar radiation play an important part in deciding growth periods and radiation regime. Deviation in day length in Iraq is not greatly pronounced. There is a 3-hours-and-ten-minutes deviation between the longest and shortest days in the year. Most plants grown in the NE region are `long-day plants´. From May to August, the NE region, as well as other parts of the country, receive a very high level of solar radiation. In the peak of summer, solar radiation is about 680 $mWh.day^{-1}.cm^{-2}$. This sharply drops during winter to below 300 $mWh.day^{-1}.cm^{-2}$, as demonstarated in table 2.7. During the main growing season in spring, the region recives a good deal of solar radiation, above 560 $mWha.day^{-1}.cm^{-2}$.

Mean number of hours per day with sunshine is also the highest during summer (about 12 hours). During spring, this is normally 8.3 hours; and in terms of percentage of possible duration of sunshine, the average during spring is 64 per cent. Data on radiation regime are scarce, and only recently (in Mosul, first registrations were made in 1970) have there been information on solar radiation. The data in table 2.7 have been calculated from the UNESCO report on Iraq´s natural resources (1975).

The intensity of the solar radiation in Iraq is responsible for the extreme levels of moisture stress in the region´s soils. Shading as a means of protecting vinyards and plant nurseries is not uncommon.

Table 2.7 RADIATION REGIME AND SUNSHINE IN NORTH IRAQ

Season	Number of hours of sunshine	Possible Duration %	Mean Rad. $mWha.day^{-1}.cm^{-2}$
Winter	5.2	69	299.8
Spring	8.3	64	563.0
Summer	11.9	88	678.9
Autumn	7.5	69	361.1

Source: UNESCO 1975.

2.1.7 OTHER CLIMATIC FACTORS

WIND. Gales are not common in the NE region. During most of the year, the region falls under an area of high pressure, and the prevailing wind in all months is north-westerly. Table 2.8 lists wind speed for two meteorological stations in the NE (As-Sarraf 1979, p. 36)

Table 2.8 MONTHLY DISTRIBUTION OF WIND SPEED (m/sec.)

Station	J	F	M	A	M	J	J	A	S	O	N	D	Yr.
Mosul	2.3	2.7	2.7	3.0	3.1	3.4	3.3	4.9	2.7	2.2	2.0	2.0	2.6
Kirkuk	2.0	2.3	2.5	2.7	2.5	3.5	2.4	2.2	2.0	1.8	1.8	1.9	2.2

Source: As-Sarraf 1979, p. 36.

During winter months, however, depressions pass eastwards from the Mediterranean. These are accompanied by unsettled weather, strong winds (often south-easterly) and rains. During late spring and the summer, wind speed rises as a result of the dry air fronts paasing over Iraq from the south, often accompanied by a climb in temperatures.

MIST AND FOG. Mist and fog at night and in the early mornings follow the rain in winter, but this is local and rarely outlasts sunrise. In the Mosul area, there are on average 17 days of the year with fog. Fog is most frequent during the cold months in winter (December-February), as shown in table 2.9 (As-Sarraf 1979, p. 51).

Table 2.9 DAYS OF YEAR WITH FOG

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1	2.6	2.9	1.0	0.6	0	0	0	0	0	0	2.5	4.0	13.6
2	5.5	1.6	1.1	0.6	0	0	0	0	0	0	2.5	5.4	16.7
3	1.1	0.2	0.1	0.0	0	0	0	0	0	0	0.2	0.6	03.3

Station	Area	Location
1	Salahuddin	35-33N/46-18E
2	Mosul	36-20N/43-08E
3	Kirkuk	35-28N/44-24E

Source: As-Sarraf 1979, p. 51.

RAINSTORMS. In the Mosul area, less than 15 per cent of days per year are with rainfall over 10mm. During spring, however, there are, on average, 8.3 days with rainfall over 10mm, and 3.7 days with strong rainfall (over 30mm). In February, showers are most frequent. The data in table 2.10 have been calculated from As-Sarraf (1979, pp. 48-49).

Table 2.10 CLASSES OF RAINY DAYS IN MOSUL (1941-1975)

Class (mm)	J	F	M	A	M	JJA	S	O	N	D	Annual
1 - 10	9.5	7.6	9.1	7.8	3.6	1.5	0.2	2.0	4.7	7.7	53.7
11 - 30	2.4	1.9	2.5	1.4	0.7	0.0	0.0	0.2	1.2	2.3	12.6
> 30	1.1	2.2	2.4	1.2	0.1	0.0	0.0	0.0	0.5	1.9	09.4
Total	13	11.7	14	10.4	4.4	1.5	0.2	2.0	6.4	11.9	75.7

Source: As-Sarraf 1979, p. 48-49.

CLOUDINESS. Cloudiness in Iraq in often measured on an octamerous scale (in Oktas). In the NE region, the highest levels of cloudiness occur in March. Cloudiness, however, seldom reaches 5/8. Clouds during the rainless months (June to August) often do not give rise to rain on a measurable scale. During summer, cloudiness ranges in the NE region between zero in some areas, and one (1/8) in high altitudes. The data from three meteorological stations in the region are listed in table 2.11 (As-Sarraf 1979, p. 52).

Table 2.11 CLOUDINESS IN NE IRAQ

(in Oktas)

Station	J	F	M	A	M	J	J	A	S	O	N	D	Yr.
1	4.5	4.7	5.0	4.8	3.6	0.9	0.4	0.6	0.5	2.8	3.9	4.3	3.0
2	4.6	4.4	4.6	4.2	3.3	0.8	0.5	0.4	0.6	2.2	3.5	4.1	2.8
3	4.0	3.8	4.0	3.6	2.7	0.5	0.4	0.3	0.4	1.8	3.1	3.5	2.3

1=Salahuddin, 2=Mosul, 3=Kirkuk (see table 2.9 for location)
Source: As-Sarraf 1979, p. 52.

FROST. Bailey (1979, p. 86) has classified frost frequency in the Mosul area as moderate. Total number of days with frost in the NE region seldom exceed 30. No frost occurs outside the period December to March, as shown in table 2.12 (As-Sarraf 1979, p. 40).

Table 2.12 FROST FREQUENCY IN NE IRAQ (Days)

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1	10	11	1	0	0	0	0	0	0	0	1	6	29
2	10	5	2	0	0	0	0	0	0	0	2	9	28
3	4	4	1	0	0	0	0	0	0	0	1	2	12

1=Salahuddin, 2=Mosul, 3=Kirkuk (see table 2.9 for location)
Source: As-Sarraf 1979, p. 40.

2.1.8 ARIDITY

Diverse climatic conditions give rise to very different situations. Beyond a simple classification into arid and semi-arid zones in the NE region, it is important to consider the distribution of rainfall, measurable through the winter concentration of precipitation (R). The classification of the seasonal distribution of precipitation can be achieved through scaling the R percentage, as shown in table 2.13 (Bailey 1979, p. 95). The value of R can be estimated from the formula:

$$R = (Wp / Ap) \times 100$$

Where,

R = Concentration of winter rainfall
Wp = Winter precipitation
Ap = Annual precipitation

In the case of rainfed cultivation, which is the predominant type in the NE region, dryland farming techniques are well suited to zones with winter rainfall, since evaporation is then relatively low and part of the water can be stored in the ground and used by the plants the following year. These techniques, therefore, cannot be useful outside the rainy season because evaporation can be very high (UNESCO 1977, p. 11). The term winter rainfall, however, is a broad one, and in this context it means all precipitation in the period October to March in the northern hemisphere and April to September in the southern hemisphere (Bailey 1979, p. 95).

Table 2 .13 THE CLASSIFICATION OF THE SEASONAL DISTRIBUTION OF PRECIPITATION AND THE NE REPRESENTATION

R %	Rainfall Class	Representative NE Zones
0 - 20	Strong summer	
21 - 40	Summer	
41 - 60	Even	
61 - 80	Winter	
81 - 100	Strong winter	All zones

It is obvious from the strict view of precipitation that rainfed agriculture can be accommodated in the NE region. However, precipitation alone cannot determine the level of aridity without the contribution of other climatic factors, especially temperature. Bailey (1979, p. 77) produced a moisture index which can be calculated from monthly and annual data of temperature and precipitation. In annual form the index is defined:

$$S = \sum_{i=1}^{12} Si$$

The monthly moisture index (Si) is:

$$Si = 0.18\, p / 1.045^{t}$$

Where p is mean monthly precipitation in cm, and
t is mean monthly temperature in ^{o}C

The index has a special relevance to the examination of aridity in the region because it offers a simple method of deriving conclusions on aridity without necessitating a body of data on other scarce inventories such as records of actual evaporation, runoff and soil moisture budgets. Bailey´s formula has accommodated most other climatic attributes which have been reduced to empirical constants. The moisture provinces as defined by Bailey´s index, along with (calcualted) representative climatic zones are listed in table 2.14 (calculated from Bailey 1979, p. 79).

A radiational index of dryness (D^*) can also serve to indicate the aridity levels in the region, through the formula:

$$D^* = R / L \times P$$

Where R is annual net radiation (%)

L is the latent heat of evaporation (cal/mg)

P is annual precipitation in cm

The lack of relaiable data on net radiation and latent heat of evaporation (although generally assumed 600 cal/mg) will make it impossible to measure the radiational index of dryness with accuracy and for all areas in the region. However, the linear regression of D^* against S (of Baileys´s moisture index), expressed by $1/D^* = 0.13\ S - 0.2$ (Bailey 1979, p. 81), shows a high D^* value which in Mosul is 4.4. This is classified as mid-way between semi-arid and arid climate systems (Bailey 1979, p. 83).

Table 2.14 ARIDITY INDICES AND NE REPRESENTATIVE ZONES

S	Moisture Zone	Realm	NE Zones	Calc. S
< 2.5	Arid	Dry		
2.5-4.7	Semi-arid	Dry	5,6	4.2,4.3
4.8-6.36	Dry Sub-humid	Dry	4	5.8
6.37	...........Dry to Wet	climate	threshold	....
	Moist Sub-humid	Wet	3,8,10	7.3,8.0,6.7
6.38-16.2	Humid	Wet	1,2,7,9,11	9.3,11.3, 15.4,9.1,10.2
> 16.2	Perhumid	Wet		

Zone	Area	Location	Altitude (m)
1	Amadiyeh	37-06N/43-54E	1200
2	Aqra	36-45N/43-54E	750
3	Chemchemal	35-30N/44-50E	700
4	Erbil	36-11N/44-01E	1080
5	Mosul	26-20N/43-08E	240
6	Kirkuk	35-28N/44-24E	310
7	Penjwin	35-36N/45-58E	1300
8	Sulaimaniyeh	35-33N/45-26E	850
9	Zakho	37-08N/42-40E	450
10	Dohuk	36-52N/43-00E	330
11	Rawanduz	36-37N/44-33E	900
12	Salahuddin	36-17N/44-13E	1080

Source: Figures are calculated from Bailey's index (see page 83).

2.2 HYDROLOGY AND WATER RESOURCES

2.2.1 INTRODUCTION

The hydrology of the NE region is governed by the following conditions:

1. Annual potential evaporation is significantly greater than annual precipitation.
2. Precipitation occurs only during well-defined seasons and tends to vary strongly from year to year.
3. Plant cover is limited primarily by the availability of soil moisture.

Practically, however, the values of potential evaporation can be expressed as a rather stable function of the year's season; and precipitation remains the only stochastic parameter of interest.

Although good quality groundwater is available in the NE region, levels of recharge/discharge vary widely in different areas. Discharge levels are generally below 200 litre/minute in areas east of the Tigris river (al-Bahrani 1979, p. 71). Springs, however, are numerous, and although no complete data are available on their actual number and levels of flow, a 1975 report prepared by the Iraqi Supreme Agricultural Council indicates the importance of these sources of water in the region, mainly in the areas of irrigating fruit orchards and meeting water requirements for human and animal consumption (SAC 1975, papers 1-4).

2.2.2 THE WATER CROP OF NE IRAQ

Empirical rules are often employed in estimating the annual water crop. One particularly useful formula has the form:

$$R = a \times (P - b)$$

Where,

R = Water crop (mm/year)

P = Precipitation (mm/year): snow and rain

a & b = Constants

In the Mediterranean climates, a and b in the above formula were found to be 0.9 and 360, respectively (Mandel 1973, p. 42-43). As shown in table 2.15, the lowest levels of water crop are in the low altitudes of the Kirkuk-Mosul-Erbil plain. It is significant, however, that no part of the NE region seems to possess a negative estimate of water crop.

2.2.3 RUNOFF

Almost all of the surface runoff in the NE region occurs at irregular intervals, in the form of local floods. A seasonal regularity of the flow characteristics is observed only in rivers that are fed from snow melt.

The time lag between the beginning of precipitation and the onset of surface runoff depends on the properties of the individul soil types. In general, however, the high clay

Table 2 .15 WATER CROP ESTIMATES IN NE IRAQ

Station	Location		Altitude	Water Crop
	N	E	(m)	(mm/Yr)
Amadiyeh	37-06	43-54	1200	459
Aqra	36-45	43-54	750	580.5
Chemchemal	35-30	44-50	700	177.3
Erbil	36-11	44-01	1080	307.8
Mosul	26-20	43-08	240	19.8
Kirkuk	35-28	44-24	310	9.9
Penjwin	35-36	45-58	1300	881.1
Sulaimaniyeh	35-33	45-26	850	324.0
Zakho	37-08	42-40	450	411.3
Dohuk	36-52	43-00	330	212.7
Rawanduz	36-37	44-33	900	504.1
Salahuddin	36-17	44-13	1080	274.5

content in the region´s soils often causes the soil to swell and become practically impervious once the uppermost layer has been wetted.

Reports on runoff in the region are scarce and often contradictory. Few years´ data on runoff cannot allow a meaningful statistical inference (ILACO 1981, p. 238). Furthermore, methods of hydrologic analysis in examining runoff can only be useful when they rely on the assumption that rain is distributed evenly over the entire catchement areas (Mandel 1973, p. 43). Therefore under the conditions in the region, accurate estimates are unattainable. In generall, however, runoff in the region is registered after 8-12mm of antecedent precipitation.

Surface runoff strongly depends on rainfall intensity, and for that reason (see table 2.10) is extremely irregular. As discussed in section 2.1.7, high intensity rainstorms tend to be few and of small areal extent.

2.2.4 GROUNDWATER

Present groundwater utilisation in Iraq in general forms only a small proportion of the water resources of the country. Of the estimated 1-1.2 km^3 groundwater reserves, less than 2 km^3 is exploited. Despite lack of sufficient data, many Iraqi hydrologists believe that high groundwater reserves can be found in the water aquifers of the NE region of Iraq (Al Ansari 1981, pp. 40-41).

On the basis of petrological, physiographical and structural characteristics, Iraq has been divided into five regions with respect to groundwater reserves (Al Ansari 1981, p. 40): 1) the mountainous region; 2) the foothills region; 3) the groundwater of the Mesopotamian plain; 4) the Jazira plateau groundwater; 5) the groundwater of the western and northern deserts.

2.2.4.1 THE MOUNTAINS GROUNDWATER

The groundwater of the mountainous region extends over a subsurface area estimated at 20,000 sq. km. The water is trapped between fractured limestones and sandstones of mainly cretaceous rocks, usually flowing out as springs. The water table is normally at depths of 4-16m.

The groundwater of these aquifers is often of good quality, especially inside valleys with recent gravel and sand deposits. Total dissolved solids (TDS: mainly carbonates) are seldom greter than 350 ppm. The discharge rate of the region´s aquifers is foten around 150 l/min (litre/minute) (Al Ansari 1981, p. 40).

2.2.4.2 THE FOOTHILLS GROUNDWATER

This subarea of the north-east covers 62,000 sq. km. The borders of the extensive Kirkuk-Erbil-Mosul plain fall within this region. The aquifers here are mainly Pleistocene and Pliocene, although sometimes Miocene. Where the geological formations accommodate limestone beds, the water quality is better (less than 1000 ppm of total dissolved solids). The gypsum beds, although sparcely distributed, have subterranean waters with higher salt content (1000-2000 ppm).

The water trapped in the aquifers of this hydraulic region can be found at depths reaching 50m (Al Ansari 1981, pp. 40-41).

2.2.5 SURFACE WATER

The rivers flowing through the NE region have made it possible to irrigate some agricultural areas. But in general, they are still incompletely used. The flow characteristics of these rivers and streams introduce considerable variation, due to corresponding variations in the snow retention at any one year. Use of these water sources is governed by topography, levels of flow and speed of current. In most cases, therefore, irrigation is very limited because of difficult terrain, high speed of river flow and lack of adequate technology.

The inconsistencies of the water supply of the region´s rivers, tributaries and streams exert strong constraints on the irrigability potential of these water sources. One solution lies in the accumulation of water behind dams. However, in order to be efficient, a dam must be able to contain a year´s supply of water and, if possible, more than one; hence raising issues beyond the technical and investment standards of the region´s rural community. Two additional issues also require attention: first, there is the widespread problem of silting which, due to the lack of erosion checking measures, gives rise to further technical difficulties; second there is the problem of intensive evaporation from such reservoirs. In general, studies on the surface water of the NE region are very scarce. And in the foreseeable future, there is little prospect of increasing the levels of irrigation in the region to meet the water requirements for agriculture.

2.2.5.1 MAIN WATER STREAMS

The mean annual flow of the Tigris (the major river demarcating the west-side of the NE region) as it enters Iraq from Turkey is 31.5 billion m^3. Mean annual flow generated in the region has been estimated at 27.9 bilion m^3 (Badry 1980, p.315). Four tributaries in the NE region feed the Tigris (Figure 2.4: Ubell 1971).

1) The Khabur. This tributary joins the Tigris at a short distance from the Iraq-Turkey border. The data available indicate that the mean annual flow is 68 cumecs (cubic metre per second) (Al Ansari 1981, p. 37).

2) The Greater Zab. Joins the Tigris about 50 km south of Mosul. This tributary drains an area estimated at 25,810 sq. km, of which 16,600 sq. km is inside Iraq (Al Ansari 1981, p. 37). The mean annual discharge of the Greater Zab is 14.2 billion m^3 (Badry 1980, p. 316).

3) The Lesser Zab. The confluence of the tributary is near the Fatha (read Fat-ha: 35-05N/43-35E, a defiled cut through Himrin mountains). It drains an area of 21,475 sq. km, 25 per cent of which is inside Iran (Al Ansari 1981, p. 39). The mean annual flow of the Lesser Zab is 7.4 billion m^3 (Badry 1980, p. 316).

4) The Adhaim (Ak Su). This tributary marks the south of the NE region, joining the Tigris north of Baghdad. Mean annual flow is 0.7 billion m^3 (Badry 1980, p. 316).

2.2.5.2 THE MAJOR RESERVOIRS

There are two major dams in the NE region; both primarily designed to help control the floods of the Tigris and regulate utilisation of water supply in the central and southern parts of the country. Regulation of the water supply at the present time, however, is far from complete. About 20 per cent of the water of the Lesser Zab for instance is still uncontrolled, leading to occasional flooding (Badry 1980, p. 317).

The necessity of improving the control of the water of the Tigris tributaries has emerged in the recent past from loss of water from the Euphrates to Syria which is storing great quantities of the total flow of the Euphrates, leading to shortages in water supply in central and southern parts of Iraq.

Two major water-storage schemes are based in the NE region: the Dokan dam (35-43N/45-19E) on the Lesser Zab (60 km NW of Sulaimaniyeh); and the Darbandikhan dam (35-06N/45-43E: 50 km SE of Sulaimaniyeh on the upper part of the Diyala river).

Dokan dam. This reservoir is a semi-circular concrete dam of approximately 116m height. It is situated on the Lesser Zab river. The storage capacity is 6.8 km^3, of which 0.7^{km} is `dead´ storage. Total discharge capacity of the spillways is 270 cumecs (cub. m/sec). The dam is designed for flood control and also for generating power (Al Ansari 1981, p.40).

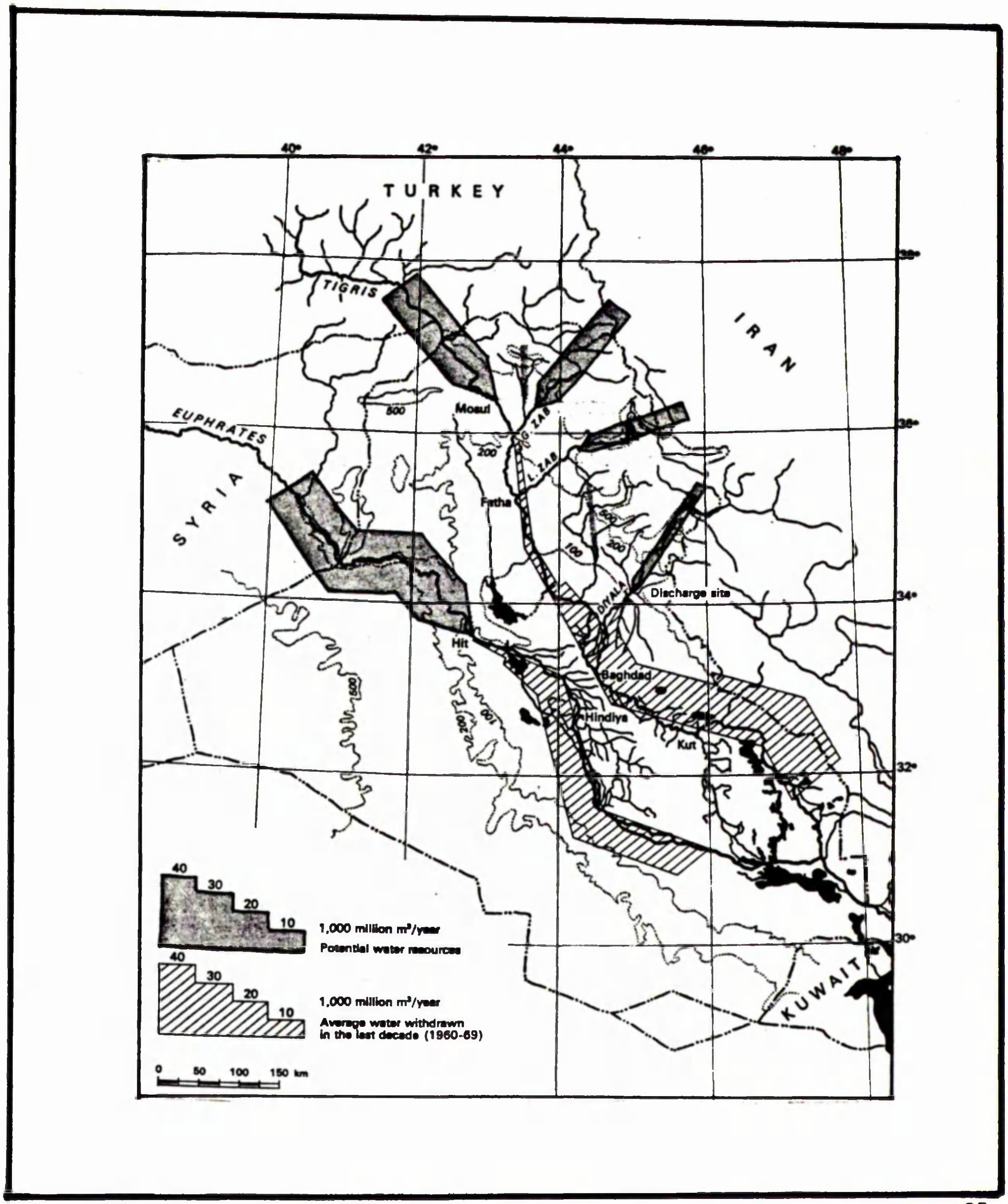
Darbandikhan dam. This is a rock-fill dam, located on the upper part of the Diyala river. The storage capacity is 3 Km^3, of which about 2.5 km^3 is live storage. Maximum discharge capacity of the dam spillways is 486 cumecs. The main functions of the dam are flood control, providing irrigation water to the agricultural fields in the lower parts of the Diyala basin. The dam can also be used to generate electricity (Al Ansari 1981, p. 40).

Three more water-storage projects are under construction in the NE region, to be operative by 1995. They include the Mosul dam on the Tigris, with 9.67 km^3 live storage; the Bakhma dam (36-37N/44-30E) with 7.1 km^3 of live storage; and the Fatha (Fat-ha) dam which will accommodate 19.3 km^3 of live storage.

Although only less than one per cent of the agricultural acreage in the region is under irrigation, the use of the surface water resources, especially the reservoirs, for power generation purposes is promising. Despite under-utilisation of the current resources for this purpose, it is estimated that generating electricity by hydro-electric methods is over 80 per cent cheaper and can serve large rural areas for diverse purposes (Badry 1980, p. 321).

Present levels of exploitation of the ground and surface water of the region are poor and inefficient. The NE region is still absolutely dependent for its agricultural purposes on rainfed cultivation, while other alternative sources mainly meet human and animal consumption.

Figure 2.4 LEVELS OF DISCHARGE OF MAJOR TRIBUTARIES IN IRAQ



2.3 VEGETATION

2.3.1 INTRODUCTION

The vegetation of the NE region is strongly governed by the type of climate, soil conditions and the hydrology. Special structural modifications and adaptations of growth cycle are manifest. Annual plants germinate with the first rains in late autumn, undergoing a rapid growth during the rainy winter; finally reaching maturity in late spring or early summer.

Survival mechanisms are restored by two important adaptations:

a) when the growth cycle is completed by the end of the cool rainy season, the plant dies while seeds survive, guaranteeing a revival in the next growth cycle;
b) structural adaptations in the form of deep rooting, bulbs and rhyzomes ensure the survival of the species in the face of strong physical constraints. Perennials develop a number of other structural modifications, including water-storage organs (water sacs), protective devices to reduce water loss and shedders.

Three major phytogeographical elements have been identified with the vegetation of Iraq, including that of the NE region: the Irano-Turanian element; the Mediterranean element (believed to be remnants of the Tertiary Paleo-Mediterranean vegetation); and the Saharo-Sindean element (Zohary 1950, p. 54).

2.3.2 THE STATE OF VEGETATION

Long term disturbance of the vegetation by deliberate mass burning, grazing and clearing for agriculture makes it difficult to assess what the natural vegetation of the region might have been. The response of the rural community in the region to the alarming pressure on the vegetation has not been always positive. Geographical mobility, adjustment of the density of the human and animal population and of the composition of herds to bring them in line with the carrying capacity of the rangelands are not keeping pace with the rapid degradation of the vegetative cover.

The main causes of the crisis are overpopulation of people and animals, particularly where animal husbandry and crop production have become competitive rather than complementary forms of land use. Despite the progressive decline of the environment, the size of herds has increased as a result of improved health conditions. Modern infrastructure and economic incentives have encouraged a new trend in motorised semi-pastoralism. During the closing weeks of spring, thousands of animals are brought into the region from the south to graze on the rangelands of NE Iraq. The grazing capacity of the region today barely meets 81 per cent of the feed requirements of the region's livestock (section 5.3.4).

The degredation of the vegetative cover has not always been always due to overgrazing. The traditinal use of wood for fuel and house construction (as well as digging sub-shrubs for fuel) has resulted in severe erosion which, in the absense of good management, has endangered many species of both grasses and fodder trees.

In a sampling process carried out by Mosul University in Iraq, an attempt has been made to investigate the correlation between density of natural vegetation (in reserve areas) and annual precipitation in north Iraq. On average, it was found that areas with limited rainfall (less than 350mm) had a density of 46 per cent. In areas with high rainfall (over 500mm), vegetation density was above 60 per cent, as shown in table 2.16 (Latif 1979, p. 183). The findings clearly demonstrated that good quality vegetation (often palatable) are most available in areas with adequate rainfall. Weeds often grow in greater densities in areas with limited rainfall, as weeds are more capable of adapting to drought and high temperatures. The table below cannot, however, be generally applicable, since the figures reflect vegetation densities in protected environment.

Table 2.16 VEGETATION DENSITY & PRECIPITATION LEVELS

Rainfall zone (mm)	Veg. Density(%)	Palatable	Weeds
< 350	46	39	7
351 - 500	57	39	18
> 500	64	53	11

Source: Latif 1979, p. 183.

2.3.3 VEGETATION ZONES OF NE IRAQ

Four vegetational zones have been recognised in NE Iraq: the moist-steppe zone; the forest zone; the thorn-cushion or sub-alpine zone; and the alpine zone. These zones are demonstrated in figure 2.5.

2.3.3.1 THE MOIST-STEPPE ZONE

The zone runs across the upper plains, the foothills and the lower mountain slopes, through a contour of 300-500m of elevation. Rainfall ranges between 350 and 500mm annually. The vegetational climax of the moist-steppe zone is represented by an open range dominated by pistachio and other small trees. Howver, hardly a trace of this climax remains today, because of human mismanagement. Even the smaller woody shrubs of the original climax vegetation have long been eradicated by the expansion of agriculture, while the more palatable plants have been eliminated by overgrazing.

The uncultivated and protected areas, though few, support a number of good (grazing) quality grasses dominated by *Poa bulbosa* (meadow-grass) and *Hordeum bulbosum* (a wild barley species). Subdominant species include *Anemone coronaria* (windflower). A number of endangered species have still survived in some areas, including timothy grass (English name for *Phloeum spp.*, known otherwise as cat´s tail-grass) (Guest 1966, p. 72).

The entire Kirkuk-Erbil-Mosul plain falls within the moist-steppe vegetational zone. However, the term moist has been used by a number of botanists, and particularly Guest, to distinguish the zone from the dry-steppe zone in the upper part of the mesopotamian plain of central Iraq (figure 2.5).

2.3.3.2 THE FOREST ZONE

Annual rainfall at this zone ranges between 700 to 1400mm, with the altitude ranging between 500 to 1750m. The dominant tree species in this zone is oak (Quercus spp.), which include three main groups: Q. aegilops, Q. Infectoria, and Q. libani. In a small area between Zawita (36-55N/43-15E) and Atrush (36-51N/43-20E), there are isolated stands of local pine trees (Pinus brutia).

The oak woodlands of the zone are usually poorly stocked and over-exploited. In less open areas (less accessible), good quality oak can be found. In general, however, the vegetation of this zone is sparcely distributed, covering steep rocky slopes and severely eroded hillsides. Human mismangement has turned the majority of the zone's oak forests into inferior coppice scrub-woodlands (Guest 1966, p. 73). Only commercial platanus orientalis (plane) and Populus alba (poplar) are raised by farmers for marketing in the region (Nasser, 1984, p. 302).

Subdominant tree species include: Juglans regia (wallnut); Crataegus azarolus (hawthorn); Juniperus oxycedrus (juniper); Rhus cariaria (sumach: a cashew-nut family tree); Pistacia khinjuk (pistachio: Iraqi dendrologists hurry to add `var. Kurdica´, to distinguish it from the `var. Atlantica´); and Celtis tounifortii (hackberry)(Shafiq 1981, pp. 60-61).

2.3.3.3 THE THORN-CUSHION ZONE

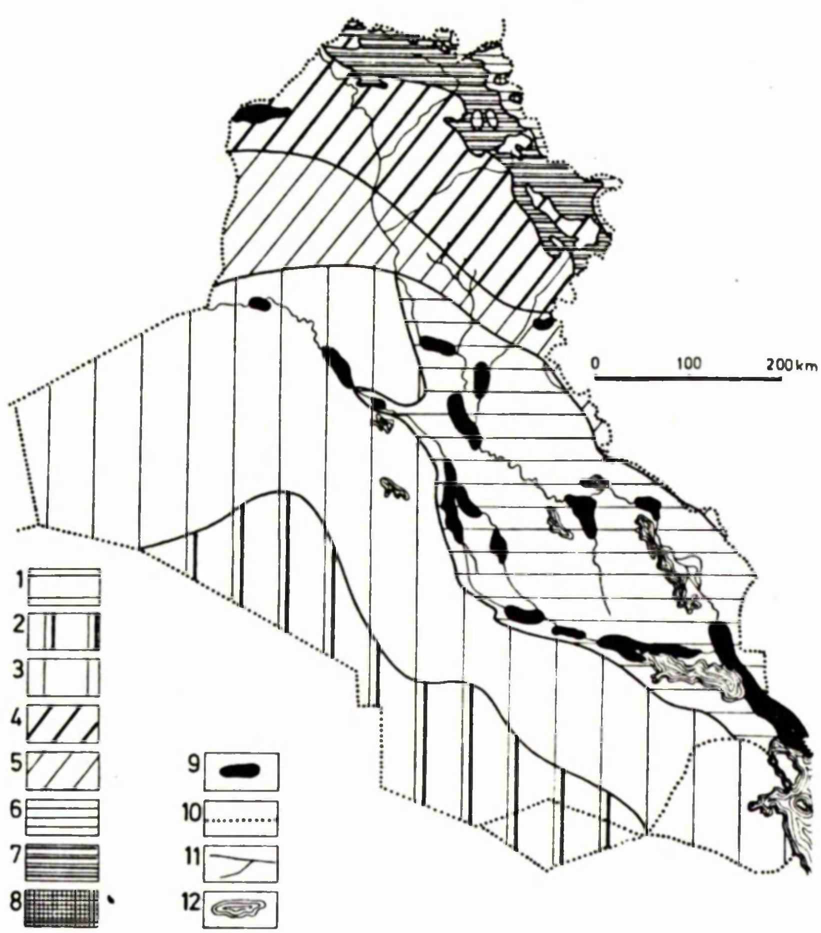
This zone is situated above the timber line from about 1750m to 2750m above sea level. Towards the lower limits of the zone, the thorn-cushion zone shares the same shrub species of the forest zone, such as Daphne acumenata (spurge berries; known for the medical qualities of its berries), Astragalus spp. (milk-vetch), Acanthus spp. (a plant akin to figworts) (Guest 1966, p. 73; Altaie 1969, p.74).

2.3.3.4 THE ALPINE ZONE

The vegetation of this zone is discontinuous and poor in species. It mainly comprises of areas with altitudes above 2750m above sea level. Aromatic perenial and annual plants covering the zone´s prairies make possible grazing on a fair scale during summer.

Most of the zone´s plants belong to the families Cruciferae (cresses), Compositae (akin to bell-flower plants) and Labiatae (mints) (Abul Haggag 1960, p. 353; Guest 1966, p. 73; Altaie 1969, p. 74).

Figure 2.5 VEGETATION ZONES IN IRAQ
(after Guest 1966)



1. Lower Mesopotamian plain region.
2. Desert zone | Desert region.
3. Subdesert zone |
4. Moist-steppe zone | Steppe region.
5. Dry-steppe zone |
6. Torn-cushion zone | Mountain forest region.
7. Forest zone |
8. Alpine region.
9. Principal areas of date palm cultivation.
10. International frontier.
11. Rivers.
12. Lake, sea.

2.4 THE GEOLOGY OF NE IRAQ

2.4.1 INTRODUCTION

There is no agreed framework for the structure of Iraq. Available accounts have not been able to produce a uniform assessment. However, the geological history of the country has been divided into three phases: a long period of marine submergence, the mountain building phase, and the subsequent period of erosional modification of the land surface (Altaie 1969, p. 67). Macfadyen (1966, p. 5) divided Iraq into three geological zones, namely the Iraqi portion of the Arabian shield, the foothills of the Zagros range, and the Mesopotamian plain. The geological strata of the foothills of the Zagros range are believed to have been strongly shaped (folded) during the Mesozoic age to form a series of NW to SE trending hill and mountain ranges. A great pressure from the NE has resulted in the formation of the mountain ranges in the region, through a process of geological rucking. A belt of confused topography stretching from near Rawanduz (36-37N/44-33E) to Halabcha (35-10N/45-59E) is made up of a variety of basic igneous and metamophic rocks.

Buday (1980, p. 19) classified the fooothill zone and the Zagros range as a part of an unstable shelf and a geocyncline successively . In the Mesozoic period, it is believed that the NE region lay in a large depression (the Tethys geocyncline), which was submerged by the sea and bordered by plateaux and tablelands. In the shallow sea (or shelf), sediments--mainly limestone--were deposited.

2.4.2 GEOLOGICAL HISTORY

The geology of the NE region has been shaped by three main geological eras: Paleozoic, Mesozoic, and Cenozoic.

The Paleozoic era. This era can be traced back to 240-540 million years. The metamorphic and igneous rocks of the Rawanduz-Halabcha strand are the product of this geological age. The lanscape of this area is characteristically complex and confused.

The geological history of NE Iraq indicates that it was covered by the sea during the Paleozoic era. The rocks of this area era mainly limestone, quarzites, shales, minor eviporites and local volcanics. The rock sequence indicates that erosional breaks had taken place during this age, although no angular unconformity has yet been recognised by Iraqi geologists to back this theory (Al Ansari 1981, p.37).

Mesozoic era. There are three geological sub-eras (periods) associated with the Mesozoic age. The Cretaceous period which has shaped the Zagros-mountains range, in the form of coastal sediments deposited on top of the mountainous area (approxiamtely 140 miilion years ago); the Jurassic period (approximate age, 175 million years) which is responsible for some geological structures found in a few parts of the NE region, especially in the area between Dohuk (36-52N/43-00E) and Zakho (37-08N/42-40E); and finally, the Triassic period whose effects are closely associated with the structures formed by the Jurassic period.

During the Triassic and Jurassic periods, marine limestones, dolmites and shales were deposited, indicating a geologic history similar to the Paleozic (namely, the NE region may have been largely still covered by sea during the Mesozoic era). It is believed that a major uplift took place on the eastern border of the region towards the end of the Cretacious period. As a result, the Mesozoic sediments were deposited in a NW-SE range (Buday 1980, pp. 110-121).

The Cenozoic era. This geological era is subdivided into two major geological periods of great importance in the geological history of the NE region: the Tertiary period (60 million years) and the Quaternary period (approximate age, 600,000 years). The deposits of the Cenozoic era show great variation. The two Cenozoic periods are discussed below.

The Tertiary period. Pliocene, Miocene (Fars formation), Oligocene and Eocene are the four common phases recognised in the region. The Pliocene constitute the Bakhtiari group, which mainly comprise conglomerates of limestone and other rocks, observed mostly in the Kirkuk-Erbil-Mosul plain. Miocene deposits consist mainly of siltstones and sandstones. Oligocene and Eocene rocks are mainly limestone.

The Quaternary Period. Two phases of Quaternary can be observed in the region: Pleistocene and Holocene (or recent Quaternary). The recent Quaternary occurs in delta fans of gravel and sand, especially where the foothills join the plains. The terraces of the region are mostly believed to have been shaped in the Pleistocene age.

2.5 THE PHYSIOGRAPHY OF THE REGION

2.5.1 INTRODUCTION

Along the NE region, the Kirkuk-Erbil-Mosul plain abuts on a series of foothills. The transition from the foothills to the Zagros mountains, of the north-east end of the region, is not always marked by an abrupt feature. It extends roughly from the lower end of the Zakho area and passes through or near such places as Dohuk, Aqra and Chemchemal. North-east of this line, the region is all mountainous, varying from some 500-800m in altitude in the lowest valleys and piedmont plains, to 3000-3500m at the summit of the highest ranges. Especially in the extreme eastern end the mountainous zone, the mountains are greatly crumpled and contorted; these are traversed by many deep gorges where streams have cut down sharply into the limestone rock. The general trend of the mountain ranges runs in a north-west to south-easterly direction. Extensive, more or less open and largely destroyed, oak forests occupy the mountain slopes in the 500-1800m belt. Above the tree line, the mountains are generally rocky and barren, and the psses are blocked with snow during the winter months.

One of the most important aspects of the physiography of the region is its influence on the distribution of the soil groups. Although the issue will be discussed in greater length in chapter 3 of this thesis, it is useful to outline the distribution of soils with reference to physiography.

Extending from the north-western borders of the Jezira plateau and the lower Mesopotamian plain of central Iraq, there is, as rain increases with increase in altitude, a transition from Reddish-Brown soils to Brown soils. Part of the region's piedmont plains and the foothills consist of shallow soils overlying gypsum, mud and sandstone, limestone and gravel; and some parts are deeply eroded, particularly in the Fat-ha district (35-05N/43-35E; a defiled cut through Himrin hills (alt. 50-100m)). In the Kirkuk-Erbil-Mosul plain, deep Brown soils can be found.

Farther to the east of this plain, most of the terrain of the high hills and mountains is rough, broken and stony lands comprising Lithosols, Rendzina soils, and shallow Brown and Chestnut soils with some deep Chernozem soils at certain places, and deep chestnut soils in the valleys between the ranges. These soils are very variable due to differences in exposure, runoff, slope, parent material, soil depth and maturity. The higher mountain tops are above the timber line and often very rocky, sometimes of limestons, or in the Nappe area on the Iran border, of metamorphic material.

The region's physiography can be broadly divided into five groups: the thrust zone; the Zagros mountains; the foothills; the upper plains. The distribution of these groups is not always continuous. Many well-watered valleys are to be found in the mountains, sometimes opening out into high rolling plains. The largest plain in the region, with agricultural importance, is the Kirkuk-Erbil-Mosul plain.

2.5.2 THE THRUST (NAPPE) ZONE

The Nappe zone, which comprises a tract of land with confused relief in the easternmost part of the region, is a large-scale tectonic overfold of the region's crustal rocks. The zone occupies a narrow strip on the farther end of the NE region. It is characterised by intensive topographic disturbances, demonstrated by the thrusting of the older over younger strata. The name Alpine is sometimes suggested to describe the uplifting which the zone has witnessed in relatively recent geological periods (the Mesozoic period, according to Macfadyan 1966, p. 8). According to Al Ansari (1981, p. 36), the zone occupies 5 per cent of the total surface area of the country, comprising of mountain ranges 2000-3500m in altitude.

The complicated mountain structures in this zone have given rise to a complicated morphological landscape. The presence of igneous and metamorphic rocks, together with sedimentary formations, add to the confusion. Glacial erosion is highest in this zone (Abul Haggag 1960, p. 353).

2.5.3 THE ZAGROS MOUNTAINS

The Zagros mountains are bounded by the north and north-eastern frontiers with Turkey and Iran respectively. This zone is characterised by anticlinical folds (often of asymmetrical structure) ranging in height between 500 and 2000m, passing from east of Zakho to south east of Halabcha.

The whole area consists of parallel ranges, trending north-west to south-east, generally with steep and somewhat overturned western flanks and more gentle north-east flanks (Al Ansari 1981, p. 36). The zone also includes some mountain valleys where the elevation falls well below the 500m contour, notably in the valleys of Zakho, and also the deep gorge and valley of the Greater Zab for some distance below Bekma (36-40N/44-14E; about 30kms to the north-west of Rawanduz). However, not included in the zone are certain outlying spurs and hills which rise above 500m, notably in the Kirkuk-Erbil-Mosul plain, such as Jabal Maqlub (36-30N/43-20E; name of a mountain 1100m high, 30 kms to the north-east of Mosul).

For the most part, the mountains form arches which are extensively eroded; the detrital material being deposited in the valleys and the rest of the area between the mountain ranges. In this process, the various older layers of limestone are consistently exposed at the top of the mountain ranges (Buringh 1960, p. 37).

2.5.4 THE FOOTHILL ZONE

The foothills constitute the lower line of hills that lie parallel with and at the foot of the higher Zagros mountain range. The foothills constitute a transition zone between the Zagros mountains of the NE region, the western Jazira plateau, and the Mesopotamian plain of the central part of Iraq (Altaie 1969, p. 69).

The foothill zone generally forms a fairly hilly landscape, consisting of low parallel hill ridges, in which several streams have cut their valleys, and where piedmont plains have been shaped. As the down-cutting was not always a continuous geological process, some terraces have been formed (Buringh 1960, p. 37).

2.5.5 THE UPPER PLAINS

The upper plains of the NE region are extensive tracts of flat or gently undulating land, without prominent hills or depressions. There are two major components of plain landscape in the region: the piedmont plains, and the extensive Kirkuk-Erbil-Mosul plain. These areas constitute a steppic sub-mpountainous belt, between the 500m contour of the foothills and the margin of the lower end of the Kirkuk-Erbil-Mosul plain.

THE PIEDMONT PLAINS. These consist notably of the plains of Zakho-Amadiyeh, Rawanduz, Dokan, Darbandikhan and Aqra. These plains are of gentle slope, leading down from the steep mountains. They are composed mainly of unconsolidated materials, such as sand and gravel, which together mantel the underlying rock. The material which may occur in the form of alluvial fan, is derived from surface runoff or intermittent streams. However, the origin of the Dokan plain (otherwise known as the Rania plain) is believed to be the result of a tectonic process rather than massive geological erosion (Mitchell 1957, p. 94).

THE KIRKUK-ERBIL-MOSUL PLAIN. The morphological landscape of this plain is of great simplicity. The general topography is a rolling synclinical structure, diversified, in places, by hills of relatively limited areal extent. The Kirkuk-Erbil-Mosul plain is the largest plain identifiable in the NE region. Most of the area of this plain is under cultivation, but grazing is also a major agricultural activity. The plain provides a relatively well-defined physical boundary, running in a north-western arc from Chemchemal to the north of Mosul.

2.5.6 MAPPING THE PHYSIOGRAPHIC ZONES

No detailed maps are available exclusively to demonstrate the physiographic zones in the NE region. In many accounts (Guest 1966; Buday 1980) no distinction is made between the Zagros mountains range and the Nappe zone; also, the plains of the region are often treated as part of the transitional foothill zone. In choosing a map, the US Army Map of the Middle East (series 1304W, prepared by the US Army Map Service (AMS) 1962 (revised), scale 1:1,000,000) has been selected as a base for mapping the physiographic zones, as it reflects relief very clearly.

The physiography of the middle sector of the region has been checked, using NASA Landsat imagery (NASA LANSAT E-30968-06480-B, band 5, scale approx. 1:1,000,000), as demonstrated in plate 1, and the final physiographic map of the region (Appendix II).

In interpreting the Landsat imagery for the purpose of mapping, the physiographic units have been broadly identified as relevant land systems. the land system is a recogniably distinct type of landscape suitable to a mapping scale of 1:250,000 - 1:1,000,000, which contains a recurrent pattern of linkable land facets (Mitchell and Howard, 1978, p. 4). However, the level of detail of the land facets in the region has been kept to a minimum, owing to lack of verification in the field, and in view of the expressed purpose of the current study in identifying broad physiographic categories.

CHAPTER 3 :

SOILS AND SOIL CONDITIONS

3.1 INTRODUCTION

Soils of the NE region of Iraq are significantly different from those in the other regions in the country. A combination of factors account for the region soils´ character:

* Regional physiography--predominantly mountainous and semi-mountainous;
* Precipitation is higher than elsewhere, furnishing a semi-arid, and in some places, humid environment;
* Characteristic parent material--often limestone-linked.

As a result of the above factors, the soils are characterised by: 1) absence of salinisation, except for in a few areas; 2) the development of some well-identified soil horizons--a sign of active soil formation processes; 3) a fair measure of leaching of the topsoil; 4) the presence of some organic matter, in little but significant quantities. Brown and dark-brown soils are direct results of the occurrence of the organic matter.

Soil moisture often drops below the wilting point throughout the year. During the summer season, excessive evapotranspiration from the soil surface adversely affects the vegetion cover and causes some exposure of the region´s soils. Soil parent materials are often limestone-derived. The special physiography of the region is responsible for the occurrence of extensive erosion. The anticlinical mountains have precipitated, through the process of erosion since the Tertiary period, different soil groups, developed in parallel stripes to the mountain crests.

3.2 INVENTORIES OF THE IRAQI SOILS: A SHORT REVIEW

Soil classification work in Iraq began in the early 1950s, following the foundation of a Development Board. By the terms of its enactment, the Board was to sponsor inventories of the resources of the country (Yawer 1978, pp. 81-82). Various groups of experts carried out soil surveys in different parts of the country. However, as general standards of classification and nomenclature were not uniform, it became difficult to assess these surveys without a full examination of each individual attempt. Some of methods used by the soil experts in classifying the soil groups have since been largely replaced by new systems.

The first, and by comparison, most reliable and comprehensive inventory of Iraqi soils was provided by a Dutch pedologist, P. Buringh, who following a field survey of the soils in the country from 1955 till 1958 has offered a great contribution to the understanding of the soils in Iraq. Buringh has emphasised the importance of physiography in his inventory of the soils, and has applied some air-survey techniques in his work for mapping purposes. A soil classification at high level was produced. Twelve major soil groups have been identified and described in the NE region. Lithosols, Brown and Chestnut soils were the most frequent (Buringh 1960).*

In 1968, Altaie, an Iraqi pedologist, presented a Ph.D. thesis to the State University of Ghent, Belgium, on the soils of Iraq. He drew his classification on the system

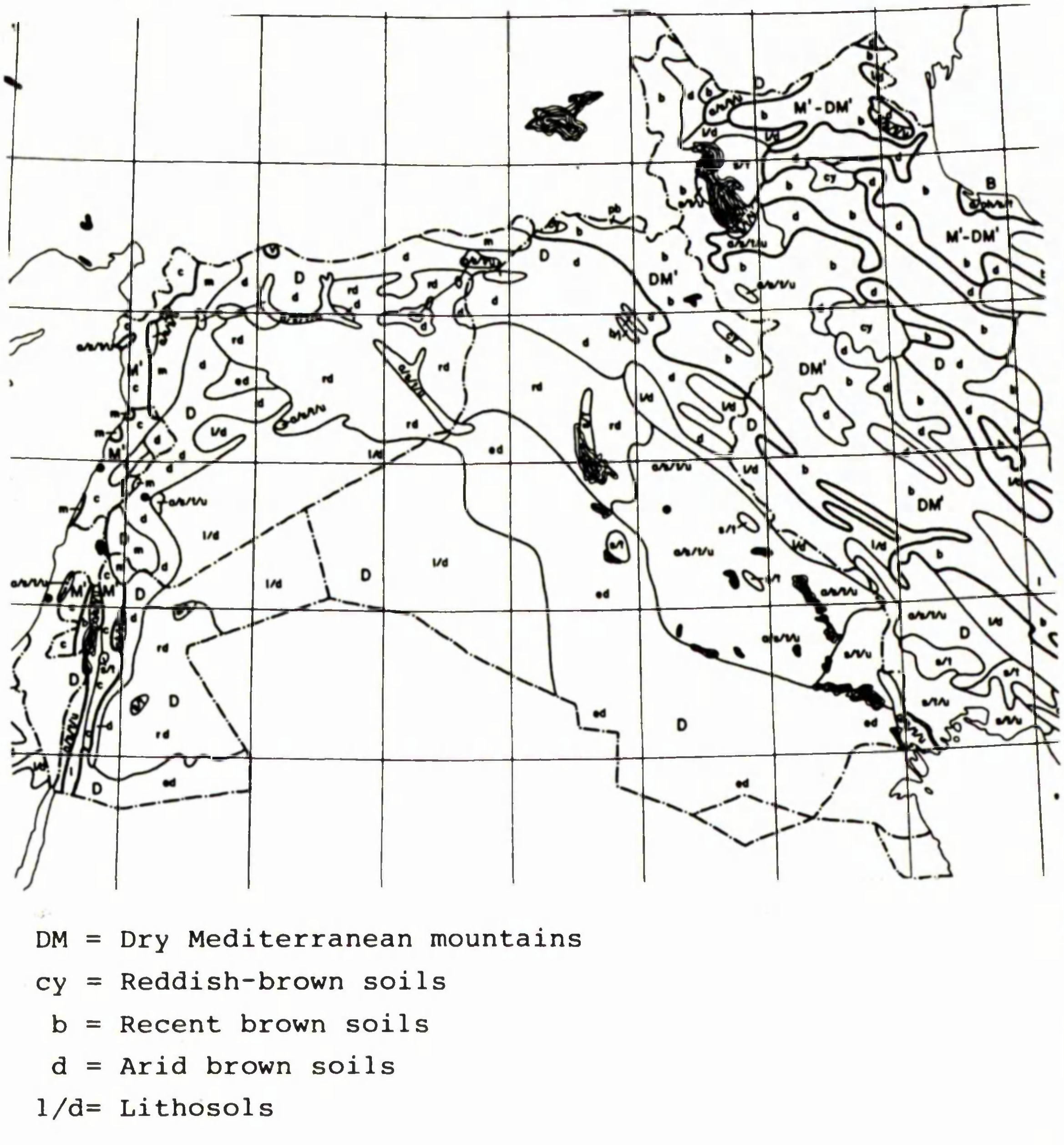
* Throughout the thesis, soil groups will be named in line with the nomenclature adopted by Buringh, unless otherwise stated. Iraqi agricultural and soil scientists have grown accustomed to these soil names.

enodrsed by the US Department of Agriculture (7th approximation). The soils in NE Iraq were largely classified as Entisols, Vertisols and Aridisols (Altaie 1968).

Papadakis (1969) has classified the soils of the world combining physiographic and climatic criteria, which he then published in his noted book Soils of the World. Papadakis has named several soil groups identified with the NE region of Iraq, most common of which were differnet phases of Brown soils characteristic of the dry mediterranean mountains (figure 3.1). Papadakis has also observed that the soils of the mountainous areas, as in NE Iraq, are bound to have a high frequency of Lithosols; a free drainage regulation; different soil groups over short intervals, and strong impact of slope on soil moisture (Papadakis 1969, pp. 73-74).

The FAO, in collaboration with the UNESCO, has published in 1974 and in the following years a Soil Map of the World, incorporating a system known today as the FAO system of soil classification. The system is monocategorical and differs from other taxonomies in that it is a list of `soil units´ comparable, at high group levels, with other known systems of classification. The desire was to create map units that are sufficiently broad to have general valididty and contain a number of elements to reflect as precisely as possible the soil pattern of a large region (FitzPatrick 1980, p. 169). This makes the FAO system of soil classification very useful in demarcating large areas of land such as in the case of the study region.

Figure 3.1 SOILS OF NE IRAQ AND THE SURROUNDING AREAS



DM = Dry Mediterranean mountains

cy = Reddish-brown soils

b = Recent brown soils

d = Arid brown soils

l/d= Lithosols

Source: Papadakis 1969

3.3 A ZONAL EXAMINATION OF THE REGION'S SOILS

The soils of the region can be broadly categorised on the basis of the physiographical zones within the NE region. In this way, five soil subdivisions can be identified: the soils of the mountains; soils of the mountain valleys; soils of mountain terraces; soils of the foothill zone; and, soils of the piedmont plains. Each zone has soils which are characteristic of the particular environment and micro-relief. By no means, of course, all the resultant soil sub-divisions are peculiar to a single zone; soil groups nonetheless are broadly identified with the special patterns of landscape and microclimate in which they occur.

3.3.1 SOILS OF THE MOUNTAINS

The mountainous area is situated in the farther end of the NE region. The summits of these mountains range in height between 2000 to over 3000m above sea level. The mountain ranges trend predominantly north-west to south-east. These are a part of the Zagros range, which belongs to the Alpine mountain system.

The processes of soil formation in this zone vary in different places, as a result of differences in topography, slope and exposure. The soils of this zone, therefore, do not always belong to a single group, although they may occur in close proximity. Most soils however, are Chestnut, Rendzina or Lithosols. The latter are formed especially in places subject to frequent erosion. At certain places, deep

Chernozem soils occur. In such areas, the topsoil is often dark greyish-brown to nearly black in colour, and of friable granular structure and alkaline chemical reaction. Guest (1966, p. 10) has stressed the importance of microclimate in the formation of the mountain soils. The mountain soils occur where the winter is very cold and the rainfall relatively high (over 500 mm), while the summer--though hot and dry--is of shorter duration compared to the areas outside the mountainous zone.

The mountains mainly consist of various kinds of limestone, except on the peaks of a number of mountains on the Iranian borders, which belong to the Nappe zone and consist of various metamorphic rocks. The occurrence of limestons, as the main parent material of the soils, has a hydrological significance. The porosity of the limestone structures allows continuous percolation of water through the soil profile to flow into the rivers(Buringh 1960, pp. 225-229).

Chestnut soils have been described by Buringh as the zonal soils in the mountains, while the others have to be considered as interzonal. Intergrades, however, are very common and numerous. The analytical data of a typical soil profile in the zone are listed in table 3.1 (Buringh 1960, p. 228).

The soils of the zone are characterised by a high percentage of small soil particles (silt and clay), and a relatively high percentage of calcium carbonate (over 10 %).*

* Throughout the rest of the chapter, the words lime and calcium carbonate ($CaCO_3$) are used interchangeably.

Table 3.1 ANALYTICAL DATA OF A SOIL PROFILE IN THE MOUNTAINOUS ZONE IN NE IRAQ *

Horizon cm	Sand %	Silt %	Clay %	Lime %	pH	Org. matter %
0 - 30	20	40	39	13	7.6	2.5
30 - 46	21	44	35	30	7.5	1.4
46 - 65	23	44	33	57	7.6	0.5
65 - 150	15	50	35	28	7.6	0.3

3.3.2 SOILS OF THE MOUNTAIN VALLEYS

Soil conditions in the mountain valleys are significantly different from those on higher altitudes. They are less subject to the forces of erosion, although they are invariably conditioned by the microrelief. On bigger valleys, the soils are fairly uniform in morphology, while small valleys are characterised by frequent variations in morphology over short distances.

The large valleys accommodate active cultivation. Rice, cotton and tobacco are the major crops grown on these areas. Again, Chestnut soils occur frequently in the inter-mountain valleys. It is belived that the formation of Chestnut soils in these valleys was due to the deposition of fluviatile-originated material, carried in during the high floods of

* Buringh has reported this profile as a typical Chernozem soil in the mountains' area. It is debatable whether this particular profile can be fully representative, especially since he made no reference to its location.

the Pleistocene era.* In the narrow valleys, the soils are highly eroded--often dark Rendzina soils of hydromorphic nature (Buringh 1960, p. 231).

Altaie (1969, pp. 92-94) has described a typical soil profile of a mountain valley in Sulaimaniyeh. His findings are very similar to those reported by Buringh (1960, pp. 234-235). In both cases, silt and clay content were high, compared to a low percentage of sand (less than 10 %). Lime content was found to be low in both accounts, below 10 per cent. According to Altaie (1969, p. 94), with good management, these soils can produce good crops of small grains. Other crops with deeper rooting systems, such as trees, may not grow successfully in such areas. The analytical data on a typical soil profile of a mountain valley are provided in table 3.2 (Altaie 1969, p. 94).

Table 3.2 ANALYTICAL DATA OF A SOIL PROFILE IN A MOUNTAIN VALLEY

(Location is Sayyid Sadegh, a village in the vicinity of Sulaimaniyeh)

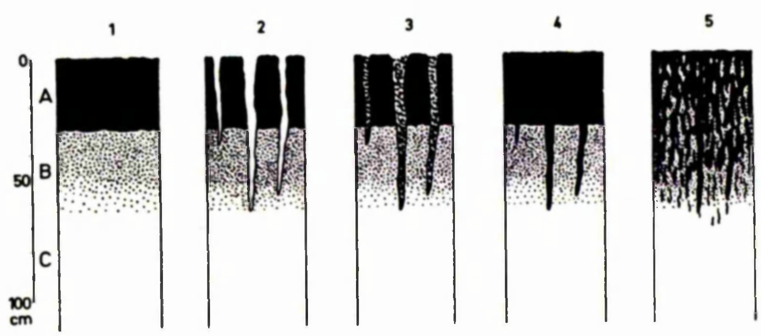
Horizon cm	Sand %	Silt %	Clay %	Lime %	pH	Org. matter %	E.C. mS/cm
0 - 25	8	34	58	3.6	7.7	1.7	0.7
25 - 55	7	36	57	2.8	7.7	1.0	0.6
55 - 100	7	35	58	2.7	7.8	1.1	0.7
100- 140	17	40	44	26.2	7.6	0.7	0.7

* Buringh has clearly not given enough evidence to support this impression that Chestnut soils are the product of a transportaion process in and geological era.

The soils of the inter-mountain valleys, and to a lesser degree the soils on the mountain terraces and the piedmont plains, are characterised by an active, and an agriculturally important, process of self-mulching. A few weeks following the end of the rainy season (may/June), deep cracks appear in the soil--often 60cm-deep and 6cm-wide. these are filled with soil material from the surface of the profile. After the fall of rain in the next rainy season, the swelling of the soil pushes upward some of the soil accumulating in the cracks, some from deeper horizons.

This process help perform a continuous homogenisation of the soil, the by-products of which are better soil structure and greater fertility and permeability.* A variety of factors enhance this process, including the minerology of the soil, the forces of gravity as well as the grazing animals which push the surface soil into the open cracks. Buringh (1960, p. 235) has provided a detailed account of the phenomenon, as illustrated in figure 3.2.

Figure 3.2 THE PROCESS OF SELF-MULCHING



* No further evidence was provided by Buringh that this particular process could actually improve permeability and fertility of such soils.

3.3.3 SOILS OF MOUNTAIN TERRACES

There are not many natural terraces in the NE region, but those in existence are of great agricultural importance (Buringh 1960, pp.242-243). Despite their importance for agriculture,however, there is some disagreement as to their exact number, location and geological history. Some geologists believe that their formation was the result of an alternation of pluvial (humid) and inter-pluvial (dry) phases in the climate of the Pleistocene period (Buday 1980, pp. 350-351).

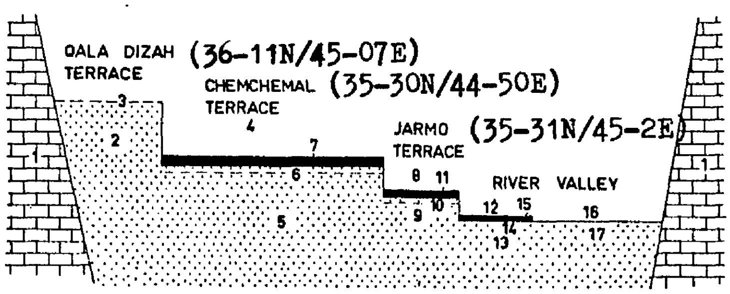
The analysis of the soil particles, lime content, acidity (pH), and organic matter, reveal great similarities with the analytical data provided for the soils of the mountain valleys. The good drainage conditions of the former soils--as terraces are located in higher altitudes compared to the mountain valleys, and therefore more distant from water table level--is reflected in low electrical conductivity (E.C.) figures. Table 3.3 provides a detailed account of the analytical data of a typical terrace soil profile. The soil particles on the terraces are characteristically granular on the surface; and coarse, angular-blocky or prismatic in the subsurface soil. Self-mulching (due to appearance of cracks in the soil in the hot season) is also wide-spread on many terraces (Altaie 1969, p. 96).

Buringh (1960, p. 246) has provided a shematic cross-section of a sequence of terraces in NE Iraq, along with their typical components (figure 3.3).

Table 3.3 ANALYTICAL DATA OF
A TYPICAL SOIL PROFILE ON A MOUNTAIN TERRACE
(Location has not been identified)

Horizon cm	Sand %	Silt %	Clay %	Lime %	pH	Org. matter %	E.C. mS/cm
0 - 10	7	40	53	11.2	7.7	1.2	0.7
10 - 30	7	39	54	13.2	7.6	0.6	0.5
30 - 70	7	40	53	15.9	7.6	0.5	0.6
70 - 90	12	39	49	18.2	7.9	0.5	0.3
90 - 115	35	35	30	44.2	7.8	0.3	0.6

Figure 3.3 SCHEMATIC CROSS-SECTION OF
A TERRACE SEQUENCE (SUNGASSAR VALLEY)



1	Limestone mountains
2,5,9,13	Bakhtiari gravel
3,6,10,14,17	Gravel crust or subsurface
4,8,12	Valley
7,11,15	Silt layer
16	River bed

Source: Buringh 1960, p. 246

3.3.4 SOILS OF THE FOOTHILL ZONE

The foothill zone is, geomorphologically, a transition between the Zagros mountains, up to the north-east, and the Mesopotamian plain of central Iraq. Eighteen per cent of the total area of the country is covered by the foothills. The geological strata of the zone are believed to have been strongly shaped (folded) during the Tertiary times, forming a series of north-west to south-east tending hills (Macfadyen 1960, p. 5; Altaie 1969, p. 69).

The majority of the soils of the foothills consist of Bakhtiari gravel, which have been deposited by the coninuous erosion of the mountains of NE Iraq. These soils, therefore, are shallow, unlevel and gravelly. Limestone--but sometimes, claystone, shale or sandstone--constitutes the major parent material of the zone's soils. Soils here are often Brown, but in a number of intrazonal plains and valleys Chestnut soils occur, of good potential for rainfed agriculture (Buringh 1960, p. 222).

Table 3.4 provides analytical data for a typical soil profile in the foothills (Majed 1982, pp. 32-35). The table reveals a high content of heavy soil separates --silt and clay. Sand percentage in all horizons is less than 5 per cent, affecting the workability of these soils in agriculture. As will be discussed in chapter 5, the foothills have been subjected to overgrazing, deforestation and overexploitation of the land; this has mined the fertility of the agricultural lands in the foothill zone.

Table 3.4 ANALYTICAL DATA OF A TYPICAL PROFILE IN THE FOOTHILL ZONE

(Location: Bakhtiari, a hilly suburb west of Sulaimaniyeh)

Horizon cm	Sand %	Silt %	Clay %	Lime %	pH	Org. matter %	E.C. mS/cm
0 - 20	3.3	25.5	41.5	28.2	7.5	2.5	0.6
20 - 35	1.0	21.9	42.2	33.4	7.5	1.5	0.3
35 - 56	1.7	18.1	44.0	33.3	7.6	1.0	0.3
56 - 90	1.9	9.6	24.8	63.2	7.8	0.5	0.2

Buringh (1960, pp. 224, 234) has observed that the productivity of the soils in the foothills is extremely poor in comparison with that in the intermo.ntain valleys. Yield ranges have been 400 to 1400 kg/ha in the foothill zone, compared to 2500 to 3000 kg/ha in the vallyes, perhaps mainly due to differences in moisture.

3.3.5 SOILS OF THE PIEDMONT PLAINS

The morphology of the piedmont plains is relatively a simple one. Although diversified in certain areas by anticlinical hills, the majority of the plains consist of only slightly rolling structures of land (Abul Haggag 1960, p. 344). Although several small plains occcur throughout the NE region, like the Sharzur, Rania and Sindi plains, the Kirkuk-Erbil-Mosul plain is the largest and most important (Buringh 1960, p. 218; Altaie 1969, p. 69).

Brown soils are the predominant group in the piedmont plains, grading into Chestnut soils in a number of smooth valleys in the Kirkuk-Erbil-Mosul plain (Buringh 1960, p. 219). Table 3.5 provides detailed analytical data of a representative soil profile in a plain in the area of Mosul (Altaie 1969, pp. 104-108).

Table 3.5 ANALYTICAL DATA OF A SOIL PROFILE IN A PLAIN NEAR MOSUL

Horizon cm	Sand %	Silt %	Clay %	Lime %	pH	Org. matter %	E.C. mS/cm
0-30	6.5	67.5	26.0	25.5	7.7	1.5	0.7
30-70	5.5	60.5	34.0	33.3	7.7	0.4	1.8
70-90	2.5	61.5	37.0	33.0	7.5	0.3	3.7
90-160	1.5	62.5	36.0	26.4	7.5	0.2	5.1
160-200	1.0	60.0	39.0	27.1	7.4	0.2	5.6

The analytical data show again a low percentage of sand, typical of the soils of NE Iraq, but the silt content is higher here as opposed to clay in the soil texture.

3.4 A DETAILED EXAMINATION OF THE REGION´S SOIL PROPERTIES

3.4.1 PARENT MATERIAL

The physical, mineral and chemical composition of parent material, through the weathering of parent rock of soil, plays an important role in determining the type of the resultant soil, as well as influencing its productivity. Most of the region´s soil groups are derived from calcareous material, limestone. The ensuing relatively high concentrates of calcium carbonate (Ca CO_3) has conditioned the majority of the region´s soils; not always contributing favourably to fertility, especially where lime concentrations exceed the acceptable limits (section 3.4.5).

In some places, however, metamorphic rocks, such as in the Nappe zone of the Zagros mountains, constitute the parent rock of a number of thin layers of soils covering otherwise bare outcrops. Claystone, sandstone and shale make up the parent material of some stretches of soils in the foothills and a number of small piedmont plains.

3.4.2 CLAY MINEROLOGY

The mineral composition of the various types of parent material is an important factor in determining the fertility of any group of soils. The balance between the negative-charged surface of the clay particles and the positive-charged cations influence to a great extent the nutrient supplying capacity of the soil medium. The clay minerology is often expressed as the clay reserves, and has therefore a bearing on the inherent chemical soil fertility.

There are three important groups of clay minerals in the soils of the NE region: the kaolinite group, the montmorillonite group and the illites. The clay fraction of the soils of NE Iraq, characterised by less arid conditions and more mediterranean type of climate, is predominantly composed of montmorillonite minerals (Altaie 1969, p. 120). The montmorillionite clay minerals are charcaterised by a high rate of cation exchange capacity.

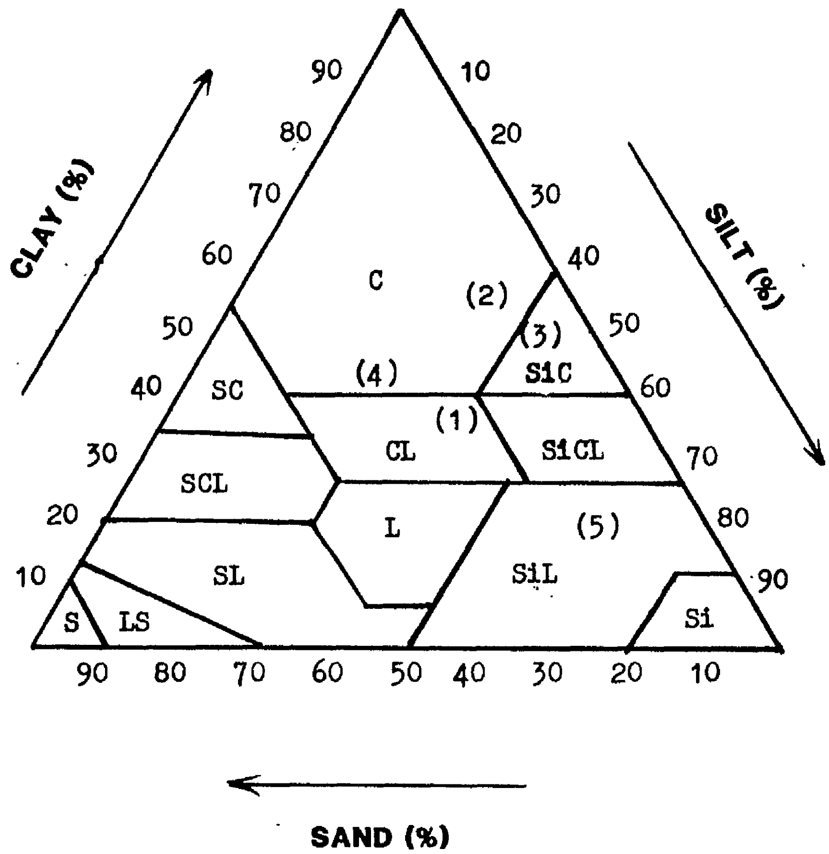
3.4.3 SOIL TEXTURE

Soil texture influences a number of other soil properties, including structure, moisture regime and erodibility. It therefore has an indirect bearing on the soil fertility. Soil texture is the main objective of the mechanical analysis of the soil separates (particles)--sand, silt and clay. If these separates exist in good balance, a loamy soil is produced. Loamy soils are best soils from the workability point of view.

The information provided by the previous examination of the soils of NE Iraq clearly shows that clay and silt are the major componenets of the region´s soils. The high clay percentage in particular is the most outstanding feature of these soils, which can be as high as 58 per cent in some mountain valleys. In the Kirkuk-Erbil-Mosul plain, however, the silt component is the highest (over 60 per cent).

In all instances, the percentage of sand is very low. While this may be a good sign in itself, clay--and to a lesser degree, silty--soils pose some constraints affecting, among other things, the workability of the soil. Pemeability and root penetration can also be hampered by heavy soils. In areas of high clay and silt content, moreover, the characteristically hot summers in Iraq encourage the development of deep cracks in the soil body which, if uncomplemented by a process of self-mulching, can seriously damage the performance of the soil as a medium for plant growth.

figure 3.4 SEPARATES DISTRIBUTION-CHART OF THE SOILS OF NE IRAQ



L = Loam
C = Clay
Si = Silt
S = Sand

(1) Mountain Soils
(2) Mountain-valley Soils
(3) Mountain-terrace Soils
(4) Foothill Soils
(5) Piedmont-plain Soils

Figure 3.4 clearly shows that Loamy soils are scarce in the NE region, and only clay-loamy soils (in the case of the Chestnut soils of the mountainous zone) and silty-loamy soils (in the piedmont plains) can occur.

3.4.4 SOIL STRUCTURE

The structure of the soil is conditioned by a number of factors, including the ratio between the various cations present in the soil, texture and the biological activity in the soils. Excessive amounts of calcium (Ca^{++} cations), often present as lime, and the absence of adequate amounts of organic matter, produce soils with poor structures. This affects the hydraulic conductivity and the water-holding capacity of the soil, consequently subjecting the plants which grow in such areas to moisture stress and weak growth.

The soils of the Kirkuk-Erbil-Mosul plain as well as those of the intermountain valleys and terraces, although high in clay and silt content, are of subangular and subangular-blocky structure, which are considerably better than the prismatic and angular-blocky structures which dominate other soil groups. Earthworm actvities also marks the soils of the mountain terraces. Low organic matter content is often responsible for poor structures (Buringh 1960, pp.234-235; Altaie 1969, pp.94-96, 104-108).

3.4.5 SOIL REACTION (pH) AND LIME CONCENTRATION

The term soil reaction is normally used to indicate the degree of acidity or akalinity of a soil (in its moist condition). Soil reaction is often measured by pH, which is a value equal to the negative logarithm of the hydrogen ion (H) concentration in the soil solution.

Most soil-dependent organisms, plants, soil micro organisms and nematodes, prefer a soil with mild reaction.

Excessively calcareous soils (where lime concentration is over 20 per cent), although high in base saturation, often reduce the productivity of the soil medium. The plants which grow in such soils will not be able to absorb many base nutrients.

As the analytical data provided earlier reveal, the pH values of the soils of the region are within acceptable limits.

Table 3.6 demonstrates the ratings of soil reaction, listing the standard subdivisions of pH against the pH values of the region´s soils. The ratings are based on the USDA Soil Survey Manual (1962). All soil groups in the region are mildly alkaline.

Table 3.6 pH RATINGS OF SOIL REACTION

Rating	pH	Representative NE Soils
Very strongly alkaline	>9.0	
Strongly alkaline	8.5-9.0	
Moderately alkaline	7.9-8.4	
Mildly alkaline	7.4-7.8	All groups
Very mildly alkaline	7.1-7.3	
Neutral	7.0	
Very slightly acid	6.6-6.9	
Slightly acid	6.1-6.5	
Medium acid	5.6-6.0	
Strongly acid	5.1-5.5	
Very strongly acid	4.5-5.0	
Extremely acid	<4.5	

3.4.6 ORGANIC MATTER

The organic matter of the soil complex (the humus colloids) has a greater cation-exchange-capacity (CEC) than most other soil components, including the clay particles. In topsoils with a good amount of organic matter (OM), the high CEC is often attributed to the humus. In general, organic matter in the soil is responsible for improving the soil structure and fertility (the humus colloids expand the surface area of the soil complex, allowing a greater capacity for exchange of nutrient elements). The organic complex (also the inorganic complex in the case of adding fertilizers) can be considered as a reservoir that buffers the ionic supply by soil minerals or fertilizers. Conversely, the organic matter complex buffers the ionic withdrawal due to leaching or crop consumption.

Table 3.7 RATINGS OF ORGANIC MATTER *

Rating	OM (%)	Representative NE Soils
Vey high	>6.0	
High	4.3-6.0	
Medium	2.1-4.2	Mountain, Foothill Soils
Low	1.0-2.0	All other groups
Very low	<1.0	

* Both Buring and Altaie have estimated organic matter by loss on ignition.

The ratings of organic matter differ according to climate and the level of humification in the soil. Generally, the above ratings are recognised, as listed in table 3.7 (ILACO 1981, p. 103). As the representative NE soils show, organic matter content in the region ranges between medium and low. Most soils, however, are poor in organic matter content.

3.4.7 SALINITY AND ELECTRICAL CONDUCTIVITY (EC)

Strong salinity is often found under arid and semi-arid climatic conditions in soils where salts from other locations have accumulated through the inflow and subsequent concentration of salt-bearing waters. The FAO system has two classes for soils influenced by salt--Solonchak and Solonetz. In NE Iraq, however, Solonetz soils are nonexistent; (orthic) Solonckaks occur, but on a very minor scale as inclusions.

Salinity is often measured by the electrical conductivity of the soil solution, measured in mS/cm at room temperature (25^{o}C). Table 3.8 gives a review of salinity classes as defined by the USDA (ILACO 1981, p. 80). The table clearly shows that the region´s soils are almost salt free. However, an examination of the soils of the piedmont plains may reveal traces of salinity, although this is classified as slight. This is probably due to a higher rate of evapotranspiration in the plains, as compared to the soils in higher altitudes where the climate--therefore, evaporation from soil surface--is milder.

Table 3.8 APPROXIMATE LIMITS OF SALINITY

Class	EC	Salt (%)	Representative NE Soils
Class 0	0-4	0-0.15	All groups
Class 1	4-8	0.15-0.35	
Class 2	8-15	0.35-0.65	
Class 3	>15	>0.65	

Class 0 = Free
Class 1 = Slightly affected
Class 2 = Moderately affected
Clsss 3 = Strongly affected

3.5 SOIL MAPS OF NE IRAQ

There is no special soil map available for the NE region. The three soil maps for Iraq (Buringh 1960; Altaie 1968; FAO 1974), however, have incorporated the soils of the region in large maps demarcating the main soil groups.

3.5.1 OBSERVATIONS ON BURINGH´S SOIL MAP

Buringh´s classification of the soils in Iraq was adapted from the older US Soil Classification System proposed by Baldwin, Kellog and Thorp in the late 1930s. In this system, Buringh has classified the region´s soils in three orders: 1) Zonal soils; 2) Intrazonal soils; 3) Azonal soils.

Zonal soils were defined in terms of their geography (occur over large areas or zones), climate and vegetation. Brown, Reddish-Brown, Chernozem, Chestnut, Reddish-Chestnut and Podsolic (?) were identified as the Great Soil Groups under the Zonal Order.

By contrast, Intrazonal soils reflected local pedogenetic factors, such as relief and parent material. Rendzina soils were the major Intazonal soil identified by Buringh in the NE region.

Soils with unknown pedogenetic background or lacking profile characteristics were known as Azonal soils. In Buringh´s map, the soils of the NE region identified as azonal were Lithosols.

Buringh´s soil map of the NE region is given in appendix II, along with explanatory notes.

3.5.2 ALTAIE´S SOIL MAP

Altaie´s classification of soils in Iraq was based on the new US System of Soil Taxonomy. Soils were classified according to a number of observable and morphometric (measurable) characteristics marking the soil diagnostic horizons.

Of the 10 Orders of the new system, Altaie (1968/9) has identified and described Entisols, Vertisols and Aridisols in the NE region. The Azonal Order of soils (Lithosols in the NE region) in Buringh´s classification corresponds very broadly to the presnt Order of Entisols in Altaie´s account. Each new Order, therefore, has its approximate equivalent in the older classification--specifically from the Great Soil Groups.

Both soil maps of Buringh and Altaie have contributed to a great extent to the FAO/UNESCO´s map of the soils of the NE region, which appeared in the Soil Map of the World (1974).

3.5.3 FAO/UNESCO SOIL MAP

This map is of special importance when used to judge and compare agricultural potential of extensive land surfaces (ILACO 1981, p. 135). In total, 11 soil units as major soil groups have been identified with the NE region of Iraq. Another 3 units are incorporated as associated soil groups and inclusions (Appendix II). Although no absolute equivalent groups can be emphasised as analogues to Buringh or Altaie´s soil classes, table 3.9 will attempt to provide a review of the FAO soil units, their symbols and description, as well as the approximate classes provided by the previous soil maps. some soil groups provided in the FAO soil map, however, have no broad correlations with any of other classification systems.

Table 3.9 SUMMARY OF FAO SOIL CLASSIFICATION WITH APPROXIMATE GROUPS IN BURINGH'S AND ALTAIE'S CLASSIFICATION

Soil Unit	Int.	Symbol	Description	Approximate Groups: Buringh (GSG)	Altaie (Order)
			MAJOR SOIL GROUPS		
Cambisols	**	B	Soils weathered in situ, with a medium or high base saturation.	Brown	Inceptisols
Rendzinas	***	E	Shallow humus-carbonate soils.	Rendzina	Mollisols (NR)
Lithosols	****	I	Soils with hard rock at shallow depth.	Lithosols	Entisols
Fluvisols	**	J	Soils of alluvial deposits and flood plains.	Alluvial	Entisols
Kastanozems	**	K	Soils rich in organic matter, some nematodal activity and a chestnut colour.	Chestnut	Mollisols
Regosols	***	R	Soils on loose material with weak or no development.	Regosols (NR)	Entisols
Vertisols	****	V	Strongly swelling and shrinking clay soils.	Brown (deep phase)	Vertisols
Xerosols	***	X	Soils with xeric (arid) moisture regime.	Reddish-Brown	Aridisols
Yermosols	**	Y	Desert and semi-desert soils.		Aridisols
			MINOR SOIL GROUPS (SMALL INCLUSIONS)		
Gleysols	*	G	Soils dominated by excess of water.	Alluvial (NR)	Entisols
Solonchaks	*	Z	Saline soils.	Solonchaks (NR)	Aridisols (NR)

**** High intensity
*** Moderate intensity
** Low intensity
* Very low intensity

NR = Not reported

MAP SYMBOLS

Major Soil Groups	Associated Soils			Soil Inclusions		Notes
I-Rc-Xk-c						Be = eutric (fertile) Cambisols
Vc1-3a						Gc = calcaric Gleysols
Xh31-3a	Gc	Rc		Zo		Jc = calcaric Fluvisols
Vc50-3ab	Xk					Kk = calcic Kastanozems
Xh33-3a	Xk					Rc = calcaric Regosols
Kk16-2b	Xk	Xk	I	Gc	Rc	Vc = chromic(high chroma) vertisols
I-E-bc						Xh = halpic (salty) Xerosols
I-Be-c						Xk = calcic Xerosols
Xk29-ab	E			Vc		Xy = gypsic Xerosols
I-E-Xk-bc						Yk = calcic Yermosols
Xk9-2/3a	I	Rc		Vc		Yy = gypsic Yermosols
Jc2-2a	Gc			Zo		Zo = orthic (common) Solonckaks
Xk26-2/3a				Rc	Vc	
Xy5-a	I	Rc		Vc		
Xk9-2/3a	I	Yk				
Yy10-2/3a	I	Yk				
Xk28-b	Vc			I		

Texture Rating	Slope Rating
1 = Coarse textured (less than 18 % clay)	a = Level to gently undulating (0-8 %)
2 = Medium textured (less than 30 % clay)	b = Rolling to hilly (8-30 %)
3 = Fine textured (more than 35 % clay)	c = Steep to mountainous (more than 30 %)

Example: Xk26-2/3a = calcic Xerosols; Unit serial number 26; medium to fine textured; level to gently undulating area.

CHAPTER 4 :

EVALUATION OF THE LAND RESOURCES FOR RAINFED AGRICULTURE

4.1 OBJECTIVES AND METHODS

4.1.1 INTRODUCTION

The major objective of land evaluation for rainfed agriculture is the assessment of land performance in the NE region for the specific purpose of dry farming. The study will select and define the land units for the optimum land use under rainfed agriculture, taking into account both physical and, where relevant, socio-economic considerations.

The current study will follow broadly the FAO system of land evaluation (FAO 1976), as illustrated by the Framework for Land Evaluation. The land is appraised and classified with respect to specified kind of use, in this case rainfed agriculture. The approach also requires that the evaluation is made in terms relevant to the physical and social context of the NE region of Iraq. The process of land evaluation is based on land resource surveys which constitute the major source of data on climate, vegetation, hydrology, geology and physiography. These have been examined in the previous chapters, and the relevant sections will be referred to in detail where necessity arises.

A land use system has been worked out for the collection of elements and their relationships. The system incorporates boundaries (degrees of limitation) and internal relationships (algorithms) in matching external inputs (variables) and outputs (outcomes). The subject will be discussed in greater length in section 4.5.3.

4.1.2 OUTLINE OF ASSUMPTIONS AND OBJECTIVES

MAIN ASSUMPTIONS. Under the physical, economic and social conditions of the study region (mainly strong physical constraints, low economic returns on agriculture, and low level of technical know-how) the following assumptions are necessary for the the assessment of the land resources of the NE region for rainfed agriculture:

i. despite some diversity, the NE region constitutes a distinct region with common physical, economic and social caracteristics;
ii. infrastructure, levels of inputs, institutional conditions and marketing situation are unlikely to undergo major changes during and immediately after the drawing of suitability classes for rainfed agriculture;
iii. physical constraints are the major limitation to the standards of utilisation, and will serve as main indicators of suitability.

OBJECTIVES. In choosing the objectives of the current evaluation, a special-purpose land evaluation has been selected--in this case, rainfed agriculture. Land in the NE region will be surveyed to locate the most suitable areas for rainfed agriculture. At a more detailed level, the appraisal of the suitability will involve the potential of the land resources for cereal crops (in the case of the NE region, primarily wheat and barley). Alternative kinds of use will also be considered.

The kind of land use proposed in this chapter, rainfed agriculture, has been selected on the basis of the physical, economic and social background of the region, as discussed in the three previous chapters. Assuming little or no change in the immediate future in the development level of the agricultural sector in NE Iraq, the use of the land under rainfed agriculture remains significant. However, in a region where livestock production is almost invariably associated with the use of the land for crops, the appraisal of the land for grazing, as the backbone of the livestock sector, will be treated as a suitable alternative. The interaction between the livestock sector and the cropping sector involving agricultural economic consequenses is strongly established in the region's rural community.

4.1.3 INTENSITY AND TYPE OF APPROACH

SCOPE AND INTENSITY. The land resources of the five provinces of the NE region (Dohuk, Mosul, Erbil, Kirkuk and Sulaimaniyeh) will be assessed for suitability for rainfed agriculture. However, the part of the Mosul province lying to the west of the river Tigris will be excluded. The latter area is part of the Jezira plateau which constitutes a zone with distinct physical and social characteristics.

A survey at a regional scale will be undertaken. A reconnaisance level of intensity has been chosen. There are two reasons for this approach. First, the NE region has not been treated in the past in any multidisciplinary study of the land resources (often, political considerations have prevented the treatment of the region as one large single unit). Second, under the present circumstances, the NE region lacks sufficiently detailed field records on the agricultural sector. Political and ethnic problems, combined with difficult terrain have diminished the prospects of intensive investigations of the farming situation. An intensive level of investigation would be impossible because of the difficulties in quantifying important parameters at a detailed level. Also, in a multidiciplinary investigation of the land resources, as in land evaluation, intensive economic studies will be of little reliability in areas where only reconnaisance-scale soil surveys are available. The low intensity of meteorological observing stations, on the other hand, has dictated a correspondingly low scale of agroclimatic surveys.

The most difficult task in any land evaluation project occurs when data on land mapping units are brought together in order to define a particular land suitability classification. At the level of reconnaisance investigations, however, such a problem is not too acute since the prime task is to eliminate areas clearly unsuitable to the proposed land use (Davidson 1980, p. 35).

TYPE OF CLASSIFICATION. The choice of type of classification is governed by the availability and nature of the data on the land resources. The current study will attempt to provide some quantitative assessments of the land resources, both at economic and physical levels. However, specific resources, both at economic and physical levels. However, specific economic estimates cannot always be reliable under the present situation.

The shortcomings of an economic approach are acute in areas where information is neither adequate enough nor coherent. The validity of economic evaluation can be very short-lived. It is dependent not only on changes in costs and prices, but also often on arbitrary assumptions on discount rate and shadow pricing. In Young and Goldsmith's words (1977, p. 430),

> "In doing this kind of economic analysis, one is left with the feeling that it is no longer a process of the evaluation of the land. A clear distinction, therefore, needs to be made between the evaluation of land and the broader matter of the economics of project appraisal."

PHASING. The available literature indicates that most land evaluation studies have employed a two-stage approach to the land appraisal process. This, however, has had a disadvantage in that promising alternatives have been missed in the initial physical evaluation (FAO 1984, p. 23). The nature of the current investigation which is designed to be mainly qualitative, need not pay undue emphasis to the phasing of the evaluation. Where economic cnsiderations in broad terms may be relevant, a socio-economic examination will be considered in discussing promising alternatives, without necessarily paying undue attention to economic relationships which lack coherence or feasibility.

RANGE OF INTERPRETIVE SUITABILITY. The FAO system of land evaluation recognises two ranges of interpretive suitability:

1) A classification of potential suitability refers to the suitability of land for a defined use assuming that specific land improvement measures have been planned. A major improvement pertains to a reasonably permanent measure affecting, in a significant way, the qualities of a land under a given use;
2) A classification of current suitability refers to the suitability for a defined use of the land resources in their present conditions, without considering major improvements. The current study will assess the land resources of the NE region, assuming little or no change in the performance of the land under rainfed agriculture.

4.1.4 LAND SUITABILITY CATEGORIES

INTRODUCTION. In the early 1970s, the FAO felt the need to develop a standard system of evaluation of land resources which could meet the widest range of needs of possible users. In 1970, two committees were commissioned by the FAO, in the Netherlands and Italy (Rome) to submit feasibility propsals. A preliminary background report was issued in 1972. The first draft of a framework for land evaluation later appeared in 1973. The 1975 FAO meeting on land evaluation took in consideration earlier comments and proposals submitted by experts, and the Framework for Land

Evaluation appeared in 1976 in its final form. A multidisciplinary approach was proposed, using a physical basis in a social and economic background for comparing land suitabilities for different types of land use. A fundamental theme in the new FAO system has been that a value of suitability given to a land unit is meaningful and relevant only in relation to a clearly defined use of the land (FAO 1976; Dent and Young 1981).

CLASSIFICATION CATEGORIES. The FAO land suitability system is a hierarchical system, which recognises the same categories in all four interpretive classification of suitabilities, according to whether they are qualitative or quantitative, current or potential. Four categories of decreased generalisation are recognised:

Land suitability orders:	reflects kinds of suitability;
Land suitability classes:	pertains to the degree of suitability within orders;
Land suitability subclasses:	reflects kinds of limitation or main kinds of improvement required within classes;
Land suitability units:	reflects differences in required management within classes.

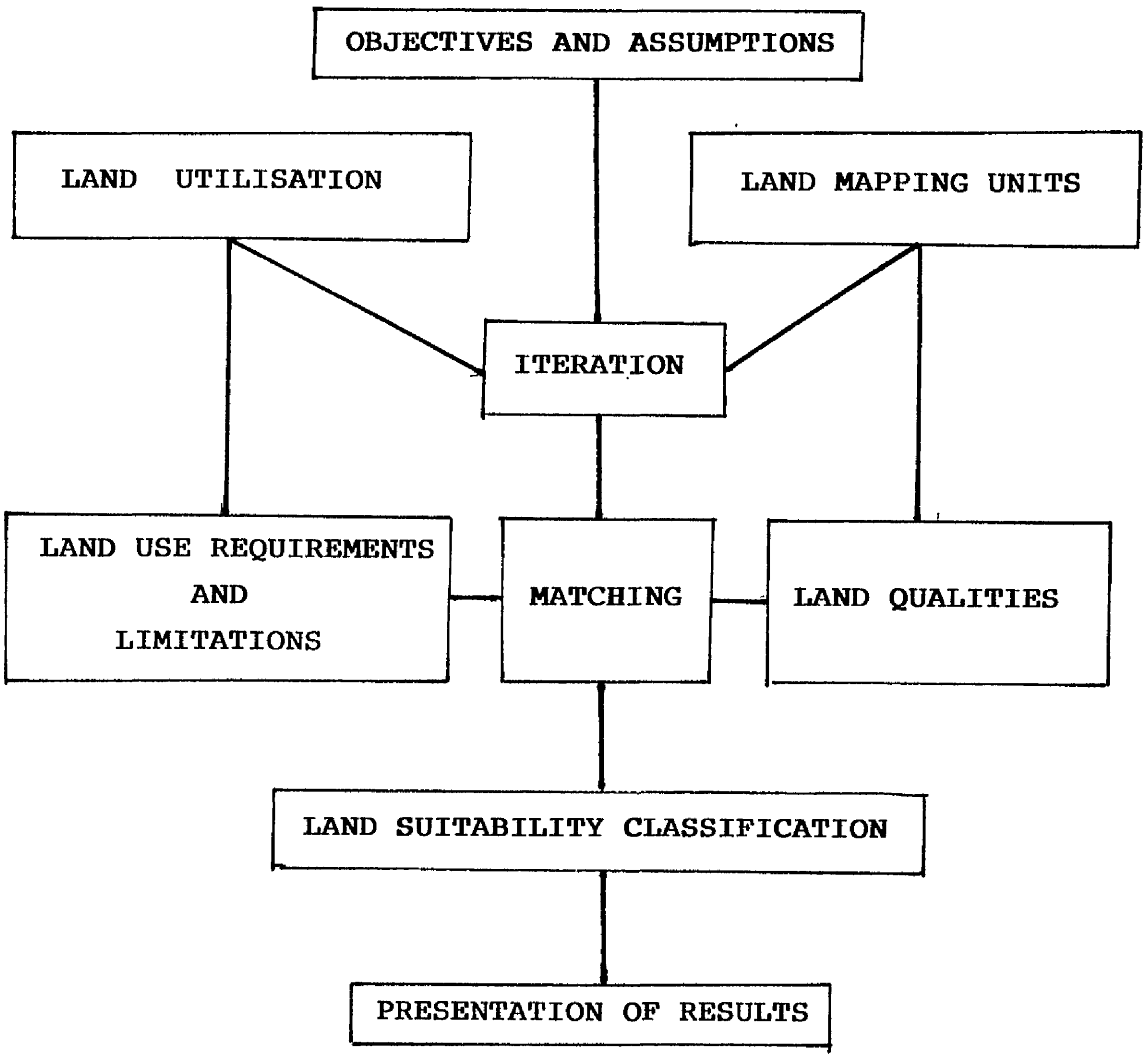
A detailed description of orders and classes of suitability are listed in table 4.1. There are two orders of suitability; three classes under the order S (suitable), and two under the order N (not suitable). Figure 4.1 outlines the processes involved in land evaluation.

Table 4.1 DESCRIPTION OF SUITABILITY CLASSES

Category (Order/Class)	Description
Order S (Suitable):	Sustained use under consideration yields benefits that justify the cost of inputs without risk of damage.
S1 (highly suitable)	No or insignificant limitations to the sustained application of a given use.
S2 (moderately suitable)	Aggregate limitations are moderately severe; lower gross margin returns.
S3 (marginally suitable)	Aggregate limitations impose severe constraints. Expenditure will be marginally justified (very low gross-margin returns).
Order N (not suitable):	Benefits do not justify costs.
N1 (currently unsuitable)	Physical possibility, but cost of inputs and technology is currently unacceptable.
N2 (pemanently unsuitable)	Physical impracticability of land improvement.
NR (nor relevant)	Not under consideration.

Source: Dent and Young 1981; FAO 1984

Figure 4.1 OUTLINES OF PROCESSES OF LAND EVALUATION



SOURCE: FAO 1976, P. 28.

4.2 LAND UTILISATION

DEFINITION. The FAO system of land evaluation has recognised two levels of detail at which land use can be defined: major kinds of land use and land utilisation types. A major kind of land use is a major subdivision of rural land use, which is usually considered in land evaluation studies of a qualitative or reconnaisance nature. Rainfed agriculture, natural grazing and afforestation, for instance, can be considered as major kinds of land use. Conversely, land utilisation types are kinds of land use, defined in greater detail, according to a set of technical specifications in a given physical and socio-economic setting. Land utilisation types, however, can be described at different levels of generalisation.

In this study, rainfed agriculture will be treated as a major kind of land use. However, as maintained by the FAO guidelines on land evaluation for rainfed agriculture (1984, pp. 25-26), even at a reconnaisance level, it is usually more useful to base evaluation on land utilisation types, defined as individual crops or cropping systems under broadly specified levels of management. In the following part of the current study, all aspects affecting rainfed agriculture will be discussed broadly, especially those related to the use of the land for the two major crops in the region under dry farming--wheat and barley. A checklist has been prepared for such issues as crops grown, management and cultural systems, cropping methods, levels of inputs and a review of relevant institutional arrangements.

4.2.1 CROPS GROWN

INTRODUCTION. The selection of crops by the region´s farmers is governed by a number of factors. The most important issues affecting the decision on the choice of crops are farming traditions, personal likes and dislikes as well as personal needs, poor transportaion and marketing facilities, and the inability of the farmers to respond to, use or receive new varieties or crop-protective chemicals. Farm managerial issues such as lack of skilled labour, machinery and modern farming management methods also restrict the choice of crops by the farming community.

On the physical level, environmental considerations which include rainfall amounts and distribution, temperatures, evaporative demand, terrain, soil types, pests and proximity of cultivable areas to rural settlements have imposed strong constraints on the choice of crops at the farmer´s disposal.

SEED SOURCES AND CHOICE OF CULTIVARS. Farmers often prefer to save some of their harvest as a seed source for subsequent years. These are not always kept in good condition becasue of poor storage facilities, damage caused by pests or adverse environmental effects on the subsequent rate of germination. Seed supply is available from local grain merchants who, in return for keeping good quality seeds, charge more for their seeds than it will cost the farmer to save his own. Some growers, especially peasant farmers, feel that purchasing seeds is not economical or, in some cases, they cannot afford it.

New hybrids (often Mexican dwarf varieties produced by CIMMYT) are normally imported by government agencies for local use, but the record of such practices has been mixed. Although chosen for their high productivity and drought-resistance qualities, the trial of many varieties has led to disastrous results. Varieties that have different cycle lengths and plant characteristics often failed due to lack of observance, by the farmers, of dates of sowing. Chemically-treated seeds, have often been consumed domestically or fed to livestock, causing widespread illnesses. In most occasions, farmers use local varieties and cross-breeds, which are characteristically of low productivity and of poor disease resistance.

4.2.2 WHEAT (Triticum aestivum)

Wheat is the most important crop grown under rainfed conditions in the region, in terms of production. The reason is obvious; to the local people, bread is the staff of life. Triticum aestivum is the most popular species, but recently some cross breeds of Triticum durum (semi-dwarf and dwarf) have been also used (Al-Fakhry 1981, pp. 307-311).

Area, production and yield of wheat in the five provinces of the NE region are listed in table 4.2 (FAO 1982, p. 45). The figures clearly demonstrate varying levels of yield between the provinces (934 kg/ha in Sulaimaniyeh, and 490 kg/ha in Kirkuk). These variations can be clearly attributed to differences in levels of rainfall (section 2.1.2).

Table 4.2 AREA, PRODUCTION AND YIELD FOR WHEAT IN NE IRAQ

Province	Area (ha)	Prod. (ton)	Yield (kg/ha)
Dohuk	36,700	33,300	908.8
Mosul	242,900	133,000	547.2
Erbil	90,300	47,900	530.0
Kirkuk	101,925	49,900	490.0
Sulaimaniyeh	97,200	90,800	934.0
Total/Average	569,025	354,900	623.7

Climate. A minimum of 300mm of well-distributed annual rainfall normally produce good wheat harvests. Local varieties are reasonably drough-tolerant. High temperatures in the last weeks of growth (late spring) often retard heading and cause premature ripening, adversely affecting yield levels. Zaki (1979, pp. 125-141) estimated the correlation coefficient (r) between wheat yield and rainfall in north Iraq at 0.6 (perfect correlation is 1.0).

Soils. Medium to heavy soils are best suited to wheat production. The optimum range includes sandy loams, clay loams and loam soils. Fine textured soils ensure lower moisture stress (Al-Fakhry 1981, p. 310).

Growth period. Normally four months (about 120 days) in the NE region are needed for the wheat crop to grow and mature.

4.2.1.2 BARLEY (Hordeum vulgare)

Barley is the second most important cereal crop grown in the NE region. Hordeum vulgare (six-row barley) is the main species of barley grown in the region. However, Hordeum distichum (two-row barley) is also grown in some areas. Although traditioanlly consumed as bread, barley is mainly grown now for livestock consumption. Unlike wheat, two or three harvests are sometimes obtained in one season. During the jointing stage (locally known as qaseel), the crop is harvested once and then left until the end of winter or early spring for the grains to grow. Area, production and yield figures for barley in the five NE provinces are listed in table 4.3 (FAO 1982, p. 45). Barley can survive a wider range of environmental conditions. 200mm of annual rainfall is often the minimum requirement for a cropping season (Al-Fakhry 1981, pp. 312-315).

Table 4.3 PRODUCTION LEVELS OF BARLEY IN NE IRAQ

Province	Area (ha)	Prod. (ton)	Yield (kg/ha)
Dohuk	8,825	7,700	871.2
Mosul	86,500	41,700	481.6
Erbil	41,300	24,200	600.0
Kirkuk	39,650	20,400	514.8
Sulaimaniyeh	40,875	33,200	812.0
Total/Average	217,150	127,800	588.5

4.2.2 CROPPING SYSTEMS

INTRODUCTION. The cropping systems in the NE region have many problems. Frequently, new conditions or combinations of conditions arise: ecological, social, ethnic, political and economic. Variability in rainfall and other physical features greatly influence crop production, and geopolitical issues continue to impose many constraints on levels of management, inputs and rural welfare. In some areas, mechanising the agricultural sector, for instance, has failed miserably where farmers had little or no access to the support systems necessary for mechanisation (technical know-how, parts, maintenance plans,etc). Diversity in levels of management have been caused in most places by direct state interference. Experimentation with capital-intensive agriculture in the region, however, has not yielded enough encouraging signs. With these thoughts in mind, in discussing crop management systems, the relevant issues will be examined mainly where ordinary farms are concerned rather than subsidised experimental farms.

CULTURAL SYSTEMS. Annual cropping is the main cultural system in the NE region. This is practised wherever and whenever there is sufficient precipitation each year to produce a crop. Annual cropping does not always involve growing a crop each year in succession. In most cases, the land, under the current management levels, produces a crop successfully and economically through an alternating crop and fallow system. The main objectives of an alternate crop-fallow system are (Al-Fakhry 1981, p.285):

i. to conserve moisture and nutrients and make them more available to the next crop;
ii. to control weeds, and minimise losses from weeds, pests and diseases (alternate crop-fallow system pemits the breaking of the seeding cycle of most annual weeds that may become serious problems with continuous cropping);
iii. to make possible, under primitive tillage conditions, preparation of seedbeds for the next crop

The issue of fallowing and rotations will be discussed independently in greater detail, but it is important here to point out that experience has revealed that the advantages of fallowing have been often exaggerated. The success of a fallow season depends on a combination of climatic conditions which are extremely variable in the NE region, including rainfall, evaporative demand and soil characteristics. The timing of the fallow is also very important. The summer fallow system, which is the dominant type in the region, will have to coincide with suitable conditions; but grazing animals are often allowed to feed on fallow tracts, and the reserves of moisture and nutrients in these cases are largely lost (Al-Fakhry 1981, p. 286).

CROPPING FORMS. Two main methods of cropping are practised in the NE region: sole and intercropping. In the first case, one crop is grown in the field at any one time. This form of cropping holds some advantages. It is mainly practised in the Kirkuk-Erbil-Mosul plain, where mechanisation and use of crop-protective chemicals are easy to apply. It also allows a good plan of timing of the farm operations.

Sole cropping is not without disadvantages. Risk of crop losses can be high, especially in years with inadequate rainfall. In a monoculture system, incidence of plant disease is great, and can destroy most of the crop, especially where application of pesticides is hampered by improper supply and lack of experience. It is difficult to assess the extent of application of sole cropping in the region, but the monocultural system of agriculture is possible only in such areas where mechanisation is not hindered by difficult terrain and other economic issues. In the Kirkuk-Erbil-Mosul plain where wheat and barley are grown largely for commercial purposes, monocultural agriculture is widespread. Even where a farm may grow more than one crop, each is planted and harvested as sole crop for ease of mechanisation and management.

Intercropping. In the subsistence-farming sector, where pest control methods, mechanisation and skillful management are not available, there are other forms of cropping. Intercropping is a system in which two or more crops are grown simultaneously in rows in a specific pattern. There are many advantages and disadvantages to this form of cropping. Advantages are:

i. generally greater overall returns per hectare;
ii. natural weed control, by crop plant competition (less nutrients or energy supply will be available for weeds to grow);
iii. risk of failure of any one crop will be minimised, to ensure continuous subsistence for the farmer and his family upon failure of a single crop;

The main disadvantage in the case of intercropping is that crop management, under these conditions, requires more time per unit area. More manual labour is required under the intercropping system, which can sometimes encourage farmers to reduce acreage to keep in line with supply of labour. No wheat or barley crops in the region are grown by this system; but in paired rows, potatoes or onions are often grown in this fashion in some areas.

Relay cropping. This form of cropping pertains to the planting of successive crops on the same soil in the same season. In the NE region, this system is not widespread, and it mainly involves periods of intercropping where harvesting of one crop overlaps sowing the other crop. Under the rainfed conditions of agriculture in the region, it is difficult to achieve success with relay cropping, because there is not usually sufficient moisture for two successive crops. Lentils and chickpeas crops are often grown in this fashion in some areas. It involves planting lentils at the beginning of the rainy season (late autumn), and later planting a short-cycle chickpeas crop in between the lentil crop rows as it matures, providing the farmer can judge that there is sufficient moisture in the soil.

Mixed cropping. Many farmers in the region keep a small area of land especially allocated to growing a small number of vegetable crops, often tomatoes, potatoes and onions, for domestic consumption. The crops are grown simultaneously with no row arrangement. This arrangement serves mainly as a source of food supply for household consumption.

4.2.3 FARMING OPERATIONS

4.2.3.1 PLANTING TECHNIQUES

TIME OF PLANTING. Environmental factors, especially rainfall and temperature govern the date of planting. Even where temperatures allow the planting of seeds, the region's farmers often delay sowing until the first rains have fallen. The reason for this delay is obvious: fluctuations in rainfall between the seasons and between the years are frequent; and farmers are too careful to attempt planting before a measure of rain has fallen in any one year. This process of delay often affects the levels of production, as premature flowering reduces yield. In general, the date of the first significant rainfall is the factor which determines planting date.

Wheat and barley are especially affected by this arrangement. Both crops must be planted at a time when they can take advantage of good growing conditions. If planted too early in autumn, or too late in spring, when weather is hot, they do not grow and yield as well as under cooler conditions. Spring-seeded crops, such as wheat and barley, can produce more the earlier they are planted after conditions are favourable for germination and growth. Patterns of rainfall are the major point of disturbance to dates of planting. Calculated from figures provided by Iraqi Meteorological Organisation (IMO, 1982 pp. 45-51), the coefficient of variance for rainfall in Mosul in the period 1950-80 was found to be 0.39.

Al-Fakhry (1981, p. 220-223) found that best time of plantining of cereal crops under rainfed agriculture in north Iraq was in the period 15th September to 15th October of each year. In this way, the results of the investigation have also reported reduced incidence of disease when planting during the proposed period was observed.

PLANTING DEPTH. The planting depth is dependent on the type of crop, the seed size, and other environmental factors including time of year and soil conditions. Samaller seeds are normally sown in lesser depths than seeds of larger size. In the NE region, the farmers are driven in selecting planting depth by two major considerations: soil structure and rainfall. In general, cereal seeds are sown at a hand-depth (locally known as kaf), which is about 8cm-depth. This level is often reduced to about 5cm in areas with high clay content. In both cases, water penetration is used as prime criterion for choice of depth by the farmers. Under fairly similar rainfall and soil conditions in Syria, Alqhewi (1976, pp. 3-9) found that 8cm planting depth was probably best suited to rainfed agriculture in the case of wheat and barley. These findings have been upheld by Al-Fakhry (1981, p. 228) as applicable to rainfed agriculture in Iraq under levels of rainfall ranging between 200-500mm.

In deciding seeding depth, the region's farmers ensure that seeds are not planted deeper than is necessary to put them into contact with moist soil to maintain sufficient moisture in the seed zone during germination and seedling establishment following rainfall.

SEEDING RATE. Uncertainty still clouds the best economical limits of seeding rates for the region's cereal crops, especially wheat. In the various areas of the NE region, the farmers adjust seeding rates to fit seedbed conditions, time of planting and local environment. Since moisture is often a critical factor under the region's rainfed conditions, adjusting seeding rates is essential to avoid excessive use of available moisture prior to next stages of crop development.

Under the broadcast planting technique, which the common type of sowing in the region, estimating seeding rates and spacing is not easy, as farmers often follow arbitrary criteria based normally on experience. In different parts of the region, different rates of seeding are applied, which range generally between 60 kg/ha and 120 kg/ha (Al-Fakhry 1981, pp. 310-311). The uncertainty remains, however, even where one individual area is concerned, as to the optimum seeding rate. In 1975, a joint experiment was conducted by Iraqi agricultural scientists (Al-Fakry and Sultan 1979) to determine the best seeding rate for wheat in Hammam El-Alil (36-10N/43-16E; 20km SE of Mosul, on the right bank of river Tigris). The experiment was phased over two sesaons (1972/73 and 1973/74), using several rates of seeding, which ranged between 20 kg/ha to 120 kg/ha. With icrease in seeding rates, above 20 kg/ha, there was no significant rise in yield levels. On average, increasing seeding rate by 500 per cent (from 20 to 120 kg/ha) has given only 8.6 per cent rise in yield, as yield increased by only 74 kg/ha (from 864 kg/ha to 938), as listed in table 4.4.

Table 4.4 EFFECT OF SEEDING RATES ON WHEAT YIELD IN HAMMAM EL-ALIL

Seeding rate (kg/ha)	Yield (kg/ha)* 1972/1973	1973/1974	Average
20	688	1040	864
40	708	868	788
60	732	1076	904
80	884	1080	982
100	664	956	810
120	788	1088	938

Source: (Al-Fakry and Sultan 1979).
* Annual rainfall were 237mm and 411mm respectively.

The calculated correlation coefficient (r) between the seeding rate is low for both seasons of the experiment (0.34 for 1972/73 and 0.31 for 1973/74). This statistical test confirms the insignificant relationship between seeding rate and yield under the rainfed conditions in Iraq. On average, however, a rise in rainfall by 73.4 per cent between the two seasons in the test has been matched by an average increase in yield by 37.0 per cent.

In another study in the same area (Ali 1978), however, 160 kg/ha seeding rate for wheat was found to give best yield results within rainfall levels ranging between 200mm and 352mm, but these new results cannot be generalised because fertilizers were used.

4.2.3.2 CROP MANAGEMENT

INTRODUCTION. The crop management standards in the region are essentially simple, and often primitive. Where direct government assistance has not arrived, agriculture is arranged extensively, and the use of the land is hindered by low fertility and primitive technology. The resort to fallow is still widespred, especially where crop-rotations are not known. The use of fertilizers for cereal crops is very rare. Activities associated with harvesting and crop processing are based largely on time-honourd traditions, on which modern agricultural technology has only limited influence.

LAND PREPARATION. In preparing the land, two technologies are employed; in the Kirkuk-Erbil-Mosul plain, mechanisation (often in the form of tractor-pulled vertical disk ploughs) is increasingly employed by croppers to prepare the land for cultivation, but animal-drawn wooden ploughs are still used in many piedmont plains where modern technology is hindered by diificult terrain or unfavourable institutional conditions. In both cases, tillage is undertaken according to the following arrangements:

1. Tillage is undertaken twice; once during the fallow year, immediately after the first rains in autumn, and by the same time in the next cropping year.

2. Irrespective of method of tillage (mechanised or not), ploughs are used to cut the soil, at a shallow depth, without exposing the undersoil.

3. Harvest litter is left on the ground, and while minimum tillage may help keep this litter to preserve moisture, weeds remain largey unscathed.

Invariably, land preparation in the rainfed region in NE Iraq is arranged according to the minimum tillage system. Zero tillage (no tillage) system is also known in the region, but is exclusively confined to small areas in the piedmont plains, especially in Aqra plain (36-45N/43-54E) where rice is cultivated. In this method, seeds are sprayed and allowed to sink on flooded areas.

In an M.Sc. thesis at Sulaimaniyeh University, Fathalla (1979) investigated the land preparation arrangements in north Iraq. The characteristics of the minimum tillage system for rainfed agriculture were summarised by Fathallah (1979, pp. 12-35) in the following points:

1. Minimum tillage is best suited for soils with poor structures, and in areas where slope acts as a constraint on extensive farming.

2. More moisture is made available to crops by keeping the tillage of the land to a minimum, as deeper tillage is bound to increase moisture loss.

3. The system has a significant, albeit limited, effect on reducing the impact of competition by other uncultivated plants, through the eradication of some of the weeds which grow in the fallow year.

4. From the economic point of view, minimum tillage entails less labour inputs.

Al-Fakhry and Sultan (1979) investigated the effect of different levels of tillage and in different seasons on the yield of wheat at Hammam El-Alil (36-10N/43-16E) in north Iraq, to determine the best method of tillage suitable for rainfed agriculture. As shown in table 4.5, there was no significant differences registered, when differences in timing and depth were experimented, from those of the traditional (autumn) ploughing with minimum tillage depth (8cm). Where herbicides were used (to eradicate weeds), the yield was also fairly similar when only ploughing was used.

In examinimg table 4.5, it immediately appears that while differences in tillage treatment has resulted in some minor changes in levels of yield, again rainfall (as discussed in section 4.2.3.1) was the single most significant exogenous factor in determining the level of the resultant yield. Quite obviously, tillage in itself does not serve as unique factor in enhancing production, and the process of land preparation is largely dependent on the critical factor of moisture. As the table shows, with increased depth of tillage, levels of crop yield have not always risen correspondingly. In the first year of the experiment there was some rise in yield with increased tillage depth, but this has not been observed in the second year. Equally with more frequent tilling, yield has risen, but the process clearly demands increased level of inputs which cannot always justify the growth-margin in yield.

Table 4.5 **EFFECT OF TILLAGE ON WHEAT YIELD IN HAMMAMM El-ALIL**

Treatment	Wheat yield (kg/ha)* 1973/74	1975/76	Average
1. Frequency:			
winter + spring + autumn	736	1132	934
spring + autumn	664	1296	980
herbicides + autumn	744	820	782
autumn	528	680	604
2. Tillage depth (cm):			
8	644	1376	1010
15	556	1008	782
23	760	1216	988

* Annual rainfall in 1973 was 411mm; and 493mm in 1975.
Source: Al-Fakhry and Sultan 1979.

FALLOWING AND ALTERNATIVE ROTATIONS. The issue of fallowing was discussed briefly in section 4.2.2, under the cultural systems. Despite some of the advantages of the fallow system, the loss in land resources by allowing for a fallow year can be eliminated with the introduction of a proper crop rotation. In the NE region, however, fallowing is still widespread. Crop rotations require expertise which is not yet available in most areas, and the advantages of growing a fodder crop in the fallow year are slowly being realised.

Worse still, due to frequent delays in rainfall or high fluctuations in the level of precipitation in the region, more than one season of fallow is still common in many areas (FAO 1982, p. 51). The 1971 agricultural census in Iraq provided figures on this group of lands (often referred to as marginal; table 1.26), which amount to over 37 per cent of total arable land. The perception of fallowing is still often exaggerated by the region's farmers. Economic losses due to leaving half of the arable land uncultivated every year do not always justify any gains which may be won from the fallow. Soil exposure in the fallow season allows erosion to impair fertility; both in the summer as a result of wind erosion, and in winter by sheet erosion which may be caused by heavy rainfall.

Several forms of rotation have been tested in the region with promising results. Crop rotation permits utilisation of nutrients and moisture from the soil more completely than sole cropping, since different crops can have different rooting systems and requirements for nutrients and water. However, a crop rotation may make the land less productive if uncarefully planned, and if soil fertility is not maintained either through the rotation or by the addition of fertilizers from external sources. With lack of incentive or inability to invest either in crop rotations or in fertilizers, rotations remain limited in extent. Furthermore, crop rotations in the rainfed NE region are, by necessity, restricted, as there is not a wide array of crops that are readily adapted because of both ecological and economical constraints.

Wheat/pulses rotation has become fairly widespread in areas with high levels of rainfall. Chickpeas and lentils are the two major grain legumes which are used in rotation with wheat. In parts of the extensive Kirkuk-Erbil-Mosul plain, where adequate rainfall is received, however, the shortages of labour and mechanisation have meant that the process is slow, especially since both chickpeas and lentils are low-crops and need specially-designed harvesting machinery. Summer rotations are still restricted to such areas where soil moisture can allow the growth of such crops as sunflowers, as is recently being tried in Dohuk (36-52N/43-00E).

The College of Agriculture and Forestry in Mosul has pioneered since the early 1970s a number of schemes to test suitable crop rotations for the rainfed region. Al-Fakhry and Sultan (1979) investigated the effect of different crop rotations on the wheat yield in the Hammam El-Alil area in three seasons, under average annual rainfall of 330mm. Beside the traditional wheat/fallow treatment, other tests were made to experiment with three rotation alternatives (wheat/lentils, wheat/lentils ploughed under, and continuous wheat). In all cases, continued wheat cultivation and the wheat/fallow treatment gave lowest levels of yield (table 4.6). The results of the trials were extremely encouraging, but by 1982, the FAO was still concerned at the limited practice of crop rotation, urging for greater encouragement to research and for issues such as necessary mechanisation to be paid greater attention, in order to eliminate fallowing (FAO 1982, p. 50-51).

Table 4.6 **THE EFFECT OF DIFFERENT CROP ROTATIONS ON WHEAT YIELD IN NORTH IRAQ**

Rotation	Wheat yield in kg/ha			
	73/74	75/76	77/78	mean
Wheat/Fallow	712	806	679	732
Wheat/Lentils	623	765	849	745
Wheat/Lentils*	705	1118	1098	974
Wheat/Wheat/Wheat	486	753	410	550

* The lentils were ploughed under in spring.
Source: Al-Fakhry and Sultan 1979.

FERTILIZATION Fertlizers are rarely used in the region by ordinary farmers to enhance fertility. Only on vegetable farms is the use of fertilizers (often manure) fairly common, albeit in small quantities. The limited use of fertilizers by the region's farmers is due to two essential points: first, fertilization is rarely judged by the farmers to be cost-effective; second, under the rainfed conditions in the region, fertilization may encourage crops to become too vegetative to sustain seed production and, as a consequence, may also cause loss of critical supply of moisture from the soil before maturity.

The application of fertilization as a substitute for fallowing is not common, the latest available data on use of fertilizers by the region's farmers are those provided by the 1971 agricultural census. As shown in table 4.7, by 1971, only 2.1 per cent of all the agricultural land in the region had received fertilizers. As the percentage figure on the use of organic fertilizers serves to indicate, organic fertilizers were more applied than chemical alternatives.

Table 4.7 FERTILIZERS APPLICATION IN NE IRAQ AS REPORTED IN 1971

Treatment	Area (ha)*	%
Chemical ferilizers	24,864	0.8
Organic Fertilizers	40,403	1.3
Total	65,267	2.1

* The census covered land on holdings; total = 3,107,947ha.
Source: Calculated from CSO 1973, table 47.

In a report on rainfed agriculture in Iraq prepared by the FAO in 1982, the use of chemical fertilizers for the rainfed region was recommended, especially nitrogen and phosphate compounds (N and P2O5). No potassium fertilizers (K2O) were advised. It was stressed, however, that the use of fertilizers will not be beneficial in areas falling under 200mm to 350mm rainfall lines. There were no indications about methods and extent of application, and more research on the subject was proposed (FAO 1982, pp. 49-45).

PEST AND WEED CONTROL. Wheat and barley diseases in the NE region are closely associated with soil and seed. Because of the long dry summer, and limited moisture, foliar diseases are not common, and often do not occur in areas under 500mm of rainfall (foliar pathogens need high moisture for infection). One of the advantages of the fallow system widely used in the region is to break the chain of pathogen development, but if the fallow system is to be eliminated in favour of continuous cropping, and to a lesser degree rotations, pest control will probably pose more difficulties in the future.

The most important diseases under the rainfed conditions in the region are rust (sada), smut and bunt (tafahhum), and root rot (taafun). In the high rainfall zone (above 500mm annual rainfall), foliar diseases are common, including leaf rust, stem rust, speckled leaf blotch, tan spot and powdery mildew. Insect pests of wheat and barley are not very common in the region. Plant pathologists, however, have occasionaly reported a number of insect-inflicted diseases on the wheat and barley crops in the region, including wheat stem maggots, cut worms, sawflies, Hessian fly and grain moths (Al-Atraqchi 1979, pp. 191-194).

There is hardly any track of research yet in the region on vertebrate-pest control such as birds, rats and rabbits. Virtually on every field, several scare-crows are posted, and experience has shown that birds of many species can destroy seeds and seedlings at planting and emergence stages to a an extreme extent in some areas.

Rodents also destroy crops from above and below ground and create enormous strorage difficulties at the village level. The primitive methods used by the peasants to control rodent pests (often rodents are left to die in man-made traps) are incapable of coping with an increased threat of loss during storage of grains.

There are no new data available on the use of pest control chemicals in the region, and the only figures which date back to the 1971 agricultural census indicate scant use of pesticides by the region's farmers. Only 6.1 per cent of the farmers of the region's five provinces reported using, or their farms being sprayed by, pesticides (calculated from CSO 1973, table 48).

Weed control in the region often does not go beyond partial interruption of the weeds seeding cycle, through fallowing and minimum tillage. In general, herbicides as a method of eradicating weeds are unknown to most farmers, and the only available figures on their use have come from academic research which find no expression in the average farmer's daily practice. Storage problems from weed contamination are encouraged by the high moisture content of the weed impurities. This increases insect and fungal damages in stored cereals and reduces the quality of the grains for human consumption. The difficulties of weed control in rainfed regions are universal, and in many places weeds probably cause more yiled loss, especially in the case of wheat production, than any other production hazards (Rajaram and Nelson 1985, pp. 320-322).

There are no sufficient data available on the weeds and use of herbicides by the region's farmers. The 1971 agricultural census did not include weed control as an investigation area. Al-Atraqchi (1979, p. 183), however, estimated that looses in yield caused by weed problems reached at least 30mn Iraqi Dinars annually (approx. US$90mn) throughout the country.

HARVESTING. Harvesting methods in different parts of the region will be reviewed in some detail in discussing the management levels of farming later. Cereal crops are generally harvested when the spikes or panicles appear yellow or golden in colour and the supporting peduncle is straw-coloured. Wheat often needs four months to reach maturity, but as sowing is almost always late in most areas, the crops normally take more time to reach maturity. Harvesting in the region is often made between April and May each year.

In general, however, farmers tend to harvest their crops early, as risk of loss by means of wind, arson, pest-inflicted damge and heat exposure becomes greater with the crops in the field for a longer time. Farmers are extremely sensitive about the prospect of loss of harvest by any means (arson during the harvest season is punisheable by death according to the Iraqi Penal Code). Farmers use experience in judging the readiness of the harvest to thresh, by means of bending the head (spike) between fingers. Al-Fakhry (1981, p. 229) estimates the moisture content during harvest in north Iraq to be between 15 and 20 per cent.

4.2.4 PRODUCTION SYSTEMS AND MANAGEMENT STANDARDS

4.2.4.1 THE PRODUCTION SYSTEMS IN NE IRAQ

INTRODUCTION. Two broad categories of production systems in the region can be distinguished: subsistence cropping and commercial crop production. Within these two sectors, gradations are common; and while crops are the same, objectives, levels of inputs and returns are different.

THE SUBSISTENCE SECTOR. The main target of subsistence cropping in the region is achieveing self sufficiency at the level of household or village. Many rural communities in NE Iraq are engaged in subsistence cropping, but with varied levels of subsidiary marketable surplus. The subsistence sector is often self-regulatory, and management decisions are taken collectively by the village community.

The subsistence sector in the NE region is essentially a self-sufficient enterprise, the main objective of which is to provide the individual farmer, his houehold or village, with access to food and commodities necessary for survival. However, in most cases where production of crops is in excess of immediate consumption, some of the output is bartered for other commodities, or sold or exchanged for cash or services (agricultural products, for instance, can still be used as marriage dowry in some villages). Input levels in the susbsistence sector are minimised; and lack of credit or cash means that fertilizers, machinery and technical advice are scarce.

Even where additional inputs are within the financial capacity of a subsistence community, access is often diminished by a host of other difficulties which are peculiar to the farming community in the NE region, such as political instability, severe terrain and limited means of transportation. Where roads have not reached small villages in the mountainous zone, there is conceivably little chance of marketing agricultural commodities over a long distance. In some areas, the journey to and from the nearest market can take days of travel on the back of mules, donkeys or horses.

The cultural systems under the subsistence sector are geared towards manual labour techniques, and productivity is very low per man-hour. There are no surveys available to serve indicate the exact extent and input levels under this system of production in the region, but in qualitative terms, experience has revealed that seeds and manual labour are the two sole components of the agricultural production in the subsistence sector. The technical know-how is extremely limited in the subsitence areas, and the farmers are conservative in their approach to cropping management methods, because of their reluctance to change from the time-honoured traditions to the unknown.

In the border areas, illicit trading, often in the form of smuggling of commodities from or to Turkey and Iran, can be the sole means of accumulating cash for some communities, while cropping serves to ensure food supply for the family or the village community.

THE COMMERCIAL PRODUCTION SYSTEM. In discussing the production systems in the region, it is necessary to point out that most agricultural cooperatives are geared towards a measure of commercial production. As previously discussed in section 1.4.5, the percentage of farmers who are members in agricultural cooperatives in the region was approximately 60 per cent by 1982. It follows that about that percentage of cooperative farmers are engaged in some commercial crop production. The five state farms in NE Iraq are also conceivably commercial producers, although only 104 farmers constituted the man-power of such farms in 1982, and their number is progressively on the decrease with the decline reported over the years in economic terms under this system of production (al-Dahiri 1982, pp. 247-262).

Under the commercial crop production system, crops are primarily raised for sale, although some of the products can be consumed on the farm by the farmer and his family. The crop grower under this arrangement is often engaged in a form of production which provides him with capital (or through the cooperative, with credit) with which the purchase of agricultural supplies, such as seeds and fertilizers, and the purchase or hire of equipment and machinery can be made. Although the farmer who is a member of an agricultural cooperative has more flexibility in decisions relating to crops grown and cultural systems, credit is often accompanied by an undertaking to grow certain crops. This has increasingly meant the growth of government-endorsed crops such as wheat, barley and fodder, to meet national demand and production targets.

Invariably, the state guarantees the purchase of almost all cereal products, as well as provision of farm supplies, at artificial prices, which are planned to give the farmers more cash for their products, compared to the international market. The region's farmers, however, do not always welcome this arrangement. In the case of such commodities as vegetables, fruits, tobacco and meat, the state buys products at prices which are well below what the consumers are ready to pay under a free marketing system.

Under the commercial sector, the use of additional inputs, mainly in the form of greater labour input and machinery, is greater than those levels in the subsistence sector. There are, however, no marked differences between the two sectors in terms of the cultivation factor (number of years of cultivation as a percentage of the total cultivation/non-cultivation cycle (FAO 1983, p. 34)). The use of fallow is equally common, and as discussed in section 4.2.3.2, there is still a long way to go before the fallow is abolished, at least under the commercial system of crop production.

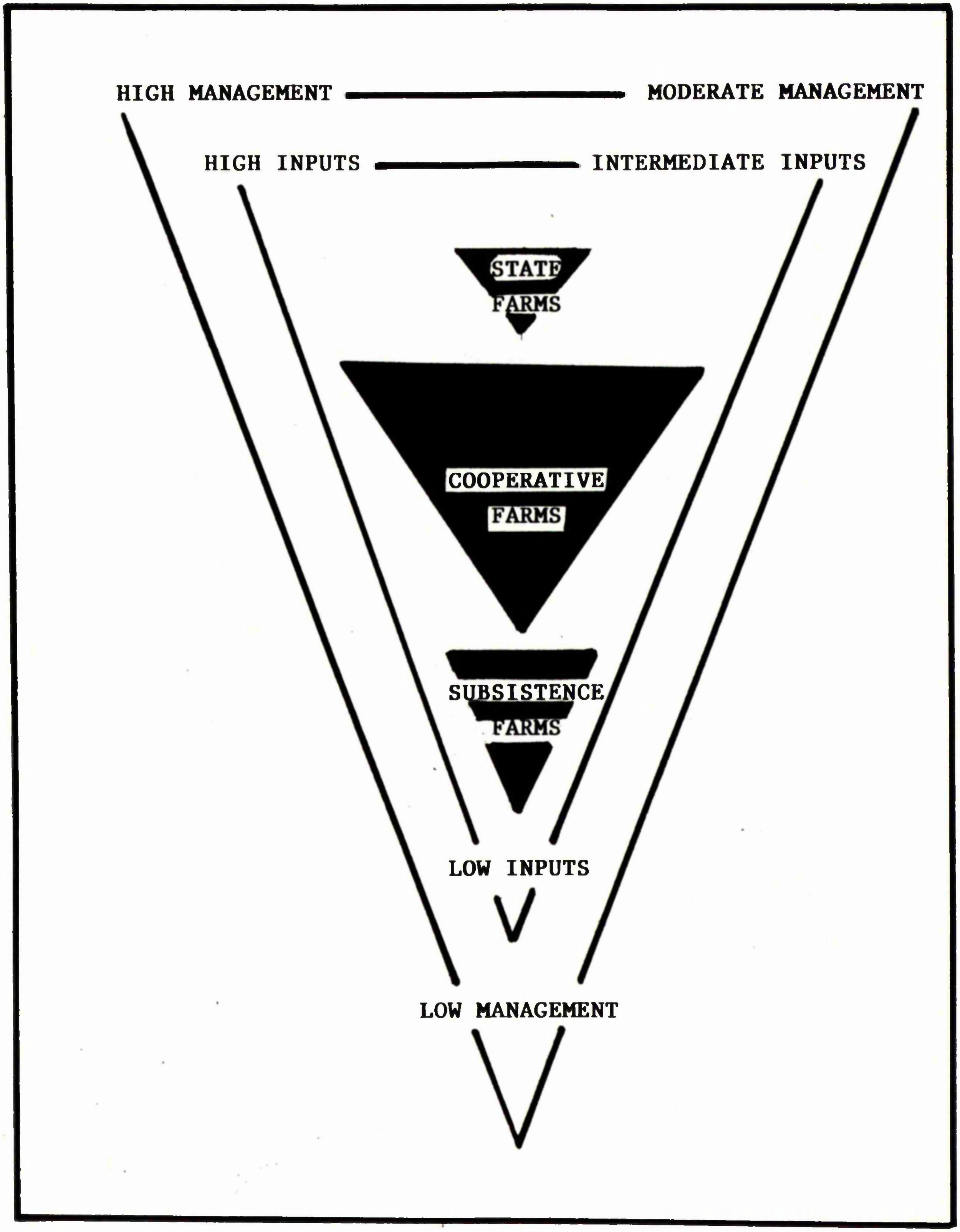
The main distinction between the two above systems of production remains, by and large, the quantity of the output. In the case of the susbsistence sector, output is limited to the immediate demand and supply levels in the subsistence-farming community, while in the commercial sector, the production process is designed to produce a greater marketable surplus, with relatively higher levels of labour input and machinery.

4.2.4.2 STANDARDS OF MANAGEMENT

DEFINITION. Standards of management pertain to how well the farm is managed, involving several aspects of agricultural operations. In qualitative terms, management standards can be expressed by a matrix of nine combinations: low, intermediate and high inputs; each combined with high, moderate and low standards. In discussing standards of management, however, it is impracticable to appraise separately each standard of management. A management class is tacitly assumed, qualified by information on technical know-how and attitudes (FAO 1984, p. 36).

INTRODUCTION. For the purpose of this qualitative evaluation of the land in NE Iraq for rainfed agriculture, levels of inputs will be examined in qualitative terms, supported by what is available of data and information on the general input qualities. Broadly speaking, two major management standards exist in the region's agricultural sector. Excluding the small government experimental farms, the subsistence sector is characterised by a low standard of management; while cooperative farms have a moderate standard of management. Correspondingly, input levels in the subsistence sector are often low; in cooperative farming with commercial production standards, the level of inputs are low, and rarely moderate. The classification of management standards and the corresponding levels of inputs are illustrated in figure 4.2, incorporating three agricultural sectors: subsistence farms, coopearive farms and state farms.

Figure 4.2 CATEGORIES OF MANAGEMENT STANDARDS



THE STRUCTURE OF THE REGION'S AGRARIAN SYSTEMS. In spite of some differences between the agricultural systems under the two main sectors in the region, the cooperative farms and family farms, broad similarities qualifify generalisations and comparisons. With the diminishing state farms, the farmers under the cooperative sector and also largely under the subsistence sector are basically rural cultivators whose prime concern is survival. In terms of levels of productivity, there is little to distinguish betweeen the two managerial systems.

For the vast majority of rural families in NE Iraq, whose members constitute the main agricultural workforce, agriculture is still more a way of life than merely an occupation or source of income. The failure of the cooperative system in introducing sufficient biological and technical innovations has elicited little change in the farmers' values and traditions. The managerial systems under cooperative farming show more structural and institutional similarities, with the traditional sector, than differences. In both cases, the farmer achieves his profits through the fortunes of rainfall or the market, rather than according to preconceived plans. The family or the village's minimal needs are obtained often through tilling an inadequate piece of land, with substandard levels of inputs and management. The farming techniques are rationally scaled to the levels of disposable capital or inputs rather than profit prospects; human and animal power rather than mechanised equipment; and traditional crops and seeds rather than experimental culitivars are the main inputs.

Since 1970, the planning authorities in Iraq have frequently attempted to draw up managerial policies, supported by the power of the law, to encourage a redistribution of farming input levels of individual cooperative farms to maximise productivity and effciency. Law no. 117 of 1970 authorised the Supreme Agricultural Council to recommend and allocate necessary funds for the attainment of an advanced level of inputs in rainfed agri-culure. The recommended rates are listed in table 4.8, along with the levels suggested for the irrigated agricultural sector, for comparison (al-Dahiri 1980, pp. 65-66).

Table 4.8 GOVERNMENT RECOMMENDED RATES (%) FOR LEVELS OF INPUTS IN IRAQI AGRICULTURE

Inputs	Irrigated Agriculture	Rainfed Agriculture
Farm supplies*	10	10
Water / Drainage	10	00
Labour	50	50
Tillage	5	10
Harvest & Storage	10	15
Management costs	15	15

* Seeds, fertilizers, pesticides.

There are many flaws to this approach of policy recommendation, as the above rates do not specify the levels of output that can justify this approach. Clearly, under the subsistence system, it is almost impossible to meet these rates neatly; and the management costs under these conditions are often inseparable part of the labour factor. In discussing the constraints on inputs (section 1.43; table 1.16), it was obvious that while input levels varied slightly between different areas, these levels, however, remained depressed and largely constrained by strong physical factors, especially rainfall.

SOURCES OF FARM POWER. The inception of mechanised farming is governed by considerations of the economy of manpower, time, capital and technical know-how. In many parts of the region, difficult terrain also affects the decision to mechanise farming. In general, land preparation (tillage) has been the first mechanised operation, especially in the NE plains. The use of tractors in such areas has become more attractive because of the wide range of possible uses of tractors, both on the farm and outside where tractors are often used for transportation by the farmers. There is also an increased tendency, encouraged by the state, to mechanise harvesting in the plains. Combine harvesters, however, are a specialised and expensive equipment, the use of which may only be limited to a few days every year, during the harvest period. And insofar as the region's farmers are concerned, individual farms are unlikely to have a combine harvester for their own exclusive use. Such equipment ise therefore often rented from private owners or state agencies. Furthermore, the use of the harvesters is only economical when large areas are harvested, i.e. for cooperatives and large estates.

For a farmer, mechanisation of a particular phase of his activities is considered only when labour costs become significantly high or in short supply, and where the quality of the work can be definitely improved by mechanisation. For all those reasons, the use of machinery remains limited in many areas. Information on the extent of mechanisation in the NE region is limited. The term 'mechanised' is loosely used by government statisticians, and can often be taken to mean land preparation by means of tractor, as there is scarcely any data on the types of equipment used, and also whether machinery is owned or rented by the farmers concerned. The figures listed in table 4.8 are those issued by the 1984 annual report of the Supreme Agricultural Council in Iraq.

Table 4.9 SOURCES OF FARM POWER IN THE NE REGION (Holdings)

Province	Total	Mechanised	%
Dohuk	21,735	5,745	26.4
Mosul	78,323	63,572	81.2
Erbil	37,361	18,832	50.4
Kirkuk	43,730	35,550	81.3
Sulaimaniyeh	47,985	21,969	45.8
Total/Mean	229,134	145,668	63.6

Source: Calculated from SAC 1984, pp. 63-64.

The figures in the above table clearly indicate that over one third of the total agricultural holdings still use no mechanised equipment in agriculture. It is also equally clear that the relatively low use of machinery in the provinces of Dohuk and Sulaimaniyeh may be due to the charcateristically mountainous terrain in these two provinces.

In areas where mechanised farmpower is not used, the technical level of the agricultural operations is unusually low, and the main implements on the farm have remained unchanged for centuries. In such areas, the land is tilled with a traditional wooden plough (mihrath in Arabic, jut in Kurdish) drawn by an ox, and sometimes a horse. In the course of the year, a pair of draught animals are employed in tilling a piece of land not exceeding 3 to 5ha. A furrow no more than 8-10cm deep can be cut in this method. Harvesting in such areas is done manually, by sickles, and in general work is organised collectively during the harvest time in which all the villagers, as well as some hired labour take part. Under these primitive condition, the threshing of the crop is a lengthy process in which two methods are traditionally employed:gera and janjar. The gera involves a small number of draught animals (ranging between one and 5) which are tied to a post and made to walk around in circles, treading on the ears of the crop (whaet or barley), until they are threshed. Unlike the gera method, the janjar is a small wooden carriage which has sharp cogs fixed to the wheels. The carriage is drawn by animals in circles, until the crop is threshed.

4.2.5 CROP YIELD AND PRODUCTION

4.2.5.1 INTRODUCTION

Yield levels form a good basis for the analysis of the land qualities in any given area, since they are the outcome of an interaction between the utilisation of the land and the land itself. Crop yield and production, under stable conditions for growth, reflect to a great extent such factors as cultivation practices and levels of inputs and management.

Although yield has been listed as a land quality in the FAO's Framework for Land Evaluation, experience has increasingly questioned this direct approach. Later in the Guidelines for rainfed agriculture, the FAO (1984, p. 148) maintained that "whilst [rating yield as a land quality is] logically suitable, this has been found to be confusing, and it is here recommended that observed crop yields be treated as a separate and distinct type of data, against which suitabilities derived from land qualities may be tested and modified."

4.2.5.2 YIELD LEVELS IN NE IRAQ

HYPOTHESIS. Where sufficient data on yield are available, yield rates for any individual crop can serve as a good means of assessing land suitability. This approach, however, can only be justified where the entire study region is covered by a closely spaced network of controlled crop variety and fertilizer trials; but at least insofar as the NE region in Iraq is concerned, such a situation does not always exist. Only estimates of wheat yield can be calculated with reasonable accuracy, as data on barley production in the NE region are scarce and often based on provincial statistics. The most difficult obstacle in establishing a credible mathematical model to estimate crop yields in the region is the fluctuation in moisture caused by erratic rainfall. The relationship between rainfall and yield levels in the region has been statistically established, and a fairly strong coefficient of correlation (r) was estimated by Zaki (1979, pp. 125-141). As the examination of the rainfall patterns in the previous chapters have served to indicate, yield levels do not always serve as a stable quality of the land.

DEFINITION & METHOD OF ESTIMATION. Yield as will be examined in the context of the region is the ratio of output per unit area. In government statistics, the yield is often expressed in kg/donum (one donum = 0.25ha), and it is therefore necessary to transform available figures into the kg/ha units to bring them in line with more universal standards.

The FAO Guidelines on rainfed agriculture (1984, p. 148-149) recognised five possible sources of crop yield data which, listed in approximate descending order of precision, are:

a. trial plots set up on representative sites;
b. existing data from trials on experimental stations;

c. yield records from official sources or individual, technically advanced, farms;
d. crop sampling from farmers' fields;
e. theoretical estimates based on climate and soil data.

Taking account of procedures b, c and e above, a mathematical model was prepared to estimate wheat yields on grounds of data available on climate and soil. combining the factors of aridity (section 2.1.8) and soil condition indices (section 4.4.5: soil conditions). The mathematical model for wheat yield in the region has the form:

$$Y = 767 + 1.7\,X + 0.1\,Z$$

where, Y = wheat yield (kg/ha); X = aridity index; and Z = index of soil potentiality (discussed in detail in section 4.4.5). The data used in constructing the regression model, along with the regression coefficients, are listed in appendix III. Data on wheat yields, climate and soils have been accumulated from verious sources (Zaki 1979; CSO 1968-1980; Buringh 1960; Altaie 1969; IMO 1982).

WHEAT AND BARLEY YIELDS IN NE IRAQ. In choosing a period to examine levels of yield for the two major rainfed crops in the region, government statistics were used to trace yields from 1968 until 1980. As shown in tables 4.10 and 4.11, variations in wheat and barley yields are very wide for the period under examination. The highest yield was observed in 1972 (1,209 kg/ha for wheat; 1,119 kg/ha for barley); and the lowest in 1980 (398 kg/ha) in the case of wheat, and 1973 (512 kg/ha) in the case of barley. Both tables, 4.10 and 4.11, have been calculated from CSO annual abstracts.

Table 4.10 WHEAT PRODUCTION PARAMETERS FOR NE IRAQ 1968 - 1980

Year	Area (ha)	Prod. (ton)	Yield (kg/ha)
1968	1,240,500	953,100	768
1969	1,170,700	621,600	531
1970	1,320,400	655,500	496
1971	531,625	304,500	573
1972	1,429,300	1,727,800	1,209
1973	719,351	340,000	473
1974	1,229,525	794,200	646
1975	1,277,489	776,950	608
1976	1,071,150	789,500	737
1977	1,310,719	682,850	521
1978	1,205,975	606,000	502
1979	1,343,950	588,750	438
1980	1,360,565	541,700	398

Source: calculated from Annual Abstracts (1968 - 1980).

Standard deviation of yield population = 202.8
Coefficient of variance (C.V.) = 33.4
Arithmatic Mean yield (1968 - 1980) = 607.7
Geometric mean yield (1968 - 1980) = 581.8
Median yield (1968 - 1980) = 531.0

Figure 4.3 GRAPHICAL REPRESENTATION (1968 - 1980)
WHAET AREA, PRODUCTION & YIELD

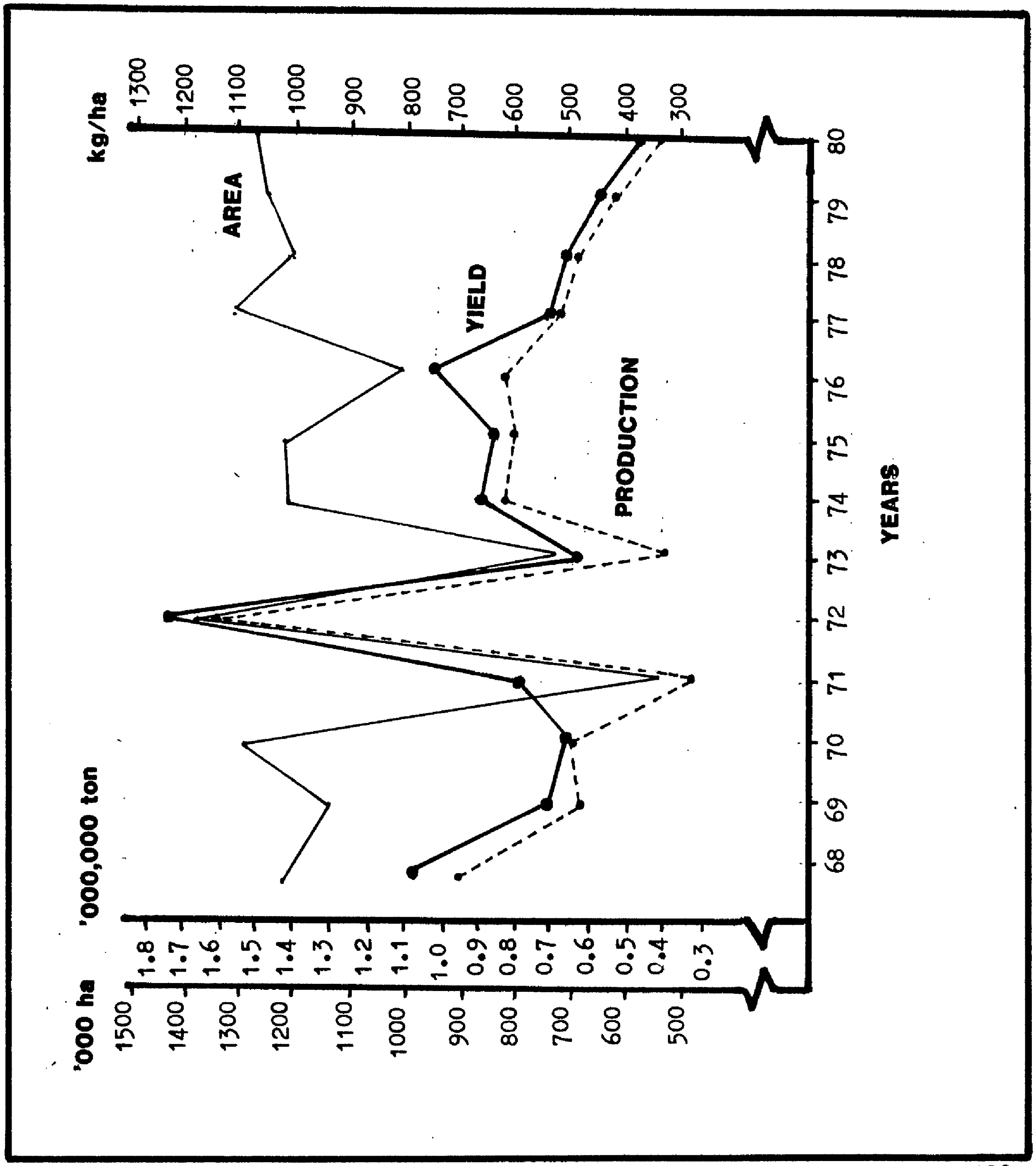


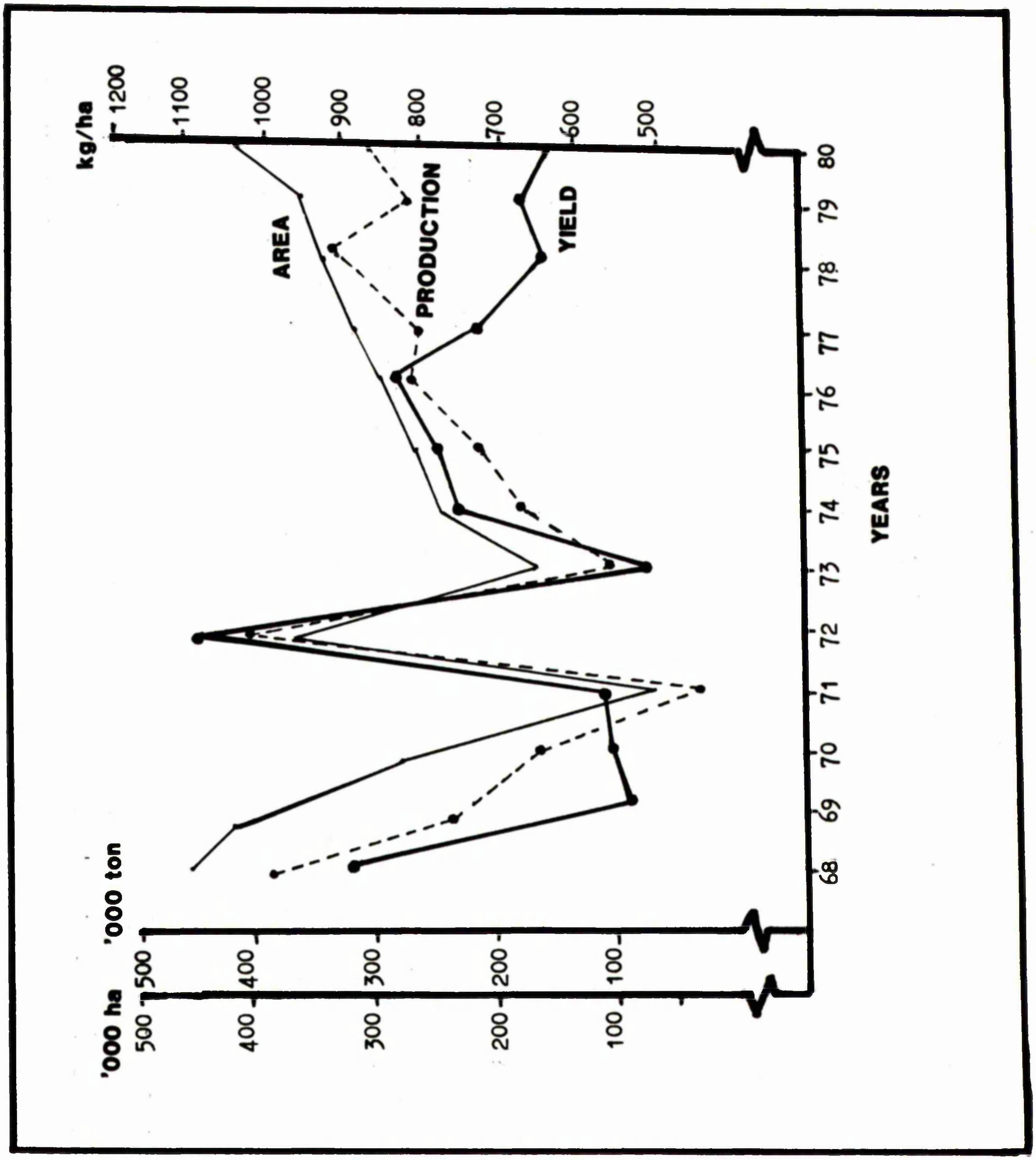
Table 4.11 BARLEY PRODUCTION PARAMETERS FOR NE IRAQ
1968 - 1980

Year	Area (ha)	Prod. (ton)	Yield (kg/ha)
1968	453,100	394,300	870
1969	422,575	229,500	543
1970	282,725	159,600	565
1971	72,300	41,500	574
1972	349,125	418,500	1,199
1973	164,775	84,300	512
1974	214,650	161,900	754
1975	245,308	189,308	772
1976	270,050	226,100	837
1977	318,458	225,358	708
1978	360,950	234,000	648
1979	391,608	261,408	668
1980	428,183	279,433	653

Source: Calculated from Annual Abstracts (1968 - 1980)

Standard deviation of yield population = 175.8
Coefficient of variance (C.V.) = 24.6
Arithmatic mean yield (1968 - 1980) = 715.6
Geometric mean yield (1968 - 1980) = 697.0
Median yield (1968 - 1980) = 668.0

Figure 4.4 GRAPHICAL REPRESENTATION (1968 - 1980)
BARLEY AREA, PRODUCTION & YIELD



STATISTICAL EXAMINATION. The most outstanding characteristic of the yield data for wheat and barley in NE Iraq is the strong dispersion in the annual levels of yield. The statistical range (highest value minus lowest value) is 398 kg/ha for the wheat data, and 687 kg/ha in the case of barley. This, however, should not be taken to mean that dispersion in annual wheat yields are lower than in the case of barley. In fact, the opposite is true. One way to confirm this is to calculate the standard deviation for both groups of data. As the results listed in tables 4.10 and 4.11 clearly show, the wheat data have greater value of standard deviation (202.8 in wheat, and 175.8 in barley). Equally, the coefficient of variation is higher in the case of wheat (33.4 in wheat and 24.6 in barley). This reflects an important quality, in that barley obviously tolerates a wider range of environmental changes, often rainfall (moisture) fluctuations.

On examining averages, it is clear that in all cases, barley levels are higher than wheat yields. Again the results broadly indicate that insofar as the NE region is concerned, under the current levels of management, the soils can generally produce higher barley yields.

In comparing the levels of yield in the region (531-608 kg/ha for wheat, 668-716 kg/ha for barley) with universal average yields under rainfed conditions, the region's average levels of wheat and barley fall well behind the norms of Third World agriculture, estimated by ILACO (1981, p. 519) at 1300-2000 kg/ha.

4.3 LAND USE REQUIREMENTS

4.3.1 INTRODUCTION

Having discussed the land utilisation in the NE region under rainfed agriculture throughout section 4.2, the present part will discuss the land use requirements for the rainfed cultivation of wheat and barley, the two main cereal crops in the region. In doing so, it is necessary to examine the conditions of growth and development of the crops, as well as the environment for the associated farm operations. The assessment of the land use requirements is designed to answer three basic questions (FAO 1984, p. 57):

1. what are the conditions which make the best use of the land possible under the proposed use;
2. the conditions which are unsatisfactory for the proposed use;
3. the range of conditions in which the proposed use of the land is deemed acceptable, though may not be strictly optimal?

In choosing the approach to the evaluation of the land resources in NE Iraq, little or no change was assumed in the land use arrangements for the study region in the near future (section 4.1.2). The crop requirments, rather than management and conservation requiremnts, will therefore be the main concern of the following sections, and these requirements will be expressed in terms of land qualities which can meet the proposed use of the land under rainfed conditions, mainly for wheat and barley crops.

4.3.2 THE CROP REQUIREMENTS

DEFINITIONS AND METHODOLOGY. The rating of land qualities can be best expressed in terms of the range of critical values which affect the use of the land for the rainfed cultivation of wheat and barley. In this context, the terms land use requiremnts and land use limitations can be often used interchangeably. The land use limitations are essentially land qualities or their expressions by means of diagnostic criteria, which can adversely affect a kind of land use. In other words, limitations are negative land qualities expressed to show the extent to which the conditions of the land fall short of the requirements for a given use. To illustrate the concept further (Dent and Young 1981, p. 165), most limitations are requirements expressed in a negative sense; thus good rooting conditions, for instance, are a requirement for crops, whereas poor rooting conditions, caused by either shallow soils, coarse massive structure or excessive stones, are a limitation.

In proceeding with the rating process for the land qualities, the first step will be to select the relevant land characteristics which can be employed to estimate the land qualities examined for the use of the land in the NE region under rainfed conditions. If established the relevant qualities will be rated in ranges, according to their effect on limiting the proposed use. The ratings will be classified in terms of the degree to which the factors in question fit or fall short of the suitability classes for rainfed agriculture, under the NE Iraq conditions.

CHAPTER 4

CHOICE OF PARAMETERS AND INFORMATION SOURCES. The land qualities will be discussed in greater detail in section 4.4 of this chapter, to establish their significance, the availability of information on the respective qualities, and the occurrence, or not, of critical values in the rainfed conditions in NE Iraq. The main objective here will be to examine the land use requirements related specifically to crop requirements, mainly crop physiology.

The crop requirements for individual crops cannot always be assessed where the land quality concerned is not significant enough for distinguishing land suitability classes. Requirements for solar energy, salinity and oxygen availably at the rooting area, for instance, are necessary for all crops, but, as discussed in part 4.4, may not be significant enough under the NE conditions for ultimate suitability classification.

The choice of the parameters governing the crop development depends on two important issues: the objectives and intensity of the evaluation; and the nature and availability of the information on the land requirements. For the purpose of appraising the land resources in NE Iraq for rainfed agriculture, with a reconnaisance scale of intensity, climate, soil and landform will be treated as the major parameters. In choosing an authoritative reference on crop requirements, ILACO's Agricultural Compendium (1981, pp. 472-515) has been consulted to determine the limits between the suitability classes. Where relevant, other sources of information have also been use.

4.3.3 CLIMATIC REQUIREMENTS

GENERAL ECOLOGICAL REQUIREMENTS. Different groups of crops can tolerate and flourish under different ecological conditions. In general, both wheat and barley prefer relatively low temperatures. Unlike maize and soybeans, for instance, which can tolerate wide climatic conditions, neither wheat or barley can tolerate high temperatures. Barley, however, is far more tolerant to drought than wheat. Table 4.12 list the ecological requirements for a selected list of annual crops, all of which, apart from wheat and barley, are subdominant crop species.

Table 4.12 ECOLOGICAL REQUIREMENTS FOR FIELD CROPS

Higher temp.	Lower Temp.	Drought Resist.	Wide Eco. Cond.
Cotton	Wheat	Barley	Maize
Sesame	Barley	Sunflower	Soybean
	Sugar beet	Sorghum	Tobacco
	Chickpeas	Sesame	
	Millet		
	Potato		

Source: Adapted from ILACO 1981, p. 561.

During the course of development of the crop, there are critical periods in which a certain development stage can be very sensitive to environmental disturbances.

The supply of moisture is an essential condition for the growth of plants. However, the demand for water is not evenly spread over the growing season. At the beginning of growth, consumption of water is normally low; it increases as plant foliage develops and the days become warmer, reaches its peak during flowering and seed formation, and rapidly decreases again during ripening. The critical development period in barley often coincides with the earlier stages of growth, compared to wheat; and where sowing is timed traditionally in the NE region with the first rains, wheat is more likely to suffer from unexpected moisture deficiency in later months.

The crop developing season is divided into four stages, the understanding of which is necessary in examining the crop requirements (ILACO 1981, p. 521):

1. Initial stage: germination and early growth.
2. Crop development stage: from the end of initial stage until effective full ground cover.
3. Mid-season stage: from effective full ground cover to time of start of maturation.
4. Late season stage: from the end of mid-season stage until full maturity or harvest.

The average length of crop development stages of wheat and barley in the NE region is four months, but growth period cannot be used as a stable quality, as the sowing and duration are dependent on erratic rainfall. In many years, experience has revealed that with late sowing, a wheat crop has only three rainy months in which to grow and mature.

RAINFALL. three main rainfall zones have been recognised by dry-farming agriculturalists in Iraq. Al-Fakry (1981, p. 60) classified rainfall groups into:

1. Limited annual rainfall: 250-350mm.
2. Intermediate (medium) annual rainfall: 350-500mm.
3. High (good) annual rainfall: over 500mm.

The classification is strictly made to suit the rainfed conditions in Iraq, and has been arrived at by calculating the annual and seasonal rates of rainfall and corresponding levels of cereal yields for 30 years. ILACO (1980, p. 475) suggested that 250mm of well-distributed annual rainfall is the minimum rainfall needed for a successful wheat crop. In table 4.13, annual rainfall levels have been classified as degrees of limitation on land use for rainfed agriculture, ranging between optimun to severe, and aligned according to their possible effect on the classification of the suitability of the land resources.

Table 4.13 ANNUAL RAINFALL AS A LAND USE REQUIREMENT

	Degrees of Limitation		
None	Slight	Moderate	Severe
Over 500mm	500 - 300mm	350 - 250mm	Less than 250mm
	Suitability Classes		
S1	S2	S3	N

TEMPERATURE. In discussing the general ecological requirements, it was clear that wheat and barley prefer a climate characterised by relatively low temperatures. The mean monthly temperature necessary for germination (late autumn) is estimated by ILACO (1981, pp. 564-566) at over 5°C for wheat and barley. For the rest of the growing period, however, temperatures should not exceed 23°C under 80 per cent relative humidity, and 28-30°C for relative humidity at 40 per cent. By examining tables 2.1 and 2.4, it is clear that temperature as a land use requirement cannot act as a limting factor on suitability, as all the above critical levels are within the normal ranges of temperature and relative humidity in the NE region.

4.3.4 SOIL REQUIREMENTS

Soil qualities constitute an important crop requirement, especially as the region's soils, as discussed in chapter 3, are largely dominated by soil groups of characteristically limited performance. As shown in table 4.14, the land requirements for wheat and barley are clearly not always met by the soil conditions in the region. Fertility requirements are especially limited in the region; and although the analysis of soil fertility requires a detailed and highly technical laboratory work, experience and judgements based on yield levels indicate a constrained fertility. The table below, however, illustrates that certain soil characteristics such as salinity and pH levels in NE Iraq are within the normal limits for the growth of wheat and barley crops.

Table 4.14 OUTLINES OF SOIL REQUIREMENTS FOR WHEAT AND BARLEY

Crop	Texture			Minimum Rooting Depth			Fertility	
	H	M	L	>90cm	60-90cm	60-30cm	H	M
Wheat	******	******			*		*	
Barley		*****	*****		*		*	

```
pH 5.0______5.5______6.0______6.6______7.0______7.5______8.0
              Wheat  ******************************
    Barley  ************************************************

Ece   0___1___2___3___4___5___6___7___8___9___10___11___12
Wheat ****************************
Barley ***************************************************
```

Source: Adapted from ILACO 1981, pp. 570-571.

4.3.5 SLOPE REQUIREMENTS

Slope is, by and large, the most common attribute incorporated in land evaluation systems (McRae and Burnham 1981, p. 27), as it affects both the conditions of the soil and also land preparation and accessibility. For annual crops, Sys (1975, p. 109) suggested the following degrees:

Slope (%)	0_____3	3_____8	8_____15	15_____25	26___
Limitation	none	slight	moderate	severe	v. sev.
Suitability	S1	S2	S3	N1	N2

4.4 LAND UNITS AND QUALITIES

4.4.1 INTRODUCTION

Land qualities and characteristics are part of the land units. In other words, land units have a number of complex attributes (land qualities) which affect land use in a specific way; and a larger number of properties (land characteristics) which can be measured or estimated to describe land qualities. For purposes of precision and clarity, the following definitions are listed, as they are perceived by the FAO system of land evaluation (Dent and Young 1981, pp. 162-165; ILACO 1981, pp. 161-163; FAO 1984, pp. 39-43).

LAND. An area of the earth's surface, the characteristics of which consist of all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area, including those of the atmosphere, soil and geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land.

LAND UNIT. An area of land possessing specific land qualities and land characteristics, which can be demarcated on a map. A Land unit (land mapping unit, in the Framework) is usually mapped, and the term is broadly one of convenience to cover any unit of land used for evaluation, e.g. agro-climatic zones, soil series and land systems.

LAND QUALITY. A complex attribute of the land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use. Examples of land qualities that are widely applicable to rainfed agriculture are temperature regime, moisture availability, rooting conditions and pot ntial for mechanisation. Land qualities can sometimes be directly measured or estimated, but are normally described by means of land characteristics.

LAND CHARACTERISIC. A property of land that can be measured or estimated, and which can be used for distinguishing between land units of different suitabilities for use, and employed as a means of describing land qualities. Examples of land characteristics are mean annual rainfall, slope angle, effective depth, topsoil texture and pH.

4.4.2 LAND UNITS OF NE IRAQ

In choosing land (mapping) units for evaluation, FAO (1984, p. 41) recommended three examples:

1. Agro-climatic units.
2. Maps of soil series and other soil groups.
3. Land systems and land facets.

The use of any of the above means for demarcating land units is governed inevitably by such considerations as the homogeneity of the units, their practical value for the particular purpose of evaluation, consistency and stability of the units.

For the purpose of evaluating the land resources in the NE region for rainfed agriculture. Three main sources have been used in demarcating land units: land use, physiography and soil groups. Four maps were drawn on a reconnaissance scale (1:1,000,000), and discussed in chapters 1, 2 and 3 (Appendix II). There are two useful soil maps which have been employed in exploring the region's soil conditions, namely Buringh's soil map (1960) and the FAO/UNESCO Soil Map of the World (1974); both were instrumental in demacating the land units and, later, allocating suitability classes. Also in demarcating the land units, account was taken of all other features which form an essential part of individual land units, including location, land use and environment. The full descriptive account of the respective land units are included in table 4.20.

4.4.3 THE SELECTION OF LAND QUALITIES

ASSESSMENT OF SIGNIFICANCE OF LAND QUALITIES. The choice of land qualities for the purpose of evaluating land resources is affected by a number of criteria:

1) whether the quality in question has a known effect on the land performance;
2) if the collection, measurement and/or estimation of information on the land quality is possible or available;
3) whether any adverse effects are possible, upon the occurrence of critical values.

The effect of any quality on the land use can be rated large, moderate or slight. Equally the occurence of critical values can be classified as frequent, infrequent, rare (ocuur over such small areas that for practical purposes, can be neglected) or nil. On the paracticability of obtaining information, the possibility can be divided into obtainable and unobtainable (where it is not practicable to obtain information on a given land quality for the specified purpose of evaluation, at a certain location).

In addition to the above considerations, FAO (1984, pp. 50-51) added the procedure of significance in examining land qualities. The significance of any land quality is the importance that needs to be assigned to it in the conduct of an evaluation, for a particular use and in a particular area. There are three grades of significance: very important, moderately important and less important as defined below:

1. Very important: land qualities which must be given particular attention during the evaluation.
2. Moderately important: land qualities which must be considered.
3. Less important:
   - 3A the use is unaffected or only weakly affected by the quality.
   - 3B critical values rarely or never occur within the study area.
   - 3C there is no practicable means of obtaining data on the quality.

4.4.4 LAND QUALITIES FOR RAINFED AGRICULTURE

Dent and Young (1981, pp. 166-167) proposed a list of land qualities for the evaluation of land resources for rainfed agriculture. The list later became the foundation for the 25 qualities listed by FAO (1984, p. 44), for the same purpose. In table 4.15, land qualities, subdivisions and assessment of significance are listed.

Table 4.15 LAND QUALITIES FOR RAINFED AGRICULTURE

Land Qualities	Effect on Use	Critical Values	Information	Significance
Energy (radiation)	Moderate	Rare (1)	Obtainable (2)	3B
Temperature regime	Moderate	Infrequent	Obtainable	3B
Moisture	Large	Frequent	Obtainable	Very important
Oxygen (soil drainage)	Moderate	Rare/nil	Obtainable	3B
Nutrient availability	Large	Frequent	Obtainable	Moderate
Rooting (soil depth)	Moderate	Infrequent	Obtainable	Very important
Germination conditions	Large	Frequent	Obtainable (2)	Very important
Growth conditions	Large	Frequent	Obtainable (2)	Very important
Air humidity	Moderate	Infrequent	Obtainable	Moderate
Ripening conditions	Moderate	Infrequent	Obtainable	Moderate
Flood hazard	Large(W)/Moderate(B)	Infrequent	Obtainable (2)	Moderate
Climatic hazards	Large(W)/Moderate(B)	Rare	Obtainable	3B
Excess of salts	Large(W)/Moderate(B)	Rare/nil	Obtainable	3B
Soil toxicities	Large(W)/Moderate(B)	Rare	Obtainable (2)	3B
Pests and disesaes	Large	Infrequent	Obtainable (2)	Moderate
Soil workability	Moderate	Frequent	Obtainable	Very important
Mechanisation	Moderate	Infrequent	Obtainable	Moderate
Land preparations	Moderate	Infrequent	Obtainable	Moderate
Storage and process.	Moderate	Infrequent	Obtainable (3)	Moderate
Production timing	Large (2)	Frequent	Obtainable (2)	Very important
Acessibility	Moderate	Infrequent	Obtainable	Moderate
Management potential	Moderate	Frequent	Obtainable (2)	Very important
Location	Moderate	Infrequent	Obtainable (2)	Moderate
Erosion hazard	Moderate	Infrequent	Obtainable	Moderate
Soil Degredation	Large	Frequent	Obtainable (2)	Very important

Source: adapted from FAO 1984, p. 58.

Notes: (1) Only if in excess.
(2) Insufficient data or instable quality.
(3) Not under consideration.

4.4.5 RATING OF LAND QUALITIES

In assessing the suitability of the land resources of NE Iraq for rainfed agriculture, at a reconnaissance level of intensity, three major groups of land qualities are significant: climate (especially rainfall); soil conditions; and landform (measurable by means of slope).

RAINFALL. The importance of rainfall as a land characteristic comes from reflecting the vital issue of moisture availability to agriculture. The FAO Guidelines recognised that rainfall, as a land characteristic, may be employed to assess many land qualities, as listed in table 4.16 (FAO 1984, pp. 81-119).

Table 4.16 LAND QUALITIES ASSESSABLE BY RAINFALL

Land quality	Subdivisions
Moisture availability	- Total moisture
	- Critical periods
	- Drought hazarda
Germination and establishment	
Excess of salts	- Salinity
	- Sodicity
Air humidity	
Conditions affecting storag	
Erosion hazard	- Water erosion hazard

SLOPE. The importance of slope in assessing land performance is derived from a practical consideration, in that slope is usually easily measured; and acts through a diversity of effects on soil, mechanised farm operations and ease of cultivation (McRae and Burnham 1981, p. 59). Slope is especially important in assessing land suitability for annual crops. The degrees of limitation caused by increasing slope on annual crops in rainfed agricultural situations is greater than the effect of slope on perennial crops (trees for instance) under such conditions (Sys 1975, p. 109). The FAO Guidelines proposed slope as means of assessing a variety of land qualities, for rainfed agriculture (FAO 1984, pp. 105-119), as listed in table 4.17.

Table 4.17 LAND QUALITIES ASSESSABLE BY SLOPE

Land Quality	Subdivisions
Potential for mechanisation	
Conditions for land preparation	
Acessibility	
Location	- Existing accessibility (limitations on existing transport network. Steep gradients cause increased transport costs.) - Potential accessibility (feasibility of road const.)
Erosion hazard	- Water hazard

Information on slope for the NE region has been compiled from two main sources: the soil map, especially the Soil Map of the World (FAO/UNESCO 1974); and from the US Army Map of the Middle East (US Army Mapping Service AMS 1962).

SOIL CONDITIONS. The rating of soil conditions prposed here for the assessment of land performance in NE Iraq is by means of combining several measurable soil parameters in a parametric model. The use of parametric models in rating land qualities, however, was often criticised on the gorounds that "parametric methods have mainly been used on easily measurable properties of the land, not on land qualities, and consequently there is a likelihood that interactions exist, thereby preventing analogies being made" (Beek 1978, p. 79). The criticism against some parametric models is justified where the land or the soil has been treated in some parametric methods as a static system, in which little attention is paid to possible interaction between, for instance, soil mositure and organic matter. In such way, many parametric models were constructed for very specific purposes, often for tax valuation (Storie 1937).

One useful parametric method which takes into account soil factor interactions is the FAO index of potentiality (IP), which has special relevance to land evaluation (Riquier 1974; ILACO 1981, pp. 164-1969). This method rates soil productivity on several soil characteristics, including soil moisture, drainage conditions, effective soil depth, texture and structure, base saturation, soluble salts, organic matter content and clay minerology

The formula has the general form:

$$IP = H \times D \times P \times T \times N \text{ or } S \times O \times A \times M$$

where, H = soil moisture (measurable by number of months where rooting zone is below wilting point)

D = drainage conditions (measured by occurrence of waterlogging and floods)

P = effective soil depth (in cm)

T = soil texture and structure (ratings are conditioned by soil moisture (H))

N = base saturation (indirectly inferred by pH level)

S = Soluble salts (measured by electrical conductivity of the soil solution (ECe) in millimohs.cm; also conditioned by moisture level (H))

A = Cation exchange capacity of the clay component (conditioned by clay minerals and estimeted in mmol%)

M = mineral reserve (conditioned by parent material and soil moisture)

The ratings for each factor is given in table 4.18. The resulting index of productivity is expressed on a per cent scale (0-100), and the outcome is assigned to one of five productivity classes:

Class 1 = excellent, with rating	65 - 100
Class 2 = good, with rating	35 - 65
Class 3 = average, with rating	20 - 34
Class 4 = poor, with rating	8 - 19
Class 5 = extremely poor or nil, with rating	0 - 7

Table 4.18 FACTOR RATINGS FOR INDEX OF POTENTIALITY (IP)

Rating for Soil Moisture Factor (H)

Factor	Description (*)	Rating
H1	All year	5
H2a	11 months	10
H2b	10 months	20
H2c	9 months	40
H3a	8 months	50
H3b	7 months	60
H3c	6 months	70
H4a	5 months	80
H4b	4 months	90
H5	3 months or less	100

(*) Number of months below wilting point at the root zone.

Rating for Drainage Factor (D)

Factor	Description	Rating
D1a	Water table 0-30cm	10
D1b	2-4 months waterlogging	40
D2b	Water table 30-60cm	40
D2b	8 days-2 month waterlogging	80
D3a	Water table below 60cm	80
D3b	Waterlogging below 8 days	80
D4	Water table below 120cm	(*)

(*) The (H) value is used in this case.

Rating for Effective Soil Depth

Factor	Description	Rating
P1	No or very shallow soil cover	5
P2	Less than 30cm deep	20
P3	30 - 60cm deep	50
P4	60 - 90cm deep	80
P5	Over 90cm deep	100

Rating for Texture/Structure Factor (T)

Factor	Description	Rating		
T1a	Over 60% stoniness	10		
T1b	40-60% stoniness	30		
T1c	20-40% stoniness	60		
		H4,H5	H3	H1,2
T2a	Pure sand	10	10	10
T2b	Over 45% sand	30	20	10
T2c	Over 30% humus	30	30	30
T3	Dispersed clay	30	20	20
T4	S,lS,sL,S,Si	40	30	30
T5	C,siC	50	60	20
T6	sL,sC,CL,siCL	80	80	60
T7	L,siL,sCL	100	100	100

Rating for Base Saturation Factor (N)

Factor	Description	Rating
N1	pH = 3.5 - 4.5	40
N2	pH = 4.5 - 5.0	50
N3	pH = 5.0 - 6.0	60
N4	pH = 6.0 - 7.0	80
N5	pH = 7.0 - 8.5	100
N6	pH = Over 25% lime	80

Rating for Organic Matter Content (O)

Factor	Description	Rating H1,2,3	Rating H4,5
O1	OM < 1%	85	70
O2	OM 1-2%	90	80
O3	OM 2-5%	100	90
O4	OM > 5%	100	100

Rating for Cation Exchange Capacity (A)

Factor	Description	Rating
A0	CEC < 5 mmol%	85
A1	CEC 6-19 mmol%	90
A2	CEC 20-50 mmol%	95
A3	CEC > 40	100

Rating for mineral Reserves (M)*

Factor	Description	Rating H1,2,3	Rating H4,5
M2c	Minerals derived from calcareous rocks	95	100

* The list of mineral reserves has been deliberately kept small, as information on Iraq's soil mineral reserves is negligible.

Note:
The ratings for soluble salts factor (S) were not examined, as virtually all the soils of NE Iraq are salt-free; the ratings would be biased (too high).

Source: Adapted from ILACO 1981, pp. 165-168.

Table 4.18 is, in some parts at least, potently unsuitable for direct application to the farming system described in the preceding chapters.

The following amendments in the factor ratings are based on the analysis of the low input, short growing season, cropping system in NE Iraq, but still require CALIBRATION with field information:

Rating for Soil Moisture Factor (H)

Group A (early rainfall)
First 10mm before 15th October

Factor	Description(*)	Rating
H1	Less than 200	30
H2	200 - 300	50
H3	300 - 400	70
H4	400 - 500	90
H5	Over 500	100

Group B (late rainfall)
First 10mm after 15th October

Factor	Description (*)	Rating
H1	Less than 200	10
H2	200 - 300	30
H3	300 - 400	50
H4	400 - 500	70
H5	Over 500	80

* Annual rainfall in mm

Rating for Texture Factor (T)

Factor	Description	Rating	
T1a	Over 60% stoniness	10	
T1b	40 - 60% stoniness	30	
T1c	20 - 40% stoniness	60	
		Group A Moisture	Group B Moisture
T2	Dispersed clay	20	20
T3	S, lS, sL, S, Si	40	30
T4	C, siC	60	30
T5	sL, sC, CL, siCL	80	60
T6	L, siL, sCL	100	80

Comment on CEC (factor A) and mineral reserve (factor M) ratings: It appears that in general, data on the above two factors are insufficient; and that for all practical purposes, there is little point in incorporating rating factors with a high degree of uncertainty. Under the conditions of the NE region, it is clear already that moisture and soil texture play a role more important, and more easily assessable, than all others.

4.5 MATCHING OF LAND USE WITH LAND

4.5.1 INTRODUCTION

The process of matching land use (rainfed agriculture in this case) with the relevant land qualities involves the comparison of the requirements of the land use with each land unit. The comparison yields a range of suitability classes for the land units under examination. Under a qualitative suitability evaluation, as proposed for the NE region, the main purpose of the matching procedure will be arriving at approximations to the final land suitabilities, taking into account the crops considered (wheat and barley) within their context of farming systems (FAO 1984, p. 139).

The matching process often requests that the requirements of the proposed land use be matched with a combination (of the land qualities and land units). The disaggregation can be reduced by preparing a conversion table in which the land qualities are aligned along predefined ranges, against which land units can be assessed with minimum combinations. For each land quality, the values of the characteristics used to assess it are obtained for the land unit, compared with the conversion table, and the factor rating is read off.

In table 4.19, a conversion table has been prepared to assist in matching the land qualities of the region's land units with the three land requirements arranged to assess the suitability classes for the land resources for rainfed agriculture.

Table 4.19 CONVERSION TABLE FOR RAINFED AGRICULTURE

Land Quality	Degrees of Limitation				
	None	Slight	Moderate	Severe	V. Sev.
IP (%)*	100-65	65-35	34-20	19-8	8-0
Slope (%)	0-3	3-8	8-15	15-25	>25
Rainfall (mm)	>500	500-350	350-250	<250	
Suitability Class	S1	S2	S3	N1	N2

* Index of Potentiality (see section 4.4.5:Soil Conditions).

4.5.2 OVERALL SUITABILITY RATING

There is no agreed single procedure for combining individual ratings, for each land unit, into an overall suitability of the site for the proposed land use. The FAO Guidelines (1984, pp. 145-150) discusses four methods, all of which, in single or in combination, may be used according to circumstances: subjective combination; the law of the minimum (limiting conditions); arithmetic procedures; and mathematical modelling.

In the subjective procedure, where the evaluator is assumed to have a good experience of the study area and the farming systems, it is possible (and sometimes preferable) to arrive at an overall suitability by subjective judgements based on intuition and experience.

The subjective procedure is designed to take into account the effect of combinations, which may be lost to the rigidity of the arithmetic procedures. Where more than one evaluator is involved, however, the same results may not be always envisaged by different individuals. The assumed knowlege and experience of the evaluator are the only possible criteria by which the soundness of subjective evaluations can be judged.

In the case of the estimation of overall suitability by applying the law of minimum, the limiting conditions are taken as the most reliable indicator of the final suitability. In accordance with the principles of the law of minimum, the overall suitability is determined by the land quality which is in lowest order. If, for instance in matching land units to the land qualities, three land qualities in a conversion table were rated S2, S3 and S1, the overall suitability is rated S3. Although considered the best method in terms of simplicity, the procedure may often underestimate overall suitability. Also in this way, interactions between individual land qualities may be overlooked.

The FAO Guidelines has discussed two arithmetic procedures for the assessment of overall suitability. One method is by multiplying values (often ranging between 0.0 and 1.0) assigned to each individual suitability class. According to whether the land qualities described are very important or moderately important, the Guidelines (pp. 146-147) has proposed the following values:

	S1	S2	S3	N
Very important	1.0	0.7	0.4	0.0
Moderately important	1.0	0.9	0.6	0.0

Another arithmetic procedure involves drawing up working rules according to the number of S2 or S3 assessments which will be taken to put the overall suitability into pre-specified classes. For example (FAO 1984. p. 147):

		Overall Suitability
Number of S2 assessments:	0 or 1	S1
	2 to 4	S2
	5 or over	S3
Number of S3 assessments:	0 or 1	S2
	2 or 3	S3
	4 or more	N

One clear disadvantage in all arithmetic procedures is that the overall suitability is very sensitive to the number of qualities considered. In the case of the multiplicative procedure, for instance, large number of qualities are bound to accentuate the low qualities by means of multiplication.

Although yield mathematical models have not been used directly as a land quality, in matching land use with land, a theoretical wheat yield regression model was prepared to give approximate estimate of land productivity, as discussed in section 4.2.5.2. The model reflects possible wheat yield in any one land unit, while a barlrey production model has not been prepared because of insufficient data (table 4.20).

4.5.3 SYSTEMS APPROACH

INTRODUCTION. The justification and rationale of a systems approach to the evaluation of the land resources is not the main theme of this research. Both the theory or review of reported systems are discussed in several textbooks (Beek 1978; McRae and Burnham 1981; Dent and Young 1981).

In discussing the issue of systems, Beek (1978, pp. 260) has broadly embraced a definition (reportedly based on lecture notes dated to 1975 by a Wageningen professor, G.H.Toebes) in which a system is defined as "a collection of elements and their relationships selected for their bearing on the questions being asked or the goals pursued and related to similarly slected systems in its environment." In the process of selection of relationships between the elements of the system, a semi-direct approach is implicitly assumed, in which fixed models are prepared to suit the purpose and the nature of the proposed system.

LEARNING ALGORITHMS. One important criticism that can be levelled against Beek's argument above is that the models proposed to reflect relationships between the various elements in the system are necessarily based on predetermined mathematical relationships in which there is no sufficient room for change of direction by forces of (statistical) chance and probability. The prediction of weather and stock-exchange, for instance, cannot be always made by models based on static relationships excluding, respectively, subjective or chance intervention.

Equally, in constructing a system to predict suitability for land resources, the system should ideally allow for subjective (experience) judgements or unexpected disturbances in the environment to be taken into account.

One way to eradicate the problem of inflexibility is by employing a learning algorithm to allow the system to readjust itself and, in more complex systems, to justify its decisions. A dynamic land system will preferably have to address itself not only to changes in the field well within the range of the constructed model, but also to differences beyond perfect distribution of events and elements, as well as changes in the attitude and growth of experience of the evaluator.

The discussion of the technical aspects of learning algorithms is beyond the declared scope of this research, and accounts on the issue of algorithms can be found in several technical texts (Knuth 1973; Hunt 1975; Michie 1979). Essentially, however, a learning algorithm suitable for land evaluation can have the form:

$$Y_j = \sum_{i=0}^{i=n} (A_{ij} \pm X_i)\, X_i$$

in which, n = number of suitability classes (i);

Y_j = the resultant suitability class for individual overall suitability classes (j);

A_{ij} = the self-regularatory modelling factor, adjustable with each i and j;

X_i = land qualities for each suitability (i).

In the above algorithm, for each of the possible overall suitability classes, initially A_{ij} is zero (i=0). The process can start with feeding of individual land qualities and the suitability classes (five if S1, S2, S3, N1, N2 are desired). With each run, the system will pick up a possible overall suitability class. The evaluator can then:

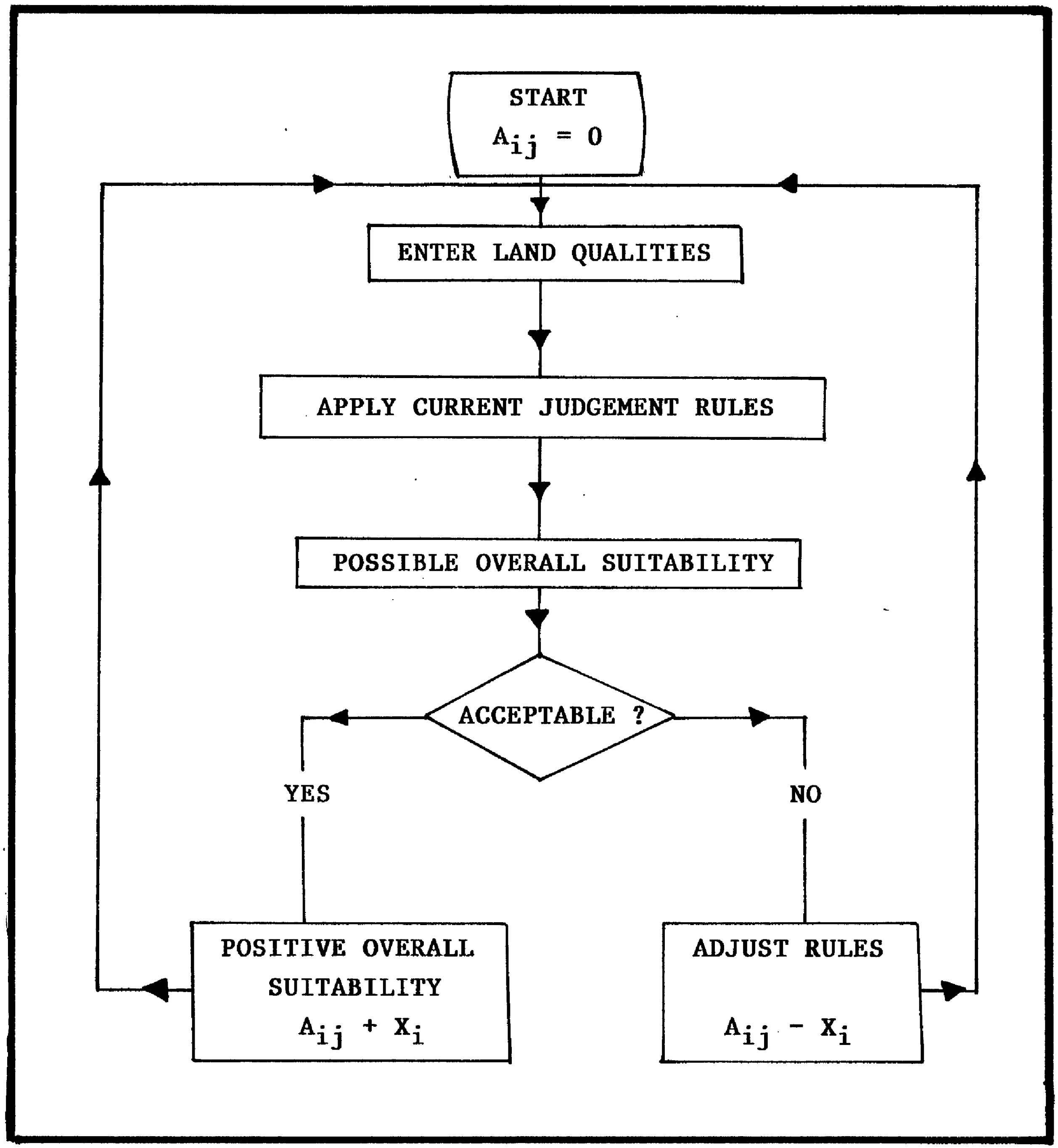
i. Either reject the result, based on considerations of experience or unexpected event, in which case the self-regularatory modelling factor will adjust itself by taking the path: $A_{ij} - X_i$.

ii. Alternatively, if the possible overall suitability produced by the system was acceptable to real situation or the evaluator's experience, the adjustment will take the form: $A_{ij} + X_i$.

With the introduction of a learning algorithm in the system, the system will take into account all changes in the field, even beyond the normal distribution of events, and can also respond to the change in the evaluator's attitude or a build-up in his personal experience.

The computer program (appendix III) has incorporated the above algorithm model. Written in a 'high-level computer language' (BASIC: Beginners All-purpose Symbolic Instruction Code), the adjustment in the rules of the system have been arranged to directly influence the overall suitability results. In this way, several arrays have been programmed, the central of which is DIMension R(I,J) (lines 470, 1230, 1240). The algorithm development and functioning are illustrated in figure 4.5).

Figure 4.5 A SIMPLIFIED ILLUSTRATION OF THE DEVELOPMENT OF JUDGEMENT RULES FOR THE LAND SUITABILITY ALGORITHM



The advantages which a learning algorithm can have if employed in a systems approach to land evaluation are:

i. the system can be continuously updated to cope with changes in the environment or upon the availability of new information or data which may ifluence the system by which the land is assessed;

ii. the system can be continuously 'exercised' (appendix III, lines 1470-1770) to review past and present data, and take account of any changes;

iii. the system will accept subjective judgements passed by the evaluator, where the current system rules may be found to be poorly reflective of possible interaction between the land qualities in question;

iv. in the Third World countries, lack of skills of evaluation may be corrected by a 'software package' to which both local and foreign experience can add several refinements to suit local needs.

The main disadvantage of this approach, however, is that the development process can be very lengthy and often demands a very large amount of data, which may not be always available. For this reason, the assessment of the land resources in NE Iraq for rainfed agriculture has taken account of all methods of rating of overall suitability. For the purpose of a qualitative evaluation of the land resources, the limited number (three) of the land quality combinations used to assess suitability have meant that it was possible for subjective judgements to intervene where experience may reject a result produced by means of alternative methods, with little risk of deviations.

4.6 RESULTS AND GENERAL RECOMMENDATIONS

4.6.1 SUITABILITY CLASSES IN NE IRAQ

INTRODUCTION. The FAO Guidelines on rainfed agriculture evaluation stressed the importance of clarity in the presentation of results (p. 179). Table 4.20 lists the land units and corresponding classes of suitability. The table of results also gives brief descirptions of the environment of the mapped areas, including indications of location, vegetation, soils, terrain, climate and land use.

MAIN CLASSES. As the map of land suitability classes shows (appendix II), good lands for rainfed agriculture are scarce. A high suitability (S1) class cannot be found in any part of the region; only in the Kirkuk-Erbil-Mosul plain that the land could be demarcated as a middle category between highly suitable (S1) and moderately suitable (S2). Most of the rest of areas currently used for rainfed agriculture can be classified as maoderately (S2) or marginally suitable (S3). In the mountainous areas in the region, almost all lands are unsuitable for rainfed agriculture, mainly because of thin soils and difficult terrain. Two issues where considered in dividing unsuitable lands into N1 and N2. Although on a reconnaissance level, both groups can be simply classified as not suitable (N), in areas where experience has affirmed a measure of cultivation on small plains, the lands (although lacking high levels of agricultural output) may be possible to improve in the future with extensive earth work.

Terrace formation is still scarce in the NE region, and where this practice may become more widespread, such lands can be more useful for cultivation under rainfed conditions. In dividing the unsuitable lands into N1 and N2, account was also taken of the comparison of the land qualities to the conversion table (table 4.19); hence dividing those areas into currently unsuitable and permanently unsuitable.

In small areas around the river Tigris and the end of the Greater Zab river, these were not demarcated for the purpose of rainfed agriculture (not relevant: NR). In such areas, irrigation is the main means of water supply.

MAJOR LIMITATIONS. Clearly, rainfall and terrain play a very prominent role in determining suitability for rainfed agriculture. Two symbols were used to indicate such limitations: for areas with strong terrain limtation (c); and (t) for areas with difficulties arising from terrain and accessibility.

4.6.2 RECOMMENDATIONS AND DEVELOPMENT PROPOSALS

The 1970 UNESCO-launched Programme on Man and the Biosphere (MAB) organised a workshop in Paris (30 January - 2 February, 1975) to discuss issues of development of arid and semi-arid lands. The proposals for the development of the land resources in such areas later appeared in a special report (UNESCO 1977). Many of the proposals can be broadly applicable to the NE region of Iraq.

CHAPTER 4

The uncertainty and limitations imposed by rainfall on the agricultural situation in NE Iraq are often very restrictive. The farmer is not only governed by the first rains, in any one year, to start cultivation, but uncertainty about ~~con~~subsequent rainfall limits incentive for greater inputs and enterprise; coupled with difficult terrain, the agricultural sector in the NE region suffers from chronic problems of land management, production and marketing outlets. The political instability characterising the NE region (because of decades of civil war) has delayed the arrival of modernisation of agriculture into most parts of the region. With primitive means of preparing the land, broadcasting seeds, and no application of agricultural chemicals, the rainfed agricultural sector in the study region falls sharply behind the phasing of agricultural development in Iraq. Unaccomplished national targets of mechanising the agricultural sector in the north, land reform difficulties and inadequate education and extension services have imposed impossible burdens on the task of modernisation. Romanticised 'revolutionary transformation of the country-side' has alienated the largely traditional sector of rainfed agriculture. Evidence still indicates a steady rural-urban migration and a lack of interest on the farmers' behalf in investing in modernised agriculture. Government contribution and capital is, however, still necessary, but only where farmers are not rushed into abandoning their traditional arrangements of the use of the land. One way of achieving a sucess in this respect is by liberalising the marketing controls, and allowing farmers to decide their crops and suggest farm policies.

One clear weakness in the rainfed agricultural sector in the NE region is the farmers' perception of productivity and soil fertility. Developing research programmes exclusively for the rainfed agricultural sector to investigate best methods for enhancing fertility, and developing acceptable alternatives for the fallow are priority areas. In discussing the alternative to the fallow (section 4.2.3.2: fallowing and alternative rotations), it was clear that while substituting fallow by lentils increased the subsequent wheat yield, lack of specialised mechanised means of harvesting fallow substitutes still constitutes a distinct problem (FAO 1982, p. 51). Trials on other alternative crops, medics, in Libya (Allan 1981, p. 208) have encouraged the Iraqi government to seek technical advice from Australian agricultural experts on introducing medics in rotations in north Iraq. The results of this plan, which is aimed at enhancing soil fertility and providing forage for livestock, are to be realised (FAO 1982, p. 49).

The issue of mechanisation of agriculture in north Iraq in general is still unresolved. Compounded by terrain and skill considerations, mechanised farming is still limited. Only land preparation and, to a lesser degree, harvesting have seen a degree of mechanisation. Other equally important aspects, especially sowing and seed-bed management, are still unmechanised outside government experimental farms. One important equipment is seed-drills, figures on which are unavailable, and which are believed to be in very short supply (FAO 1982, p. 49). Specialised inputs in general are the main deficiency in farming in NE Iraq.

Table 4.20 TABLE OF RESULTS

* LAND UNIT	SUITABILITY	LOCATION & Est. AREA	TERRAIN	SOILS	VEGETATION	ANNUAL RAINFALL	LAND USE	** EST. WHEAT YIELD kg/ha 100
1	S1/S2	Kirkuk-Erbil-Mosul; 1,104,000ha	Ext. plain; alt. 240 - 500m; slope 0-30 %	Brown & Chestnut soils	Moist-steppe zone	350-600mm	Rainfed annual crops; grazing	8
2	S3c	Makhmour; 690,000ha	Plain;alt. 300m;slope 8-30 %	Brown soils (shallow)	Moist/dry-steppe zone	Less than 350mm	Grazing; ann. crops (rainfed)	5
3	N1	Dohuk; 483,000ha	Foothills; alt.>330m; slope>20 %	Broken Rendzina	Moist-steppe zone	500-800mm	Grazing; forestry	Not applicable
4	S2t	Aqra; 138,000ha	Plain;alt. 750m;slope 5-25 %	Brown soils	Moist-steppe zone	over 900mm	Ann. crops (rainfed)	7
5	S3t	Zakho-Amadiyeh; 345,000ha	Plain;alt. 450-1000m; slope 5-25%	Chestnut soils	Forest zone	800-900mm	Rainfed crops; for-est.; graz.	6
6	N1	Batufa; 414,000ha	Mountainous; alt. >1000m; slope>30 %	Lithosols	Forst/thorn-cushion zones	1000-1200mm	Grazing; forestry	Not applicable
7	S2t	Rawanduz; 69,000ha	Plain;alt. 900m;slope over 15 %	Mainly Chestnut	Thorn-cushion zone	900-1000mm	Ann. crops (rainfed)	7
8	N1	Baradost; 545,100ha	Mountainous; alt. >900m slope > 25 %	Lithosols	Forest zone	900-1100mm	Grazing; forestry	Not applicable
9	N2	Rayat; 984,900ha	Thrust area; alt.>2000; slope >30 %	Skeletal soils; Lithosols	Alpine/thorn-cushion zones	700-1000mm	Grazing	Not applicable
10	N1	Sefin; 400,200ha	Foothills; alt.>500m; slope >20 %	Shallow Brown	Moist-steppe zone	600-800mm	Grazing	Not applicable
11	S2/S3	Dokan-Rania 331,200ha	Plain;alt. 700m;slope 0-30 %	Chestnut	Forest zone	800-900mm	Ann. crops (rainfed)	6
12	S3t	Sulaimaniyeh; 614,400ha	Rolling;alt. 850-1000; slope >15 %	Lithosols & Rendzina	Forest zone	700-1100mm	Grazing;ann. crops (rain-fed);forest.	6
13	S2t	Penjwin; 131,100ha	Plainlets; alt.>500m; slope <10 %	Rendzina & Brown	Thorn-cushion zone	over 1300mm	Grazing;ann. crops (rainfed)	7
14	S2t	Darbandikhan; 427,800ha	Plain;alt. <700m;slope < 20 %	Chestnut soils	Forest/moist-steppe zones	900-1100mm	Grazing;ann. crops (rainfall)	8
15	S3t	Qaradagh; 420,900ha	Rolling; alt.>700m; slope>30 %	Brown	Moist-steppe zone	600-900mm	Grazing;ann. crops (rainfed)	6
16	NR	Zab; 759,000ha	plains;alt. 100m;slope 0-5 %	Brown & Alluvial	Moist/dry-steppe zones	200-400	Irrigated ann. crops	Not applicable

Land units map (figure 6.1); gazetteer of place-names (appendix I)

* These suitability ratings integrate the variations of suitability within each unit. They have been arrived at, first by strict application of limiting factor rules, then by expert over-ride, as explained on page 214, to allow for special circumstances that cannot easily be incorporated in the general rules. In the case of the above table, land units 5 and 12 are classified as S3t (originally S2t) because of severe (land) management constraints.

** Estimated wheat yield by kg/ha (by regression) rounded to nearest 100 kg/ha.

CHAPTER 5 :

EVALUATION OF THE LAND RESOURCES FOR GRAZING

5.1 INTRODUCTION

5.1.1 OUTLINE OF RESOURCES

THE LIVESTOCK SECTOR SITUATION. Livestock production constitutes an important sector in the Iraqi agricultural enterprise. In the NE region and the rest of the country, it is the sheep population which is the most numerous. Pressure on the livestock population, however, continue to affect the total figures. The degradation of the region's grazing resources, against a sharp increase in demand on livestock products, has compelled the government agricultural authorities to encourage greater engagement in crop production. The farmers' income in the region, nontheless, continues to rely on a combination of both: mixed farming of crop production as well as livestock husbandry. In general, however, livestock productivity is low because of limited feed resources and strong physical constraints on the current level of the region's carrying (grazing) capacity.

LIVESTOCK BREEDS. The majority of livestock species in the region are local breeds. Sheep types are all fat-tailed, long-legged and long-haired. Cattle are often fixed cross-breeds between the Zebu type (Bos indicus) and the temperate (Bos taurus). There are three major local breeds of sheep in the NE region: Karradi (Kurdish), Awwasi and Arabi; all fat-tailed, long-legged and long-haired. The main type of cattle reared in the region is Sharabi (black bovine with a white line along the back). The majority of the local breeds are of characteristically low productivity.

On modern farms and a number of cooperative farms, cross breeds of the local bovines with Friesian, Ayrshire, Jersey and Sindi are exclusively reared for milk production. In villages along the river Tigris, water buffaloes are bred for their milk, which has a high content of fat. Sheep breeding projects under government supervision have been established on a fairly large scale in the last ten years. Fattening sheep and steers projects are financially supported by the State. In 1982, the Agricultural Cooperative Bank released loans totalling ID 9.8 mn, 42.4 per cent of which went to animal and poultry farmers (Central Statistical Organisation 1982, p. 24). New factories for feed processing have been erected and old ones expanded to meet some of the demands of the region's modern and experimental farms.

DRAUGHT ANIMALS. Donkeys, horses and mules are raised in the region's countryside for their use for transportation in the mountainous areas and as draught animals on the farm. There is evidence, however, that the population of draught animals is decreasing with the advent of modern means of transport and the construction of rural roads in some areas.

DEVELOPMENT. Despite the potential of the livestock industry and the expanding demand on animal products, animal production development has received relatively little attention, and the apparent opportunities argued by the government agricultural authorities are often based on an optimistic interpretation of the limited grazing resources and the productivity of the livestock popultion.

There is reason, however, to believe that livestock output could possibly be increased, but solid evidence to justify this optimism is hard to find. The poor system by which the range resources are exploited and organised need not, however, be a permanent situation. In this chapter, the region's land resources are examined and assessed for suitability for grazing. The evaluation will focus on extensive grazing for cattle, goats and sheep.

5.1.2 OBJECTIVES AND METHODS

OBJECTIVES. In this chapter, the grazing resources, mainly in the form of natural pastures, will be assessed to determine the suitability of the land resources in the NE region for grazing. As discussed in the chapter on evaluating the land resources for rainfed agriculture (chapter 4), no major changes are assumed in the immediate future in levels of input and management. The main purpose of the results of the appraisal will be to provide broad suitability indicators on a reconnaissance level of intensity.

METHODS. The FAO Framework for Land Evaluation (1976) will be the main reference on methodology. Account will also taken of a number of researchs which have used the Framework in evaluating land resources for similar purposes (Baig 1977). The FAO system of the evaluation of the land resources has been outlined in section 4.1 of this thesis. The same levels of interpretive suitability and scale have been used as discussed in chapter 4.

5.2 LINKAGES BETWEEN RAINFED AGRICULTURE AND LIVESTOCK

5.2.1 INTRODUCTION

The strong linkages and interaction between the two major agricultural sectors in the NE region, rainfed agriculture and livestock husbandry, can justify the treatment of the latter sector as an alternative kind of land use, with important ties to rainfed farming. Often this linkage is incorporated within a mixed farming system, in which the farmers have fairly equal interests in cultivating the land, as well as promoting the livestock on the farm. The interaction between the two sectors takes the form of exchanging products and recycling inputs, either on the farm in using animal manure for fertilisation for instance, or in a wider context, by a cohabitation arrangement between animal breeders and pastoralists on the one hand, and the crop farmers on the other.

Considerations of self-sufficiency at the village level increases this trend, in which animal and crop farmers constitute a unit of production with strong economic as well as ecological ties. Barter deals, although increasingly substituted by money exchanges, engage livestock farmers and pastoralists in an interdependent framework. The distinction between pastoralists and crop farmers at a village level, however, are very difficult to distinguish; crop farmers are steadily become involved in a mixed farming pattern, drawing the two traditional sectors of pastoralism and cropping nearer to each other.

5.2.2 ECOLOGICAL INTERACTIONS

The occurrence of crop farming and pastoralism as two self-sufficient units is rare in the NE region. The continuous process of merger between the two has had both important ecological as well as economic consequences. An economic and ecological supporting linkage on the farm has produced a system of mixed farming, with the farmers becoming increasingly dependent on the livestock component in deriving farming income.

Insofar as supporting linkages are concerned, animal manure can be a useful source of fertilizers (especially for growth of vegetables); and, in barren areas, animal manure constitutes an important source of fuel. In times of harvest or in the fallow year, the animals are allowed to graze on live or harvested vegetation, ensuring, in the farmer's view, a maximum exploitation of the land. This traditional method of mixed farming, however, has equally many disadvantages. The grazing resources in most parts of the NE region are over-burdened with large number of animals, often exceeding the carrying capacity of the land.

5.2.3 ECONOMIC INTERACTIONS

The economic hypothesis underlying the choice of grazing as an alternative land use and source of supplementary income on the farm, is based on the perceived benefit of livestock rearing in the farm economics of the NE region.

CHAPTER 5

As illustrated in table 5.1, the agricultural income of the region's farmers is derived from a mixed-farming system: combining crop production with livestock farming. In his account of the farm economy in the rainfed region in north Iraq, al-Najafi (1979, pp. 97 - 110), found that farms in the low rainfall zone (less than 350 mm) were more dependent on livestock husbandry in deriving their income than those under rainfall exceeding 500 mm. The contribution of the livestock farming to the agricultural income of the region's farmers is shown in table 5.1.

Under all levels of rainfall, the contribution of livestock to the agricultural income is higher than income derived from cash crops cultivation. However, despite the higher returns enjoyed by the farmers, the latter are often unwilling to invest more in livestock husbandry. Livestock farming involves higher inputs, and with the risk of insufficient fodder supply during the dry years, uncertainty limits the prospects of greater investment in livestock.

The input-output ratio in cultivating cash crops in low rainfall zones (less than 350) is 37.9 per cent, while the ratio is 56.6 per cent in the case of livestock husbandry. And in areas receiving high rainfall (over 500 mm), the difference is greater: 13.2 and 39.1 per cent respectively (calculated from al-Najafi 1979, pp. 97-110). This explains why farmers in the high rainfall areas are less inclined, economically speaking, to increase their investment in the livestock industry. The economic parameters in the livestock enterprise in the region are demonstrated in table 5.2.

Table 5.1 CONTRIBUTION OF LIVESTOCK PRODUCTION TO FARMER´S INCOME (Iraqi Dinars)

Source of Income	Low Rainfall	Medium Rainfall	High Rainfall
Cash Crops	54.4	174.3	113.3
Livestock	161.3	211.2	170.3

Source: Calculated from al-Najafi 1979, 97-110.

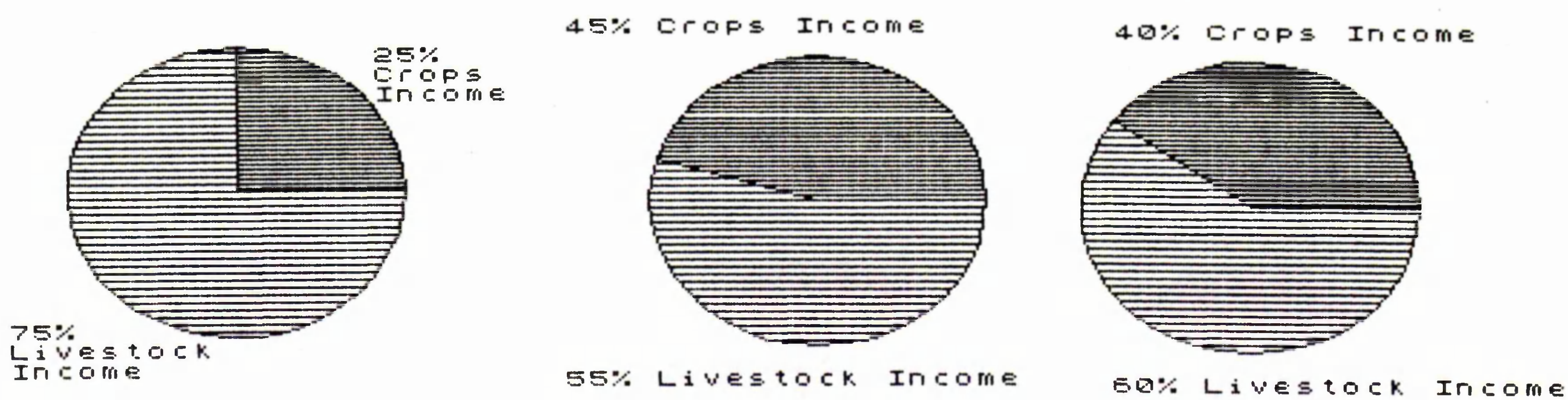


Table 5.2 ECONOMIC PARAMETERS OF FARM LIVESTOCK PRODUCTION IN NORTH IRAQ

(Iraqi Dinar / Farm)

Parameter	Low Rainfall <350 mm	Medium Rainfall 350-500 mm	High Rainfall >500 mm
Value of Stock	226	191.2	98.3
Value of Products	146	252.6	181.6
Standing Value	372	443.8	279.9
Value of Inputs	210.7	232.6	109.5
Net Income	161.3	211.2	170.4

Source: Calculated from al-Najafi 1979, p. 109.

5.3 INVENTORY OF THE RESOURCES

5.3.1 THE LIVESTOCK POPULATION

There is a serious paucity of data about livestock. Generally speaking, Iraq does not have a complete set of livestock industry statistics; and this shortage is more serious in the Kurdish region, which is the subject of this study. The last census of livestock population was held in November, 1978.

As far as the north-eastern region provinces are concerned, the results of the census confirmed that sheep population is higher than all other livestock population. Compared to Iraq proper, however, the highest population of goats is in the region, amounting to 50.7 per cent of the entire goat population in the country. Cattle population is approximately one quarter of the country's total (table 5.3). The distribution of the population of livestock in the region reflects sveral important points. In all cases, numbers of sheep and goats exceed number of cattle. Considerations of terrain and available management skills have hindered the expansion in cattle population. Although of greater economic value, in terms of meat production and milk, cattle can only be raised in areas where the animals can negotiate the terrain, and where farmers have access to a number of supporting systems, including veterinary services, market outlets, good roads for transportation and where local price supervision authorities allow a freer sale of cattle at more liberal prices.

Table 5.3 LIVESTOCK POPULATION IN NE IRAQ

Province	Sheep	Goats	Cattle
Dohuk	141,621	250,493	24,494
Mosul	1,536,556	315,152	131,719
Erbil	291,211	287,305	43,991
Sulaimaniyeh	556,808	511,566	196,011
Kirkuk	520,705	151,446	59,666
Total	3,046,901	1,515,962	455,881
Country Total	8,400,939	2,989,270	1,804,235
% NE Iraq	36.3	50.7	25.3

Source: FAO 1982, p. 46.

There are a number of reasons explaining the increase in sheep population over other livestock in the NE region. Mutton is the most favourable meat in the consumer markets, closely followed by beef. Government agencies in the region encourage sheep rearing, and attempt at gradually replacing the goat population, through the establishment of sheep breeding projects on a large scale.

The damage inflicted by goats on the grazing capacity and the forest (browsing) vegetation is great and causing concern. Goats are still kept in relatively large numbers, because they thrive and produce meat and milk in conditions where it is difficult to keep other domestic animals. They possess great ability to scavenge and find edible vegetation in the worst climatic and terrain conditions. Because they can browse on a wide variety of vegetation which has been rejected by cattle and sheep, they are extremely cheap to keep.

Despite all their good economic merits in a peasant agricultural economy, goats are very destructive. They strip the bark off trees, causing serious exposure-affiliated diseases and often death of the plant, and this often leaves the land open to soil erosion. Goats are also capable of overgrazing the land more than any other domestic animal. Despite all the odds, the goats are still the backbone of the region´s livestock industry, and the goat population holds its ground by virtue of the goats ability to negotiate the severe physical and institutional constraints.

In table 5.4, values for some production parameters and food intake requirements for goats and sheep in the region are illustrated. Notwithstanding the constraints on greater sheep farming, the latter are generally more productive under reasonable conditions. Rearing sheep holds more advantages in adult weight (indicator of meat production), wool/hair weight and dressing-out percentage. Goats are only more productive than sheep in milk production, and the goat´s milk is a major ingredient of the peasants´ staple diet. Sheep´s milk is rarely produced in enough quantities for marketing, and is often directly consumed by the farmer and his family. Ewes are normally milked once daily. A good nanny-goat grazed on the range can produce as much as 120 kg milk yearly (table 5.4).

The half-million strong cattle population in the region are fixed cross-breeds between the Zebu cattle (Bos indicus) and the temperate cattle (Bos taurus). As far as milk is concerned, the indigenous cattle are poor milkers, producing an average 600 kg of milk per year, against a standard norm of 4000 kg. Only the baffaloes, of which the region has 6500 heads, are considered good milkers, producing annualy 1300 kg of milk - an acceptable level of milk production against a standard norm of 1850 kg (Radhwan 1975, p. 24). Due to their special feeding needs and unability to negotiate difficult terrain, however, the cattle and buffalo population constitute only a relatively small fraction of the region´s livestock. Cattle in the region is raised almost entirely on the grass and herbage of land which is too poor for any other type of agriculture, or on fallow land.

Table 5.4 PRODUCTION PARAMETERS AND FOOD INTAKE REQUIREMENTS FOR SHEEP AND GOATS

Product	Sheep	Goat
Adult Weight (Kg)	18 - 30	15 - 30
Wool/Hair Weight (Kg)	1.5 - 2.5	1 - 1.5
Dressing-out Percentage	36 - 40	30 - 40
Milk (Kg/year)	50 - 100	75 - 120
Daily Feed Intake (Kg)	1 - 2	1.5 - 3

Source: The General Committee of Agriculture in Erbil 1983, passim.

Almost every farm in the region owns some poultry, but because they are usually left to find their own food and shelter, their yield, both in meat and eggs, is low. The domestic fowls bred in the region are excellent at finding their food, hatching their broods, and protecting themselves against predators and disease, but their egg production is low (20 - 100 eggs yearly); the eggs are small, and the chicks take a long time to grow and mature (over 3 months). The poultry (the absolute majority of which are chickens) are kept on open-range. The birds are allowed a large amount of room on land where they can find some of their food (herbage, seeds, kitchen scraps and insects). They are housed at night. The open-range system which is traditionally the way the poultry is kept in the region has many disadvantages; diseases are frequent, and poultry and men are partial competitors regarding their food requirements. An average farm, therefore, does not keep more than a dozen of poultry.

Notwithstanding the increasing use of farm machinery, animal power is still the backbone of traditional farming in the region - especially in areas inaccessible by modern machinery. Animal power is used for land preparation, threshing, operating water-lifting devices and transport. Donkeys and mules are the most versatile beasts of burden. Their power output is remarkably flexible, especially on difficult terrain. A good donkey or mule is capable of transporting loads of up to 150 kg over a distance of 15 - 20 km/day. Experience has shown that a strong mule can meet the power requirments of a farm of 1 - 3 ha size. Although camels are not indigenous animals in the NE region, about 3000 camels are grazed every year in the Jazira zone (west of the river Tigris) by Bedouin camel herders who come from the western desert (Radhwan 1975, p. 168).

Although livestock population is normally expressed in terms of numbers, a more accurate way of describing livestok population is by estimating livestock units (LU) or animal units. Livestock unit (LU) is the equivalent of a healthy cattle over two years old and weighing approximately 455 kg. In NE Iraq, an average cattle constitutes 0.8 LU; a goat or sheep 0.2 LU (Radhwan 1975, p. 107). Calculated from table 5.3, the NE region is accommodating approximately 1,277,277 LUs. This figure can permit a reasonable assessment of both the livestock production and, later on, the carrying capacity (grazing capacity) of the region´s grasslands.

5.3.2 THE GRAZING RESOURCES

In the NE region, large areas of natural grasslands are found where the annual rainfall is moderate or low, and where there are one or two dry seasons each year. Although grasslands of good quality occur in certain areas in the NE region, most of the rangelands are of poor quality. The main limitation to good grasslands is the climate. The rainfall is not only low, but it varies considerably from year to year. The severe dry seasons stops grass growth for many months of the year. The natural grasses rarely forms a dense cover of vegetation, and so there is bare soil between the individual tufts of grass. Also the pastures often consist of coarse grasses which are palatable and nutritious only when they are young.

Grazing resources in NE Iraq are two-fold: farm pastures, and open ranges. In 1975, farm-pastures constituted only 1.8 percent of the agricultural acreage in the region. Open ranges are 2.2 percent of the total area of the region (table 1.26). The natural vegetation in the region ranges in density between zero in some highly arid strips, to moderately dense vegetation in areas with high rainfall in the mountainous zone. The ecological balance in the region is extremely delicate, and climax vegetation is rare. ?

An important yard-stick to determine the amount of exploitation of the rangeland is the Proper Use Factor, which is the ideal percentage of exploitation of the range resources, permitting regeneration of the vegetation. The proper use factor for the region's open ranges is 50 per cent of the vegetation; on cultivated pastures, this percentage is ideally around 70 per cent. In general, therefore, 30 to 50 per cent of the grazing resources should be left ungrazed if maximum feed production is to be achieved (Radhwan 1975, p. 105).

On most open ranges, only one harvest can be produced; but on cultivated pastures, up to 10 harvests are possible, depending on the plant species and management. In addition to their economic merits, cultivated leguminous species enhance soil fertility and prevent waste of resources.

5.3.3 GRASSLANDS PRODUCTIVITY PARAMETERS

The presence of an apparently suitable environment does not mean that livestock development is readily possible. Advanced standards of grazing management can not be achieved under the current traditional system of grazing.

The productivity of the livestock husbandry in the NE region depends on many factors, including type of livestock kept on the farms, climate, vegetation, the grazing capacity and the present standards of management. All these factors vary widely in the study region, and it is especially difficult, therefore, to formulate average utilization parameters.

The region´s vegetation, and its suitability for consumption by livestock, is summarised in table 5.5. Climate is an important factor determining suitability for grazing in the region. Areas with high rainfall, however, are often situated in the mountainous zone, and they, therefore, may not be suitable for rearing types of livestock which are unable to negotiate difficult terrain.

A large number of grass species grow in the NE region. They vary both in growth characteristics and tolerance of the environmental constraints. They have, however, on quality in common: their crude fibre content is high, even at early growth stage. Some of the more important species, along with their productivity and nutritional parameters are listed in table 5.6.

The fodder plants in the region can be divided into cultivated fodder crops, and rangeland vegetation. Although fodder grown on the farm is more productive and far more nutritious than rangeland plants, the former is grown on a far smaller scale. In table 5.6, nutritional value was expressed in terms of the starch equivalent (SE) to the digestible crude protein (dcp). SE is based on the nutritive value of pure starch; dcp, the crude protein content in the feed.

One way of increasing the nutronal value of animal feed is silage making. Alfalfa silage has a nutritional value of 4.0 SE/dcp, against a lower 3.0 SE/dcp in fresh alfalfa fodder. Silage making, however, is impossible under the present standards of fodder production as little fodder is left ungrazed every year to allow it.

Hay stacking, in contrast to silage production, is very common, but may not have the high nutritional value as in the silage. During the dry season, most of the feed stuff is highly fibrous, and in general good-quality feed is scarce. So far, little progress has been achieved in encouraging farmers to produce hay and silage in greater quantities.

Table 5.5

APPROXIMATE PARAMETERS OF CLIMATE, VEGETATION AND SUITABILITY FOR LIVESTOCK

	Low Rainfall Zone	Medium Rainfall Zone	High Rainfall Zone
Vegetation	Steppe Zone Veg.; Desert Assocs.	Moist Steppe Veg.	Forest Veg.; Alpine Assocs.
Climate	Very hot summer; Very cold winter; Low relat. humid. (av. 10%)	Hot summer; Cold winter; Moderate relat. humid. (av. 30%)	Moderate summer; Very cold winter; High/moderate relat. hum. (>30%).
Sheep farm.	Marginal	Moderate	Moderate/good
Goats farm.*	Moderate*	Good*	Very good*
Cattle farm.	Very marginal	Moderate	Not relevant+

* Uncontrolled goats grazing is very destructive.

\+ Since high altitude is associated with higher rainfall, cattle farming may not be possible on such areas.

Table 5.6 **PRODUCTIVITY PARAMETERS FOR THE REGION'S FODDER CROPS**

Plant	Species	SE/dcp (starch/protein)	Av. yield* '000 kg/ha	Area '000ha
1. Cultivated fodder crops				
Grams	Phaseolus radiatus	6.0	7.3	11.2
Alfalfa	Medicago sativa	3.0	8.1	14.0
Clover	Trifolium alexandrium	3.7	13.0	8.4
Sorghum	Surghum vulgare	15.4	9.0	7.3
Other species		5.7	8.0	15.1
	Subtotal/Subaverage	5.7**	8.8(wt.)	56.0
2. Open range (native plants)				
All species		13.3(wt.)	6.0(wt.)	184.4
	Total/Average	8.7**	6.7(wt.)	240.4

* Average yield includes number of harvests.
** Geometric mean.

Source: calculated from the annual reports of the State Establishment for Fodder.

Feed stuffs may be divided into roughages and concentrates. The latter are scarcely used on small farms; they include grains, seeds and food-industry by-products, e. g. brans and sugar beet molasses. Roughages include all grasses, cultivated or otherwise, as well as their derivatives in the form of hay and silage. The major fodder legume grown in the NE region is the clover (Berseem) and alfalfa. The legumes are generally grown on the farm. Some varieties, however, can be found as uncultivated vegetation. The usefulness of the legume plants are not restricted to feeding, since they contain a relatively high content of protein; they are capable of fixing nitrogen from air into the soil through their root nodules (rhizobia). Legume

plants, therefore, act as enhancer of soil fertility, and can be introduced into crop rotations to encourage both soil fertility and eradicate the problem of fallow in the region, by putting the land to better use through allowing the incorporation of livestock on the farm.

However, legumes cannot normally grow in the areas with medium or low rainfall. Table 5.5 presents approximate parameters of climate and vegetation in the region. Legume plants can only grow in areas with rainfall higher than 500 mm.

5.3.4 THE REGION´S GRAZING CAPACITY

The examination of the region´s grassland productivity can help arrive at the region´s grazing capacity. The grazing capacity (or carrying capacity) is the ability of the land to accommodate a sustained feed supply to the livestock. The results are expressed in optimum livestock unit (LU) per area of pasture land per year. The grazing capacity is a function of a number of independent variables. The mathematical relationship is (adapted from Baig 1977, p.114)

$$GC = (A \times Y \times UF) / FR$$

where

GC= grazing capacity (optimum LU per area per year)
A= area (ha)
Y= yield (kg/ha)
UF= use factor (proper percentage of vegetation consumed in grazing: 70 per cent)
FR= Livestock unit (LU) feed requirement per day x year

The proper use factor estimated for the region is 50 - 70 per cent. The feed requirements per LU per day in the NE region is estimeted at 3 kg (Radhwan 1975, pp. 120, 105).

As illustrated in table 1.26, 56000 ha of cultivated areas are under fodder crops. In addition to that, 186,448 ha of the total area in the region´s five provinces is classified as open grazing land. In the light of the above figures, and the productivity parameters for the region´s fodder plants, the estimated grazing capacity of the region´s grazing areas is:

1) Cultivated Fodder Crops

GC = (56,000 x 8,800 x 0.70) / (3 x 365) = 315,032 LU/year

----

2) Open-range Grasses

GC = (186,448 x 6,000 x 0.50) / (3 x 365) = 715,143 LU/year

As estimated in 5.3.1, the region´s livestock population is equivalent to 1,277,277 LUs. The implications of this result are clear: the grazing capacity of the region´s grazing area barely satisfies 81 per cent of the feed requirements. In other words, only 81 per cent of the region´s livestock population can be fed on local sources of forage. The rest are left either to be supplied by imported feed, which restricts the farmers´ investment in livestock, or supplied with low quality feed, e.g. weeds, kitchen scraps, etc. This further explains why farmers are less inclined to invest more in livestock husbandry: in areas with less or varying annual rainfall, especially, the uncertainty is great and the farmer can be, more often than not dependent on purchased feed.

5.4 EVALUATION OF THE LAND RESOURCES FOR GRAZING

5.4.1 INTODUCTION

The purpose of this chapter has been to evaluate land resources in NE iraq for grazing. The approach for the appraisal of land qualities to explore the suitability of the region for grazing is derived from the FAO Framework for Land Evaluation (1976).

The strong constraints on farming, both the physical as well as the structural impediments, are such that extensive grazing will remain the best use that can be made on those areas largely unsuitable under alternative types of use. However, since the earlier examination of the land resources for rainfed agriculture has shown that large tracts of land in the region can sustain only marginal use for the purpose of dryland farming, such areas could be put to better use under grazing. Grazing suitability classes will be demarcated for the main types of livestock in the region, namely sheep, goats and cattle.

Although some economic parameters of relevence have been examined during the course of this study, the assessment of land suitability will draw heavily on the qualitative approach to the classification of suitability. Data available on the livestock industry in the region are sketchy, many estimates optimistic, and the validity of any economic assessments are questionable in the light of the inconsistencies in price policies.

5.4.2 RATING OF THE LAND QUALITIES

5.4.2.1 INTRODUCTION

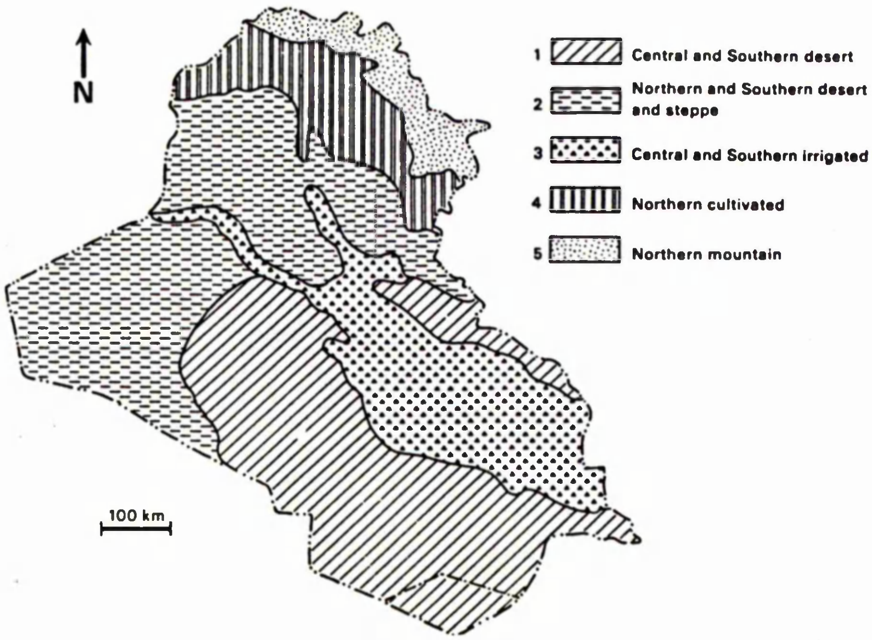
In determining the land suitability for grazing in the region, the factors of standing grazing capacity, water supply and terrain and soil qualities have been considered. This was based on the assumption that suitability appraisal is examined mainly under the current levels of performance, to explore the possibilities of a more rational organisation in order to replace the present standards of use.

No detailed account of the region's grazing resources is available. Thalen (1979) investigated the ecology and utilization of desert shrublands in Iraq. Attempts have been made by Radhwan and Al-Fakhry (1975) to provide some information on the rangelands in the region, but they failed to quantify the result of their examination of the region's grazing resources, and their work has been mainly intended as teaching material. The only map available on the rangelands of Iraq was demarcated by Springfield in 1957. It was, however, only a general outline of the country's pasture lands (figure 2).

5.4.2.2 CLIMATE

Although most livestock are well adapted to climatic changes. However, climate has an important impact on the well-being of grazing animals.

Figure 5.1 AGRO-CLIMATIC REGIONS IN IRAQ
MAINLY WITH RESPECT TO FORAGE PRODUCTION
(after Springfield 1957)



CHAPTER 5

Climatic conditions have been dealt with in chapter two. It is important, however, to mention a number of points relevent to pasture and livestock rearing. Temperature and humididty have an important impact on the health and productivity of the livestock. Generally, temperatures decreases with increasing height. At higher altitudes, above 1400 m normally, the vegetation can remain covered with snow and may not be available for grazing during the winter months (December to March); while on lower altitudes, the hot dry summer hampers fodder production for livestock grazed on such areas. The altitude, therefore, can have a direct impact not only on atmospheric conditions, but also indirectly on type of livestock and feed supply. In Salahuddin area (36 17N/44 13E; alt. 1080m) 29 days a year, on average, winter temperatures fall below zero; the average relative humidity is 35 per cent. On lower altitudes, in Mosul for example (36 20N/43 08E; alt. 240), average days with temperatures below zero are 21 days per year, with average annual relative humidity of 54 per cent (Iraqi Meteorological Organisation 1982, pp. 31 - 35).

Thalen (1977, cited in Baig 1977, p. 114) has treated climate as a correction factor in his model for the estimation of grazing capacity. The fact that different types of livestock react differently to the climatic conditions, and because of inconsistencies in the region's relief and corresponding changes in the temperatures, climatic harshness has been treated separately during the process of suitability classification. Bearing in mind the strong correlation between altitude and temperatures, altitude has been used as a diagnostic criterion for climate. The following ratings of altitude have been used:

Rating (degree of limitation)	Altitude (m. above sea level)	Description (zone)
Very severe	> 2000	Thrust zone
Severe	1500 - 2000	Zagros Mounts.
Moderate	900 - 1500	Foothill zone
Slight / None	< 900	Piedmont Plns.

5.4.2.3 WATER SUPPLY

Water is the medium for all physiological processes in the animal body. sixty to eighty percent of the body weight of growing animals consists of water. Water requirements vary according to type of feed available; water intake increases with the increase of dry matter in the animal ration. If the forage was green and succulent, the amount of water needed would be considerably lower. Water requirements also vary according to climate, as animals consume more water during the hot seasons, and when atmospheric humidity drops.

Generally, animals in the region are watered at least once a day. Under emergency conditions, however, animals may be watered every other day, and sometimes once in three days. Reduction in water supply can seriously affect productivity, as animals tend to consume less dry matter. Dehydration can also cause stress and poor health.

Different animals have different water requirements. Radhwan (1975, p. 116 - 117) reported the following daily water requirements for the animals in the region.

Animal	Normal Water Intake litre/head	Emergency Water Intake litre/head
Cattle	38 - 45	20
Goats and Sheep	3 - 4	1 - 1.7

An important condition governing efficient water supply to livestock is the distribution of watering points. This is expressed in terms of the distance animals have to travel to reach the water source. Different animals have different abilities to travel, and range use is dependent on the distance from water. On the plains, range use decreases almost in exact proportions to the distance from water points. To attain 50 per cent of use of forage, the appropriate distance from water should be 400 to 800 m. This factor is less significant in the case of mountainous areas, where the pressure of dehydration on animals is reduced by the amount of atmospheric moisture in the form of dew, fog or rain (Baig 1977, app. C2, pp. 5 - 6).

Baig (1977, app. C2, p. 6) has reported the following distances the animals can travel to and from watering points- accordingly rating land qualities as listed below:

Land Quality Rating	Distance to and from Watering Points (km)
Very high	1 - 2
High	2 - 4
Moderate	4 - 10
Low	10 - 20
Very low	> 20

It is significant that (Radhwan 1975, p. 117) reported the following distances travelled by the grazed livestock in the region. The results had been based on sampling carried out on two zones within the region: the Jezira and the areas to the east of the river Tigris. The following are the results of the investigation carried out in the latter area.

Animal	Maximum Distance (km)	
	Winter	Summer
Cattle	1 - 2	2 - 4
Sheep and Goats	2 - 4	5 - 8

Cattle normally receive preferential treatment and are watered at closer distances, while sheep and goats are normally travelled over longer distances to reach water points.

It is obvious from the results presented by Radhwan, as illustrated on the previous page, that distance from watering points does not constitute a significant limiting factor affecting suitability in the study region.

Another important factor affecting the water supply is the quality of water. According to As-Sarraf (1979, p. 72), over 97 percent of the area lying between the Tigris and the Lesser Zab river have water resources with total soluble salts (TSS) of less than 640 part per million (ppm). Less that one per cent of the entire area has a TSS exceeding 2500 ppm, which can be classified as poor quality. In his analysis of the rain water and irrigation water in the vicinity of Sulaimaniyeh, Majid (1982, p. 73) has provided the following results:

Factor	Measuring Unit	Spring Water	Rain Water
Calcium (Ca^{++})	ppm	5.0	0.24
Sodium (Na^{+})	ppm	8.6	0.70
Chloride (Cl^{-})	ppm	0.6	0.30
Carbonate ($Co3^{--}$)	ppm	6.0	0.30
Acidity (pH)	pH scale	8.39	7.6

Using the water quality criteria recommended by the International Land Development Consultants (1981, p. 302), the quality of the water in the region is within the acceptable standards.

Both cattle and sheep, however, can tolerate high salt content in their drinking water. As high as 7000 ppm salt content may not have any ill effects (Alexander and Ijaz 1957; cited in Baig 1977, app. C3, p.8). In the case of the study region, therefore, water quality does not act as a limiting factor affecting the suitability.

5.4.2.4 RATING OF SOIL AND TERRAIN

Livestock generally thrive on almost all types of soil. However, as the acreage of cash crops expands along with the rapidity of human population, more livestock have to survive on the marginal and poor soils that are unsuitable for cultivation.

The importance of examining terrain lies in its impact on accessibility by the animals. Irrespective of the nutritive value of any range vegetation, rangelend suitability for grazing is minimal if accessibility is hampered by difficult terrain. In the previous chapter, on the suitability of land for rainfed agriculture, slope was treated as a degree of limitation on accessibility, rockiness and stoniness. The rolling landscape of the region limits the accessibility to the grazing areas by the livestock.

Goats and sheep, which constitute the majority of the livestock population in the region, however, are well adapted to using rough grazing area, but slopes greater than 40 per cent normally have minimal value for cattle grazing (Baig 1977, p. 8). Experience has shown that goats, in particular, can be grazed on slopes as steep as 85 per cent or more.

Slope, however, is not necessarily an unbiased criterion in determining suitability. It is not always possible to predict suitability only on steepness of an area. The convex or concave curvatures affect accessibility and suitability differently; and what is considered extremely steep in a certain country may not be necessarily held in the same light in another place. Experience is important to verify all these considerations. All types of livestock generally prefer flat landscape. Sys (1975, p. 109) has suggested the following categories of slope relevent to the use of land for livestock production, serving, therefore, as rating qualities.

Degree of Limitation	Slope %
None	< 5
Slight	5 - 12
Moderate	12 - 25
Severe	25 - 50
Very Severe	50

5.5 RESULTS AND POLICY RECOMMENDATIONS

5.5.1 SUMMARY

A conversion table has been set to match the land qualities and limitations with the requirements of land use for grazing in NE Iraq. The matching was processed on the individual mapping units to permit corrections called for by experience and further considerations, e.g. where land had been classified more suitable under other use. The conversion table used for the matching is shown in table 5.7.

In order to speed up the process of matching and ensure efficiency, the conversion table was fed to a computer to extract an unbiased assessment. The program used is shown in appendix III. The results were then compared with experience and local considerations. The resulting land units were incorporated in the suitability map is provided in appendix II. The results are listed in table 5.8.

Grazing is most suitable on areas largely under marginal use for other types of utilization. As proposed earlier, however, assuming current levels of land management, land could be put to optimal use incorporating crop rotations of alternate cultivation of fodder and cash crops. This process can confer both economic interest and better land performance. It is important to bear in mind that drawing suitabiliy classes is meaningless under backward levels of rangeland management. Meanwhile, efficient management of grazing resources is still some years away in NE Iraq.

Table 5.7

CONVERSION TABLE FOR LAND SUITABILITY CLASSIFICATION
FOR GRAZING

Land Quality	Criterion	Degree of Limitation				
		None	Slight	Moderate	Severe	Very Severe
Climate	Elevation(m)	< 900		900-1500	1500-2000	> 2000
Terrain	Slope (%)	< 5	5 - 12	12 - 25	25 - 50	> 50
Suitability Class		S1	S2	S3	N1	N2

Table 5.8 TABLE OF RESULTS

LAND UNIT *	SUITABILITY	LOCATION & Est. AREA	TERRAIN	SOILS	RANGELAND CONDITIONS	ANNUAL RAINFALL	LAND USE	EST. GRAZING CAPAC. '000 LU **
1	S3	Kirkuk-Erbil-Mosul; 1,104,000ha	Ext. plain; alt. 240 - 500m; slope 0-30 %	Brown & Chestnut soils	Poor range conditions (fallow grazing)	350-600mm	Rainfed annual crops; grazing	161
2	N1	Makhmour; 690,000ha	Plain;alt. 300m;slope 8-30 %	Brown soils (shallow)	Very depleted ranges	Less than 350mm	Grazing; ann. crops (rainfed)	Not suitable
3	S2	Dohuk; 483,000ha	Foothills; alt.>330m; slope>20 %	Broken Rendzina	Good range conditions	500-800mm	Grazing; forestry	70
4	NR	Aqra; 138,000ha	Plain;alt. 750m;slope 5-25 %	Brown soils	Very limted rangelands	over 900mm	Ann. crops (rainfed)	Not relevant
5	S1	Zakho-Amadiyeh; 345,000ha	Plain;alt. 450-1000m; slope 5-25%	Chestnut soils	Very good range conditions	800-900mm	Rainfed crops; forest.; graz.	50
6	S2	Batufa; 414,000ha	Mountainous; alt.>1000m; slope>30 %	Lithosols	Good range conditions	1000-1200mm	Grazing; forestry	60
7	NR	Rawanduz; 69,000ha	Plain;alt. 900m;slope over 15 %	Mainly Chestnut	Very limited rangelands	900-1000mm	Ann. crops (rainfed)	Not relevant
8	S2	Baradost; 545,100ha	Mountainous; alt. >900m slope > 25 %	Lithosols	Good range conditions	900-1100mm	Grazing; forestry	79
9	S3	Rayat; 984,900ha	Thrust area; alt.>2000; slope >30 %	Skeletal soils; Lithosols	Scarce (summer) ranges	700-1000mm	Grazing	71
10	S2	Sefin; 400,200ha	Foothills; alt.>500m; slope >20 %	Shallow Brown	Good range conditions	600-800mm	Grazing	58
11	NR	Dokan-Rania 331,200ha	Plain;alt. 700m;slope 0-30 %	Chestnut	Very limited rangelands	800-900mm	Ann. crops (rainfed)	Not relevant
12	S2	Sulaimaniyeh; 614,400ha	Rolling;alt. 850-1000; slope >15 %	Lithosols & Rendzina	Good range conditions	700-1100mm	Grazing;ann. crops (rainfed);forest.	89
13	S1	Penjwin; 131,100ha	Plainlets; alt.>500m; slope <10 %	Rendzina & Brown	Very good rangelands	over 1300mm	Grazing;ann. crops (rainfed)	19
14	S3	Darbandikhan; 427,800ha	Plain;alt. <700m;slope < 20 %	Chestnut soils	Limited rangelands	900-1100mm	Grazing;ann. crops (rainfall)	62
15	S2	Qaradagh; 420,900ha	Rolling; alt.>700m; slope>30 %	Brown	Good range conditions	600-900mm	Grazing;ann. crops (rainfed)	61
16	S3	Zab; 759,000ha	plains;alt. 100m;slope 0-5 %	Brown & Alluvial	Limited pastures	200-400	Irrigated ann. crops	111

Land units map (figure 6.1); gazetteer of place-names (appendix I)

* These suitability ratings integrate the variations of suitability within each unit. They have been arrived at, first by strict application of limiting factor rules, then by expert over-ride, as explained on page 214, to allow for special circumstances that cannot easily be incorporated in the general rules. In the case of the above table, land unit 11 (Dokan-Rania) is classified as NR (originally S3) because of depleted pastures.

** Estimated grazing capacity (by regression) rounded to nearest 1000 LU.

The grazing potential of the NE region of Iraq is dependent on the associated cropping patterns. Additional forage would be available only if the livestock farming in the region was reconciled with the cropping system. However, an increased fodder supply must not encourage an immediate increase in the livestock population. A rational land use policy of the land resources should attempt at fixing the animal population, while output per head is increased through encouraging higher levels of fodder production. A reduction of the livestock numbers may be necessary in some areas to match the grazing capacity of the land.

The serious problem of overgrazing in the region is an inevitable consequence of insecure land tenure. In NE Iraq, the first man on the land with his livestock wins the grass. Farmers often do not have the incentive to observe rational and proper use of the rangeland, when they realize that it will only lead to someone else taking advantage of their forbearance. Firm land tenure is a necessary, although may not be a sufficient, condition for maximum forage production from the rangeland.

An especially uneconomical land management practice in the region is allowing weeds to grow on the land left as fallow for the livestock to graze on.

5.5.2 THE PROSPECTS OF SELF-SUFFICIENCY

Beside the role played by the range resources in the production of forage crops for the livestock, these resources also have a considerable value for, among others: providing a habitat and feed for wildlife; production of firewood for the peasants´ housholds; and, conservation of water and soil.

Although the value of the range resources can be best expressed in a form that allows comparison with other resources, most of the values of the range resources cannot be expressed in economic terms. In his assessment of the ecology and utilization of desert shrub rangelands in Iraq, Thalen (1979, p. 350) observed that:

> "certain resource values can never be evaluated in economic terms because of their abstract and subjective nature. Although in Iraq the resource values, pertaining generally speaking to environmental quality, are increasingly being realized, nevertheless there are no data available on which an assessment in economic terms could be based."

The assessment of the range resources in the region, and indeed in all other parts of the country for that matter, is especially difficult because the contribution of the rangelands to the national income through livestock production is not clearly established. Inconsistencies in government policies and erratic rainfall cause fluctuations in annual output. The following index numbers of total production of fodder crops in Iraq shed light on the issue. Fixing the 1974-1976 production as the index year, the Central Statistical Organisation (1982, p. 12) gave the follwing data on the fodder output:

1974-1976	100
1977	95.0
1978	105.3
1979	92.8
1980	101.9
1981	128.8
1982	137.6

The unstable supply of animal feed, along with an expanding demand on animal products, has called for increasing import of animal feed. In as early as 1978, animal feed imports in Iraq are estimated at ID 737,000 (approximately £ 1,253,000), and in 1980 the State Establishment for Fodder alone spent 12 per cent of the total expenditure of the agricultural sector in the country (Arab-British Chamber of Commerce 1980, pp. 47, 49).

Another difficulty arising during the process of assessing the contribution of rangelands to the national economy is the amount of the part of forage contributed by the native plants growing on open rangelands in relation to the cultivated fodder crops. In his account of forage production in Iraq, Springfield (1957, passim) divided Iraq, with respect to fodder, into five agroclimatic regions, as illustrated in figure 5.1. He estimated that in the NE region approximately 85 per cent of the forage came from open-range plants, with only 15 per cent from cultivated fodder crops. However, a shown in section 5.3.4, the cultivated fodder crops in the region can meet the feed requirements of 315,032 LUs in the region, with open-range grasses supplying 715,143 LUs. Having mentioned in the same section that the region is accommodating 1,277,277 LUs, the forage contributed by the different sources of feed supply in NE Iraq is in the follwing order:

Source of Forage Supply	%
Forage supply from cultivated fodder	25
Forage supply from open range	56
Other sources (including imports)	19

As illustrated above, the region´s grazing resources meets 81 per cent of the livestock feed requirements in NE Iraq. Under the current levels of feed consumption and range management, 19 per cent of the required fodder comes from other sources: feed exports, food industry by-products, etc. Because of the depressed income of farmers in the region´s rural commnity, however, overgrazing has been practiced to extract greater feed supply from the limited grazing resources, causing a severe depletion of the vegetation.

5.5.3 THE PROBLEMS OF INCREASING LIVESTOCK PRODUCTIVITY

In recent years there has been a decline in livestock numbers, particularly in the case of sheep. The rapid increase in domestic demand on animal products, as a result of a corresponding expansion in the country´s oil economy, has caused a high off-take rate. Deterioration of the region´s vegetation resources and the decline in feed output are responsible for the characteristic inefficient herd-structure and low productivity.

A general depletion of the natural vegetation is the result of a lack of grazing controls and adequate farm management. The flocks are grazed out into the range shortly after the grass has germinated. Uncontrolled grazing has hampered regeneration and caused a general reduction of the better species. As a side result, the top soil has become compacted, water penetration hindered, and coarser soil materials, gravels, have replaced the finer soil particles which are of higher water and plant nutrient adsorption.

The Jezira subregion is gradually giving way to a desert-pavement, as a result of the unfavourable soil metamorphosis. The water runoff, following the fall of first rains, tends to act destructively for the soil-washing the seeds which should give a new vegetation- rather than encouraging new growth.

Another reason for the reduction in grazing acreage, and hampering the grazing capacity, is the replacement of areas formally under open rangelands by cash crops. With the introduction of modern farm machinery, certain areas, which in the past were good rangelands, have been ploughed up.

The progressive decline in livestock industry is belied by a major change in the pattern of expenditure on food by the population, due to the high income elasticity of demand on livestock products. The population growth calls for an increased food supply to be provided by farming. In addition to the overall increase in food requirements, there is a particular shift towards a larger consumption of animal products, especially by the expanding middle income groups.

The majority of the rural population consume little meat, but and dairy products have become more in demand by the higher income groups in the urban areas. Domestic demand for red meat and dairy is anticipated to increase by five-fold and four-fold respectively in 1990, against the levels of 1970. Total per capita of intake of animal protein is anticipated to rise to 28.9 to 36.8 gms in 1990, against 14.2 gms in 1970 (FAO 1973, pp. 4 - 6).

There is a clear competition between much of the livestock production and the crop production which leads to conflict. Most livestock in NE Iraq obtains its feed from open ranges. Some of the reasons for the state of the region´s grazing resources are institutional. By and large, the grazing areas are neither formally owned nor leased to the farmers. The farmers, therefore, have less interest in the maintenance of the pastures.

Insecure tenure means that even where livestock farmers may show interest in maintaining the pasture's performance, they are unable to control its use by others. Unless grazing-land tenure was organised and observed, through legislation, attempts at increasing fodder output and maintenance of the grazing capacity would continue to offer a constant paradox.

The physical potential for increased output still exists, and the technical requirements for achieving better standards of rangeland management are not especially difficult; it is largely the current ineffective system by which the ranges are grazed that is responsible for the deterioration of the performance of the region's pastures, a situation, which if allowed to persist, may become intractable.

Another element of land resource disutility is that large tracts of land are left uncultivated each year, as fallow. If replaced by leguminous fodder plants, both the land and the livestock can benefit from this.

5.5.4 PROSPECTS OF CHANGE

The improvement of the region's grazing resources cannot be achieved by any single recipe. The progressive deterioration suffered by the region's rangelands cannot always be ascribed to the strong physical constraints. Despite evidence of profitability, the lack of integration of livestock into the farming system is due to poor organisation and inefficient planning for the agricultural industry. The suppression of competition through setting a rigid pricing system has hampered improvement in the livestock enterprise. The prices of agricultural commodities are interfered with by the State through pricing criteria based on national targets.

The need to develop the livestock industry has acquired greater importance today because of the need to increase farm income, as well as meet the expanding demand for livestock products. In order to meet the demand on livestock in 1990, the FAO estimates have been adapted for the NE region. Projected output should increase by three fold at current prices; and levels of input are to witness an uplift of similar magnitude. And in order to achieve these increases, it will be necessary to change the level of inputs, especially range management costs. The increase in input ratios must also be matched by a similar trend in the allocation of relevent crops in the agricultural acreage. This trend necessitates a major change in the cropping pattern in the region to permit the utilization of more area for forage production, against an over-stretched cereal crops acreage. The perspective plan for the livestock industry in the region is demonstrated in quantified terms in table 5.9.

Meeting the eccelerating demand for livestock products involves a reduction of the area under cereal crops, which is clearly over-stretched.

Table 5.9 1970 AND PROJECTED (1990) LEVELS OF INPUTS AND OUTPUTS OF LIVESTOCK INDUSTRY IN IRAQ

	1970	1990
1) Livestock products:		
('000 tons)	225.3	452.5
Red meat, including offals	60.4	159.7
Milk and dairy products	155.7	272.6
Wool, hides and skins	9.2	20.2
2) Inputs (ID '000,000):	8.0	24.5
Feed	7.9	23.7
Range management	0.1	0.8
3) Output (ID '000,000)	31.3	84.8
4) GVP (ID '000,000)	23.3	60.3

	Projected annual growth (1970 - 1990) %
Products ('000 ton)	3.5
Inputs (ID '000,000)	5.8
Output (ID '000,000)	12.5
GVP (ID '000,000)	4.9

Source: Adapted from FAO estimates (1974, pp. 12-15).

Reduction in cropping acreage must not, hoever, underplay projected demand on the cereal crops. The proposed reduction in cropped area must be patched by an increase in yied performance for the cereal crops, since in the absence of an improvement in the yield of the cash crops it will be doubted whether it is possible to reallocate the land taken from the food-grain crops for feed production.

The inevitable result of the current standards is overgrazing, inadequate feed supply, and unhealthy livestock. In order to achieve a more adequate use of the region's grazing resources, rangeland management practices should be developed and observed.

The following tasks are of paramount importance and should assume priority over other future policies in the region's livestock industry: 1) adjustment of stocking rate to carrying capacity, by reducing the current number of animals if necessary; 2) encouraging periods of rest of the grassland from grazing during the critical growth periods; 3) enforcing rangeland control regulations; 4) special provision for dry season feeding by encouraging, for instance, hay stacking and silage making; 5) adjustment of the cropping acreage to allocate more area to fodder crops; 6) enacting laws to facilitate security of rangeland tenure for livestock farmers; and 7) introducing new species for cultivated pastures on the bases of ease and rapidity of establishment, higher yield, palatability and nutritive value, persistence under intensive grazing, and ability to survive the dry season.

CHAPTER 6 :

CONCLUSION

6.1 ASSESSMENT OF METHODS AND THE SIGNIFICANCE OF THE FAO APPROACH

One clear distinction between the FAO approach to land evaluation as compared to the previous systems (of land capability classification) is the greater empahsis paid by the Framework to socio-economic parameters; where a class of land suitability is relevant only to a clearly defined use of the land. The old environment-orientated systems of land capability classification has the disadvantage of offering a set of capability grades which may not always reflect the level and standard of the use of the land. In the case of the NE region, such a system (of land capability classification), if adopted is likely to produce capability classes exaggerated by the strong physical features of the region in any one part. Equally it may point to tracts of land of seemingly good quality, whose advantages may nonetheless be lost to severe institutional constraints, strong enough to minimise the physical potential of the land.

An alternative to the land capability system can be found in the land systems method of surveying. Despite its huge advantages in achieving rapid and cheap reconnaissance, the risk of overlooking good areas of land can be high, especially in such areas as the NE of Iraq where ground inspection is often hampered by restrictions on movement and great uncertainty about level of cooperation from the population as well as the authorities. However, under better terms of logistics, including freedom of access to information and ground inspection sites, the land systems can offer opportunities unattainable at the present time.

Under the present situation in the NE region, the FAO approach to land evaluation, as outlined in the Framework can allow a greater measure of flexibility than those made possible under the alternative systems of suitability classification. In the words of C. Sys (FAO 1975, p. 107):

> "An important fact is that separate stages of both qualitative and quantitative land evaluation have been accepted. This distinction is especially useful in situations where there is neither practical experience nor data on yield and economics. Under these conditions, reliable quantitative interpretations is impossible as long as the necessary experimental data are not available. In such cases one has to proceed to interpretive work without quantitative data, while the value of the qualitative data depends largely on the experience of the expert."

The above point can be strongly argued in the case of the NE region, where resort to economics will inevitably mean loss of certainty of real value of inputs and outputs to shadow prices and discount rates that are neither consistent nor easy to determine. Such an uncertainty can expose the results produced by the land evaluation in such cases to serious doubt.

In the course of the period from September 1981 to November 1982, an attempt was made by the author to arrive at a full picture of the agricultural sector in the NE region, both in the government controlled areas and (from April to November 1982) in the zone outside government control. The gap found between the agricultural economies in the two zones was impossible to bridge. Not only levels and quality of inputs were different under such conditions, but also the value of the agricultural commodities under the two settings were unrelatable. A brief visit to parts of the study region in February 1985 sterngthened the conviction that an economic appraisal in the region cannot offer a meaningful study of land suitabilities: the two different sectors of the rural economy in the region (that under government control around the major towns and cities, and another half of the entire area of the region outside state control) had totally different means of exchange--Iraqi dinars on one side, and Turkish lira, Iranian riyal and barter on the other.

Where logistics of field work can be extremely restricted by political tension and factional violence, the task of assessing the land resources of the NE region remains unaccomplished so long as no suitable and flexible method of evaluation is available. By employing a system which can accept a reconnaissance qualitative approach to land evaluation, the FAO Framework for Land Evaluation was a natural choice. Under such broad terms of inventory as offered by the FAO system to an area like the NE region, the results of the evaluation has a significant role in preparing a solid ground for future plans of rural development under freer economic and logistical conditions.

In the early chapters of the thesis, the question of obtaining first-hand data was faced. The field work of an individual cannot substitute alone the work achieved by a multidisciplinary team with access to means of data gathering. To offer a suitable medium of analysis, a synthesis of the environmental parameters in the region was carried out largely through a careful process of selecting data from sources perceived as reliable and subjecting the resulting body of information to a systematic procedure of handling the data through indices of such collective attributes as aridity, water crop and soil potentiality. Minimising the risk of unreliable data overshadowing the assessment of the region's physical setting was a prime consideration. Initially several environmental indices were chosen; many were later disregarded, while those which gave results supported by experience were taken into account. An example in point was an attempt to arrive at the water crop requirements in selected areas. It was found in this case that the data on evaporation (for example the UNESCO figures presented in table 2.5) gave very high crop evaporation estimates impossible to accept especially under the low rainfall conditions in parts of the region. The authority of the environmental data gathered on the region were therefore tested against indices that could offer room for interaction between constituent variables, and that could also withstand the test of experience.

In the case of soils, use of names of soil groups such as Brown, Chestnut, etc. was preferred on most occasions to other more recent terms. The former are more readily identifiable and frequently used by Iraqi agricultural scientists in general field work. Approximations of soil names, however, were given in a special table (table 3.9) in order to bring the context in line with the terminology of the Soil Map of the World of the

FAO which was instrumental in drawing suitability classes especially in the assessment of the region's land resources for rainfed agriculture in chapter 4 of this thesis.

In discussing the overall suitability of the region's land resources, the several methods of determining overall suitability were discussed. Although the number of criteria employed in the matching process in this research was relatively small, allowing therefore greater flexibility of choice, the subjective procedure involving the experience of the evaluator, among other considerations, was highlighted. The issue of systems analysis in land evaluation was discussed in some detail. Previous attempts with regard to the approach to systems for land evaluations were critically examined. The restrictions imposed on the choice of variables, outcomes and rules were criticised. The nature of data and information likely to be acquired under conditions similar to those in NE Iraq is believed to justify this critical view. In locations where experience of the expert assumes a very important role against limited--and often unreliable--data, judgements of overall suitabilities are very likely to evolve and perhaps need be reassessed in the future in the light of inevitable growth in experience and techniques.

A learning algorithm was therefore suggested as an essential ingredient of any land evaluation system. A short computer programme was written in support of this argument (appendix III). Preliminary experiments with the proposed system supported the conviction of possibility of this approach substituting 'fixed rules' systems under conditions similar to those of the NE region. In addition to the major advantage of a system based on a learning algorithm in allowing the system to develop its own rules, the experience of the evaluator (subjective judgements) as well as other considerations (e.g. law of minimum, arithmatic techniques) can intervene to create a more accommodating system.

To sum up the argument for the significance of the FAO approach to land evaluation, it is clear that the FAO system of land evaluation is flexible enough and very useful in accommodating a large variety of circumstance, and can therefore serve as a suitable means of appraising the land resources under such conditions as those of the NE region of Iraq.

6.2 RESULTS AND CONCLUSION

In all areas of environmental sciences, the results of any one investigation are subject to the forces of time, growth in experience and further work. The need for a start in the area of exploring the overall suitability of the region of NE Iraq for the various agricultural purposes has been overdue. It was the intention of this thesis to further this argument.

As in all processes of evaluation, a stage of consultation was observed. The preliminary plans, the theoretical arguments and later a tentative set of results were communicated to Iraqi agricultural and soil scientists, particularly academics from the universities of Mosul and Salahuddin (previously Sulaimaniyeh). The level of approval was overwhelming and yielded a double advantage of encouraging an exchange of literature and comments. The need for an assessment of the region's land resources was discussed (albeit not in any final form) by the author on the pages of the Iraqi Journal of Agricultural Sciences in January 1986. These consultations have confirmed both the need for the actual systematic process of land evaluation of the NE region's land resources, and also of the suitability of the FAO system for such an undertaking despite difficulties.

CHAPTER 6

Insofar as the results of the current investigation are concerned, a systematic attempt was made to investigate the standards of management of the land resources in the region to throw light on levels of utilisation. The issue of discussing management levels in some detail was made necessary both because experience on the issue is available, and also in order to reassess the interaction between the region's physical and institutional constraints. Discussion of management was particularly important in chapters 4 and 5 in the light of the perceived impact of management of levels of inputs and outputs which are often governed by local institutional arrangements, and also to throw light on the impact of the management on the physical performance of the region's land resources.

In discussing the performance of the land of a large area such as NE Iraq, a reconnaissance level of intensity was adopted. As argued earlier, the choice of reconnaissance has also been due to the chronic shortage of very detailed quantitative data. The recommended scale of 1:250,000 as the typical scale for land suitability mapping as outlined by the Guidelines was impossible to meet. While terrain attributes were possible to incorporate at a more detailed mapping level, such constraints as the precarious levels of management brought about by volatile adminstrative and economic conditions could only be realistically reflected on a broader mapping basis. The shortage of detailed climate, soil and vegetation variables also meant that mapping on a scale greater than 1:1,000,000 would place judgement on soil and weather conditions in a great doubt. There is, for instance, no soil map available of greater scale than 1:1,000,000 which accounts for the entire region. Relying on a small number of local surveys in some western parts of the region would have inevitably produced a patchwork of mapping units with a great number of gaps that are impossible to bring together in a detailed survey of suitability. A reconnaissance scale at 1:1,000,000 has in the past offered reasonable opportunities of assessing soil conditions. And in the light of the necessity of adopting such a scale for purposes of land evaluation for the NE region, the mapping units presented in this thesis are designed to furnish an equally useful foundation for selecting future areas of priorities on a firmer ground of certainty.

In chapter 4 and 5, the results of the evaluation have been separately prepared. A joint table of overall suitability for the region's land units was then produced (table 6.1). The main reason for undertaking the suitability classification separately was to allow an investigation of the management arrangements independently, and allow a wider range of options in arriving at a general outline of suitabilities incorporating both or either kind of land use on a regional basis.

In dividing the NE region of Iraq into land units, 16 units were mapped and examined as the basis for the demarcation of the suitability classes. As illustrated in table 4.20 and 5.8, account was taken of the physiography, location, soils, climate, land use and vegetation in deciding the choice of any one unit. The location of these is illustrated in figure 6.1.

One important advantage in this approach is the feasibility of creating a legend for overall suitability of the land resources in NE Iraq; it will also make possible establishing the comparative advantage of using any single land unit for a prescribed kind of land use. Table 6.1 lists the qualitative current suitability classes for the land units, under the two examined activities of rainfed agriculture and grazing.

As the table shows, the total mapped area (in the suitability maps in appendix II) is estimated at 7,857,600ha, or approximately 93 per cent of the total area of the five provinces of the region (9,443,600ha).

The reconnaissance scale of the suitability classification has clearly demarcated large areas of land which although reflecting characteristics that can be encompassed within distinct land units, variations are inevitable, especially where large units are concerned. As argued in the preceding chapters, accessibility to many areas within the region is hampered by various problems, but two examples can be given to point out levels of variation.

The Kirkuk-Erbil-Mosul plain is clearly the largest area within the region which has been identified as a distinct unit. Despite the overall similarities in the mode of use (rainfed agriculture) and the common management factors, this extensive plain gives way in certain areas to variations in morphology and rainfall. Although most parts of the plain fall within close rainfall levels, morphology has been responsible for a higher level of rainfall in the parts close to the city of Erbil, because of higher elevation in the immediate vicinity of Erbil. Rainfall levels registered in Mosul (alt. 240m) are on average around 400mm annually, but in Erbil (alt. 1080m) the city and the surrounding farmlands receive about 700mm annual rainfall on average (table 2.3). It is important, nonetheless, to point out that provincial yield levels in three provinces of the plain (Kirkuk, Erbil and Mosul) are very close (see table 4.2).

In another large land unit in the region (Baradost), there are some variations between the mode of the land use in the southern part compared with the northern part of the land unit. In the northern part of the Baradost area, many of the inhabitants can still be classified as nomadic pastoralists, travelling into the neighbouring Rayat and Batufa during the summer, and returning to areas near Rawanduz in winter. The pastoralists of southern Baradost are more settled and their seasonal migrations are limited and local. As a result of this situation, the grazing resources in the south are more exploited and there is a small scale rainfed farming enterprise, albeit constrained by severe terrain. In both examples mentioned above, variations are illustrated in order to point out that while all the land units enjoy homogeneity, there are some variations within each individual unit, especially in large ones.

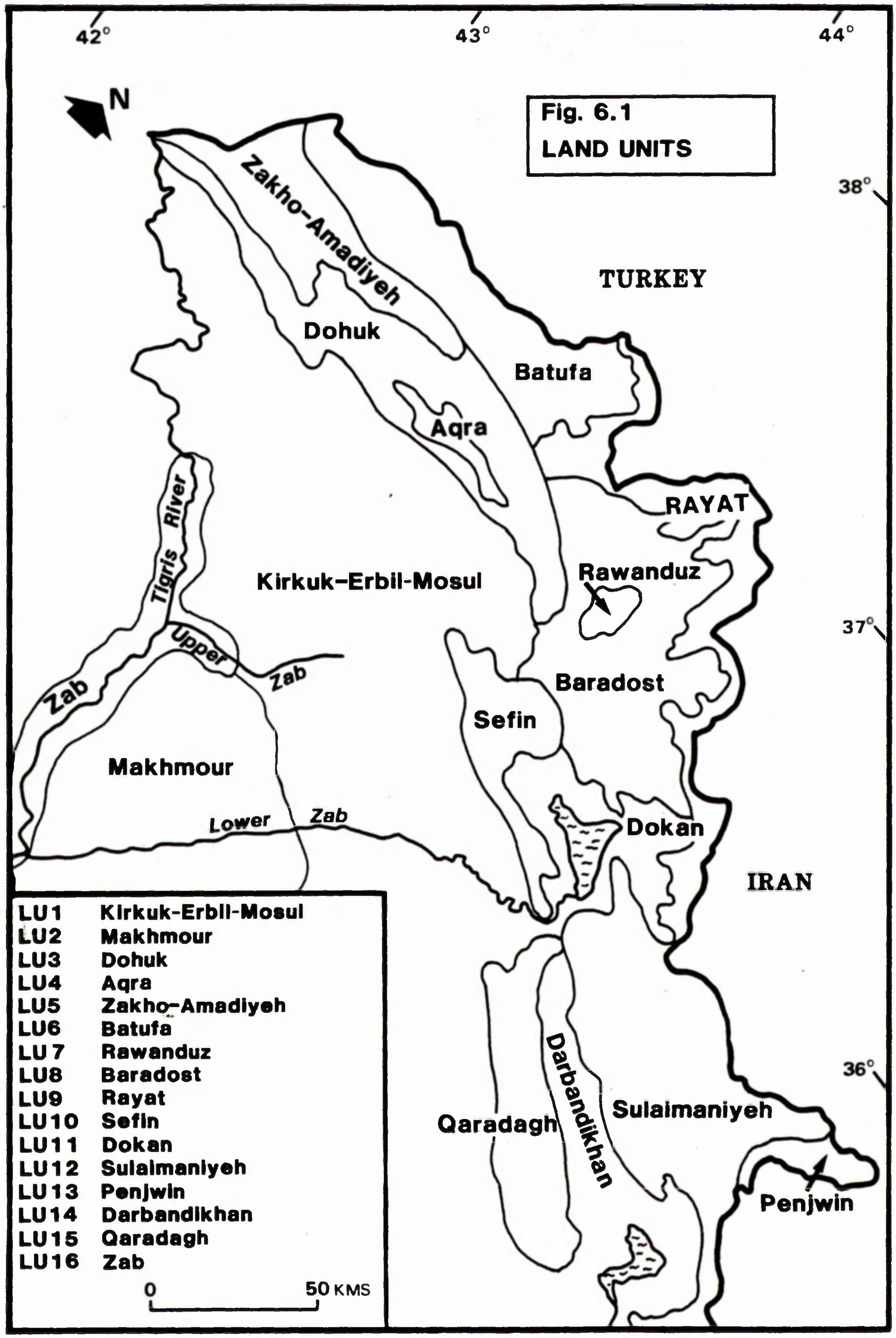

42°
43°
44°
N
Fig. 6.1
LAND UNITS
38°
37°
36°
TURKEY
IRAN
Zakho-Amadiyeh
Dohuk
Batufa
Aqra
RAYAT
Rawanduz
Kirkuk-Erbil-Mosul
Tigris River
Upper Zab
Zab
Baradost
Sefin
Makhmour
Lower Zab
Dokan
Darbandikhan
Sulaimaniyeh
Qaradagh
Penjwin
LU1 Kirkuk-Erbil-Mosul
LU2 Makhmour
LU3 Dohuk
LU4 Aqra
LU5 Zakho-Amadiyeh
LU6 Batufa
LU7 Rawanduz
LU8 Baradost
LU9 Rayat
LU10 Sefin
LU11 Dokan
LU12 Sulaimaniyeh
LU13 Penjwin
LU14 Darbandikhan
LU15 Qaradagh
LU16 Zab
0
50 KMS

Table 6.1 OVERALL SUITABILITY LEGEND FOR NE IRAQ

Suitability by land units			Suitability Class	
Land Unit	Area ('000ha)	%	Rainfed Agr.	Grazing
Kirkuk-Erbil-Mosul	1,104.0	14.1	S1/S2	S3
Makhmour	690.0	8.8	S3	N1
Dohuk	483.0	6.1	N1	S2
Aqra	138.0	1.8	S2	NR
Zakho-Amadiyeh	345.0	4.4	S3	S1
Batufa	414.0	5.3	N1	S2
Rawanduz	69.0	0.9	S2	NR
Baradost	545.1	6.9	N1	S2
Rayat	984.9	12.5	N2	S3
Sefin	400.2	5.1	N1	S2
Dokan	331.2	4.2	S2/S3	NR
Sulaimaniyeh	614.4	7.8	S3	S2
Penjwin	131.1	1.7	S2	S1
Darbandikhan	427.8	5.4	S2	S3
Qaradagh	420.9	5.3	S3	S2
Zab	759.0	9.7	NR	S3
Total	7,857.6	100.0		

Suitability by sector

Suitability	Rainfed Agriculture Area ('000ha)	%	Suitability	Grazing Area ('000ha)	%
Suitable	4,271.4	54.4		6,629.4	84.4
S1/S2	1,104.0	14.1	S1	476.1	6.1
S2	765.9	9.8	S2	2,877.6	36.6
S2/S3	331.2	4.2	S3	2,275.7	41.7
S3	2,070.3	26.3			
Not Suitable	2,827.2	35.9		690.0	8.8
N1	1,842.3	23.4	N1	690.0	8.8
N2	984.9	12.5	N2	0.0	0.0
Not Relevant					
NR	759.0	9.7	NR	538.2	6.8
Total	7,857.6	100.0		7,857.6	100.0

Table 6.1 also clearly shows that nearly half the mapped area of the region is unsuitable for rainfed agriculture. However, over 80 per cent of the mapped was found to be suitable (at different classes) for grazing. In both cases, nonetheless, highly suitable lands are very scarce (no S1 class for rainfed agriculture, and only about 6 per cent for grazing).

Table 6.2 presents a proposed plan for the utilisation of the region's land units for the purposes of rainfed agriculture, grazing or both combined in a mixed farming system. The table points out the region's plains (Kirkuk-Erbil-Mosul, Zakho-Amadiyeh, Darbandikhan and Penjwin) as capable of accommodating a mixed farming arrangement. In the districts of Sulaimaniyeh and Qaradagh, mixed farming is also proposed. This, however, barely accounts for 40 per cent of the entire mapped area in the region. For the rest of the study area, the research revealed that only one mode of agricultural activity can be practised successfully, i.e. either rainfed agriculture or grazing.

In conclusion, the investigation into the performance of NE Iraq's renewable land resources clearly indicates that good lands are scarce, and that in most areas the constraints on land use are great.

Table 6.2 PROPOSED PLAN FOR LAND USE IN NE IRAQ

Land Unit	Area ('000ha)	Proposed Use
Kirkuk-Erbil-Mosul	1,104.0	Suitable for RA as well as grazing. Pastures are however overexploited.
Makhmour	690.0	Of low suitability for RA. Pasture resources are extremely depleted, except on areas with the Makhmour state agricultural project.
Dohuk	483.0	RA is hampered by unsuitable terrain. Of moderate suitability for grazing.
Aqra	138.0	Of moderate suitability for RA. Very limited acreage for grazing except on fallow.
Zakho-Amadiyeh	345.0	Highly suitable for grazing, but of limited use under RA because of terrain limitations.
Batufa	414.0	Very mountainous, and RA is only possible in the valleys. Of good use for grazing.
Rawanduz	69.0	Well suited for RA, but grazing is limited by space except on fallow.
Baradost	545.1	Terrain limitation on RA, but moderately suitable for grazing.
Rayat	984.9	Extremely mountainous. Unsuitable for RA and marginally suitable for grazing.
Sefin	400.2	RA is limited by terrain, but of moderate suitability under grazing.

Table 6.? (continued)

Land Unit	Area ('000ha)	Proposed Use
Dokan	331.2	Well suited for RA in most parts, but limited space is avilable for pasures which are already heavily exploited.
Sulaimaniyeh	614.4	Hilly, but on man-prepared lands are reasonably well suited for RA. Pastures are of good quality.
Penjwin	131.1	Well suited for grazing as well as RA.
Darbandikhan	427.8	Moderately suitable for RA, but pastures are heavily exploited.
Qaradagh	420.9	Marginally suitable for RA because of hilly terrain, but of good quality for grazing.
Zab	759.0	Irrigated agriculture. Extensive grazing seldom occur, except on cultivated pasture.

6.3 SUMMARY OF POLICY RECOMMENDATIONS

The institutional and socio-economic constraints are scarcely less significant in determining the types and methods of farming in the NE region than the strong physical settings. The socio-economic background of the region was examined in chapter 1, and issues of policy were discussed individually in the final sections of chapters 4 and 5. While the identification of the institutional constraints affecting agriculture in NE Iraq is possible, farming policies have often lacked both consistency and sound procedures.

The bulk of the agricultural plans drawn up for the NE region have adopted a direct approach, often involving a high measure of government interference. In most cases, such plans have made very great demands on scarce resources, particularly skilled management. The capital-surplus economy of Iraq has not succeeded in drawing up agricultural plans with a sound range of priorities. Government plans have often addressed issues which diminished incentives by the farmer to increase productivity. Price incentives and marketing reforms remain crucial for a successful policy. Of all incentives, agricultural price policies advocating relaxed controls are the most important.

In Iraq, the government holds down the prices of most agricultural products to provide cheap food supplies for urban consumers, often at the expense of the producers. The political instability which characterises the NE region has also compounded policy considerations, and many of the region's rural areas have remained outside government control for decades.

The promise of subsidies on agricultural inputs cannot take the role of greater flexibility in encouraging higher production of agricultural surplus, especially in the subsistence sector where farming traditions have not responded in any significant way to the government's agricultural policies. The central issue to the sizable subsistence sector in the region is survival and self-sufficiency at the village level. The level and quality of inputs remain suppressed by immediate calculations of providing the farmer's family with food. Although often generously subsidised, the application of additional inputs is restricted by the absence of experience and skilled management. With weak links between agricultural scientists, substandard education in the rural areas and inadequate support systems, there is little prospect for immediate change.

One important issue regarding the use of the land resources in

NE Iraq is the distribution of the agricultural acreage. In particular, the acreage of the cereal crops in the region is clearly over-stretched, and more land should be given over to the cultivation of fodder crops. The increasing demand for livestock products, because of the higher income elasticity produced by the oil wealth, has put greater pressures on the region's limited pastures. The cultivation of fodder crops, however, demands new skills and machinery which are not yet available in sufficient quantities. Until greater investment in fodder production is achieved, the region's farmers will continue to resort to cheaper methods of land utilisation under cereal production.

To sum up, in order to reduce the impact of the physical constraints in the region on farming, greater managerial flexibility is crucial: greater investment can be brought about only where such controls as inflexible marketing, politicised land reform and state-controlled cooperative farming are reassessed. Only where better management is encouraged (mainly through relaxing controls over the agricultural enterprise) that incentives are created on the part of the farming community to embark on such improvements as better methods of land preparation and a wider use of marginal lands for pasture and fodder production.

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APPENDIX I :

GAZETTEER OF PLACE-NAMES & LOCATIONS

IMPORTANT NOTE. There are many points to be borne in mind about the names of the different places in the north-east region of Iraq. In general, almost all locations are named differently by different people in the country. Although the names mentioned in the text of the thesis are mostly those used by official agencies in Iraq, the spelling and pronounciation may be found to be different in different texts. Some areas in the region are given Kurdish names by the ethnic Kurds, which can be totally different from those used by Iraqi officials. For instance, the city Erbil is often called Hewler or Hevler by the Kurds. Synonyms have been mentioned below for this purpose. It is also important to note that a human settlement described as a town may not be considered so in the European sense of the word.

Adhaim. Seasonal river situated at the lower part of the foothill zone; joins the river Tigris north of Baghdad.
Synonyms: Adhim, Adhaim.

Amadiyeh. Town; 37-06N/43-28E; alt. 1200.
Synonyms: Amadiya, Amadi, Imadiyah.

Aqra. Town; 36-45N/43-54E; alt. 750m.
Synonyms: Akra, Aqri, Akri.

Atrush. 36-51N/43-20E; small town 30km south east of Dohuk.
Synonyms: Atrish

Baradost. Name of a mountainous district surrounding Rawanduz.
Synonyms: Baradust, Baradoust.

Batufa. Mountainous area NE of Zakho, and name of village approx. 25kms NE Zakho.
Synonyms: Batifa, Batoufa.

Bekma. 36-40N/44-14E; a site of a small dam and town on the river Greater Zab.
Synonyms: Bekhma, Bekme.

Chemchemal. 35-30N/44-50E; alt. 700m; small town approx. 30km north-east of Kirkuk.
Synonyms: Chamchamal, Chamichamal.

Darbandikhan. 35-06N/45-43E; site of a reservoir and small town; approx. 50km south-east of Sulaimaniyeh.
Synonyms: Darband, Darbandichan.

Dohuk. 36-52/43-00E; capital city of Dohuk provnce, approx. 60 north-west of Mosul.
Synonyms: Dohok, Duhok, Dhok, Dahok.

Dokan. Site of a major reservoir and a sall town; approx. 60km north-west of Sulaimaniyeh.
Synonyms: Dukan.

Erbil. 36-11N/44-01E; capital city of the 'autonomous region: Dohuk, Erbil and Sulaimaniyeh' and the province of Erbil.
Synonyms: Arbil, Arbila, Arbela, Hawler, Havler.

Fat-ha. 35-05N/43-35E; the meeting point of Lesser Zab and Tigris.
Synonyms: Fat'ha, Fatha.

Greater Zab. A major tributary in the region; meets Tigris approx. 40km south of Mosul.
Synonyms: Alzab Alkabir, Great Zab.

Halabcha. 35-10N/45-59E; alt. 720m; small town approx. 60 south-east of Sulaimaniyeh.
Synonyms: Helebcha.

Hammam El-Alil. 36-10N/43-16E; small town approx. 20km south-east of Mosul.
Synonyms: Hammam el-Alil, Hammam Al-Alil, Hammam il-Alil.

Jarmo. 35-31N/45-02E; village in the suburbs of Chemchemal.
Synonyms: Jarmu, Jarmou.

Kirkuk. 35-28N/44-24E; alt. 310m; major oil city and capital city of Ta'meem province.
Synonyms: Karkuk.

Lesser Zab. The second majortributary in the region.
Synonyms: Alzab Alsaghir, Little Zab.

Lower Zab = Lesser Zab

Makhmour. 35-46N/43-35E; site of an agricultural project and small town.
Synonyms: Makhmur.

Mosul. 36-20N/43-08E; The largest city in the region and the capital city of Ninevah, Ninevah, Nineva.
Synonyms: Musol, Musul, Musil, Misil.

Penjwin. 35-36N/45-58E; alt. 1300m; border town, approx. 40km north-east of Sulaimaniyeh.
Synonyms: Panjwin, Panjawin.

Qala Diza. 36-11N/45-07E; small town, approx. 20km SE Rania.
Synonyms: Diza, Dizeh, Qala.

Qaradagh. 35-16N/45-23E; name of a mountainous district and a small town, approx. 30km SW Sulaimaniyeh.
Synonyms: Qara Dagh, Garadagh, Dagh.

Rania. 36-15N/44-53E; town, approx. 80 south-east of Erbil.
Synonyms: Ranya, Ranyah.

Rawanduz. 36-37N/44-33E; alt. 900m; 60km north-east of Erbil.
Synonyms: Rawandiz, Rawandoz, Ravanduz.

Rayat. 36-40N/44-58E;alt. over 1300m; name of a small town on Iranian frontier, and mountainous district.
Synonyms: Riat, Rayet.

Salahuddin. 36-17N/44-13E; alt. 1800m; small summer-resort town 30km north-east of Erbil.
Synonyms: Saladdin, Saladin, Salahiddin.

Sefin. 36-20N/44-23E; name of mountainous district east of Erbil.
Synonyms: Safin, Sifin.

Sulaimaniyeh. 35-33N/45-26E; alt. 850m; capital city.
Synonyms: Sulaimania, Sulaminya, Slaimaniyeh.

Sungassar. 36-13N/44-59E; small town.
Synonyms: Sangassar, sagassar.

Upper Zab = Greater Zab

Zab. Literally means river in Arabic, and often made in reference to the areas surrounding the Greater and Lesser Zab.

Zakho. 37-08N/42-40E; alt. 450m; border town (with Turkey). Synonyms: Zakhu.

Zawita. 36-55N/43-15E; small town and tourist attraction, approx. 15km north-east of Dohuk.

APPENDIX II :

MAPS :

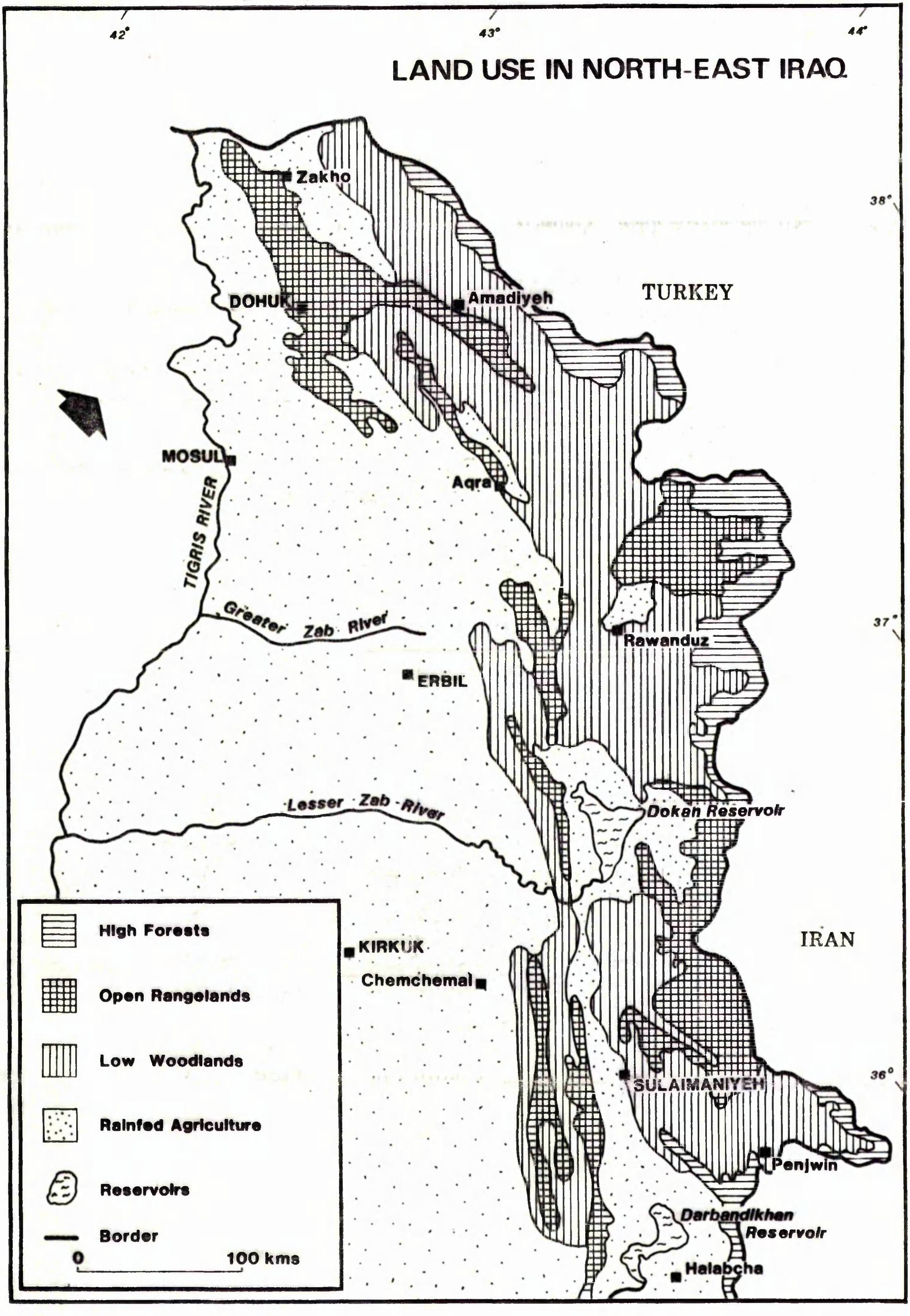
- LAND USE

- PHYSIOGRAPHY

- SOILS

- SUITABILITY FOR RAINFED AGRICULTURE

- SUITABILITY FOR GRAZING



42°
43°
44°
LAND USE IN NORTH-EAST IRAQ
38°
37°
36°
TURKEY
IRAN
Zakho
DOHUK
Amadiyeh
MOSUL
Aqra
TIGRIS RIVER
Greater Zab River
Rawanduz
ERBIL
Lesser Zab River
Dokan Reservoir
KIRKUK
Chemchemal
SULAIMANIYEH
Penjwin
Darbandikhan Reservoir
Halabcha
High Forests
Open Rangelands
Low Woodlands
Rainfed Agriculture
Reservoirs
Border
0
100 kms

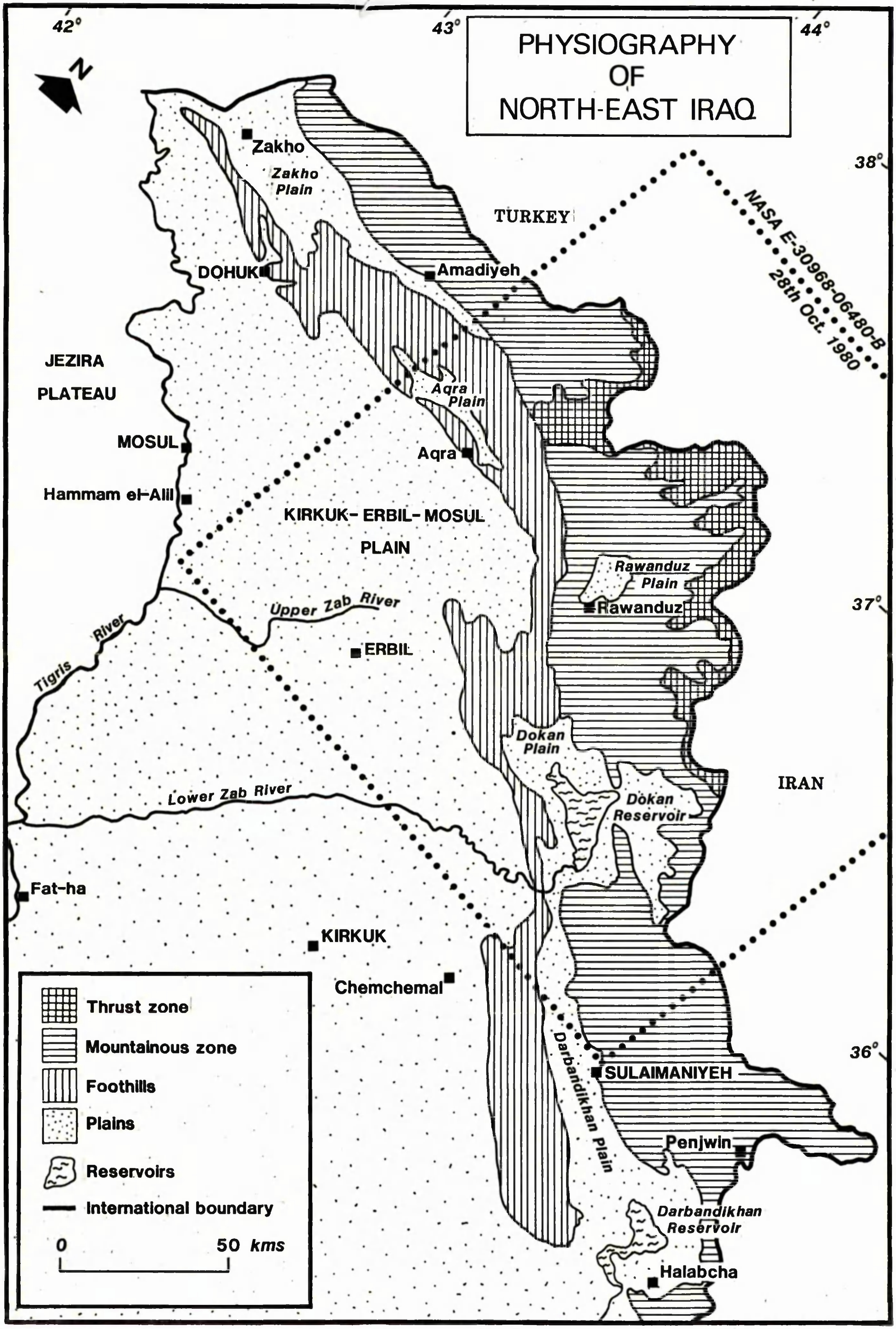
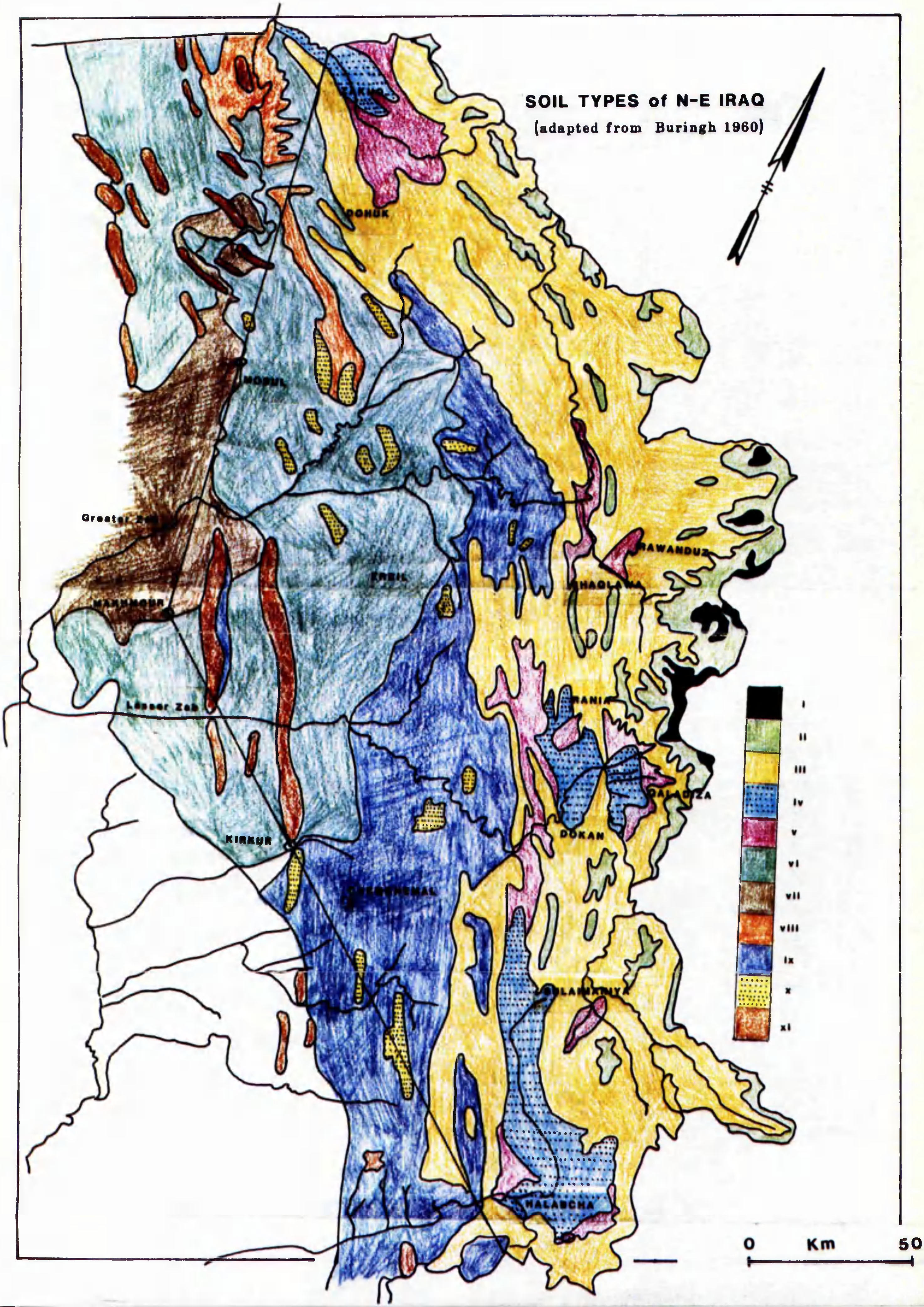

PHYSIOGRAPHY OF NORTH-EAST IRAQ
42°
43°
44°
38°
37°
36°
N
Zakho
Zakho Plain
TURKEY
NASA E-30968-06480-B 28th Oct. 1980
DOHUK
Amadiyeh
JEZIRA PLATEAU
Aqra Plain
MOSUL
Aqra
Hammam el-Alil
KIRKUK- ERBIL- MOSUL PLAIN
Rawanduz Plain
Rawanduz
Upper Zab River
Tigris River
ERBIL
Dokan Plain
IRAN
Dokan Reservoir
Lower Zab River
Fat-ha
KIRKUK
Chemchemal
Darbandikhan Plain
SULAIMANIYEH
Penjwin
Darbandikhan Reservoir
Halabcha
Thrust zone
Mountainous zone
Foothills
Plains
Reservoirs
International boundary
0
50 kms

Plate 1 LANDSAT PICTURE OF THE CENTRAL PART OF THE NE REGION



SOIL TYPES of N-E IRAQ
(adapted from Buringh 1960)
DOHUK
MOSUL
Greater Zab
MAKHMOUR
Lesser Zab
KIRKUK
RAWANDUZ
RANIA
DOKAN
HALABCHA
i
ii
iii
iv
v
vi
vii
viii
ix
x
xi
0
Km
50

DESCRIPTION OF BURINGH'S SOIL MAP

SOIL UNIT (I): ALPINE PHASE ROUGH MOUNTAINS
Major soil groups: Lithosols
Minor soil groups: Podsolic (?)
Land form: very steep
Parent material: Metamorphic rocks, limestone
Soil depth: shallow

SOIL UNIT (II): ROUGH MOUNTAINOUS LAND
Major soil groups: Lithosols
Minor soil groups: Brown and Rendzina soils
Land form: steep to very steep
Parent material: Metamorphic rocks, limestone
Soil depth: shallow

SOIL UNIT (III): ROUGH BROKEN AND STONY LAND
Major soil groups: Lithosols and Rendzina soils
Minor soil groups: Brown and Chestnut soils
Land form: steep, mountainous
Parent material: Limestone
Soil depth: Shallow, small areas deep

SOIL UNIT (IV): CHESTNUT SOILS, DEEP PHASE
Major soil groups: Chestnut soils
Minor soil groups: reddish Chestnut and Chernozem soils
Land form: level
Parent material: Fluviatile and limestone
Soil depth: moderately deep to deep

SOIL UNIT (V): CHESTNUT SOILS, SHALLOW AND SLOPING PHASES
Major soil groups: Chestnut soils
Minor soil groups: reddish Chestnut, Rendzina and Lithosols
Land form: hilly and steep
Parent material: Limestone
Soil depth: Shallow to moderately shallow

SOIL UNIT (VI): BROWN SOILS, DEEP PHASE
Major soil groups: Brown soils
Minor soil groups: Lithosols
Land form: level to undulating
Parent material: old Fluviatile
Soil depth: deep and moderately deep

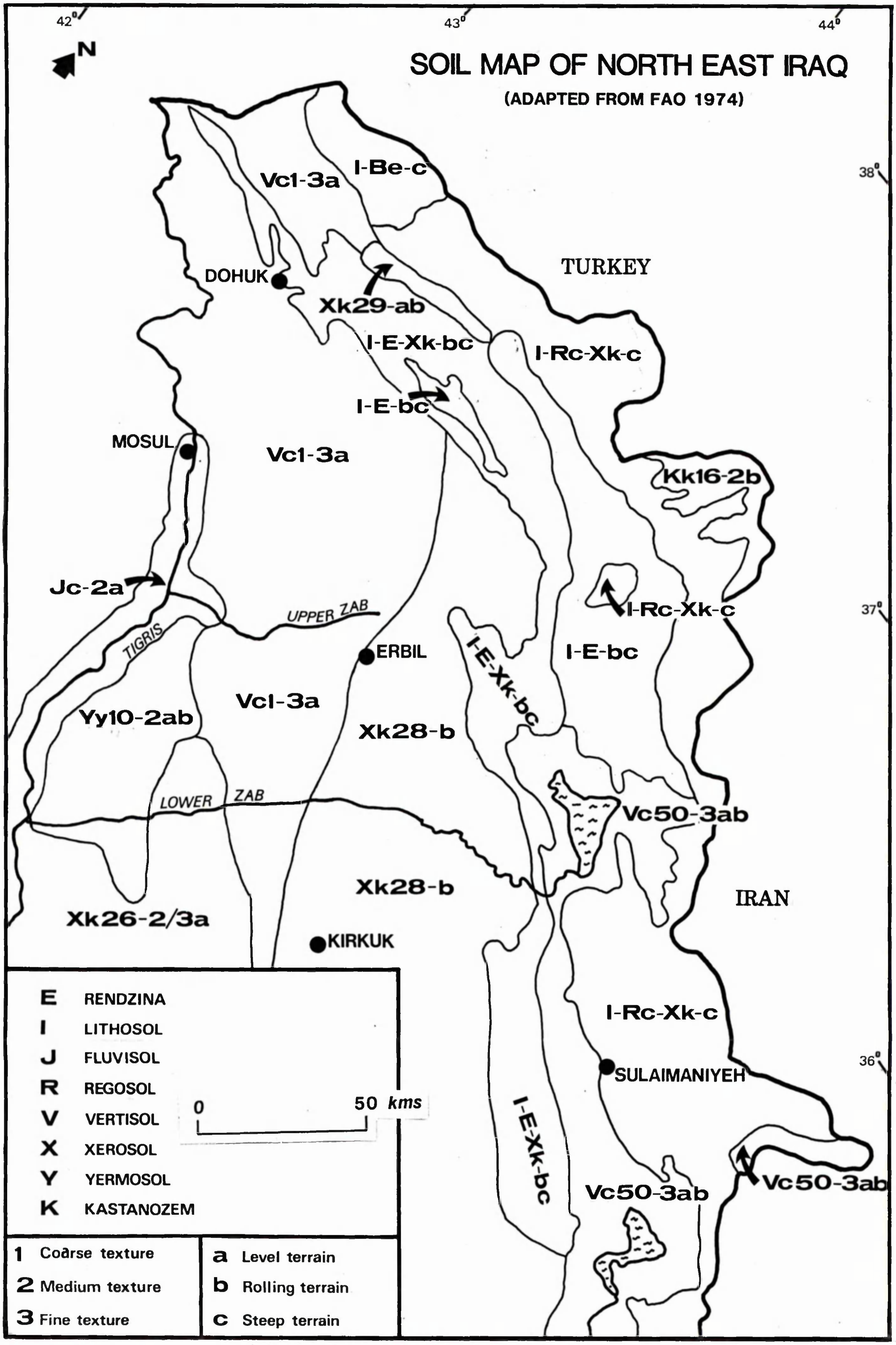
SOIL UNIT (VII): BROWN SOILS, SHALLOW AND MEDIUM PHASE
Major soil groups: Brown soils
Minor soil groups: Lithosols
Land form: hilly and steep
Parent material: gypsum and limestone
Soil depth: shallow to moderately deep

SOIL UNIT (VIII): BROWN SOILS, OVER GYPSUM BEDS
Soil groups: same as above
Land form: undulating and rolling
Parent material: mostly gypsum
Soil depth: shallow and moderately shallow

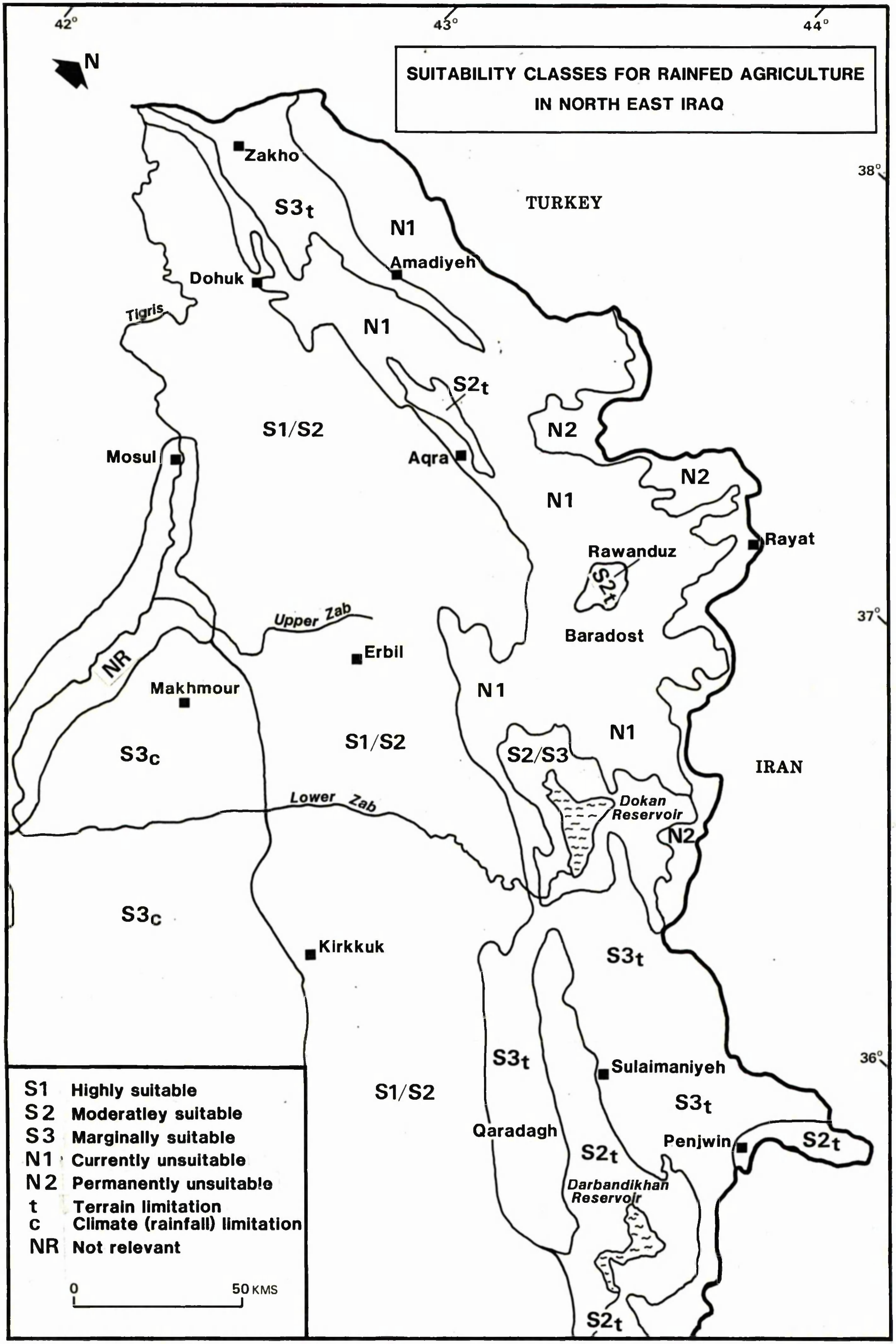
SOIL UNIT (IX): BROWN SOILS OVER BAKHTIARI GRAVEL
Soil groups: same as above
Land form: undulating and rolling
Parent material: limestone and Bakhtiari gravel
Soil depth: shallow and moderately shallow

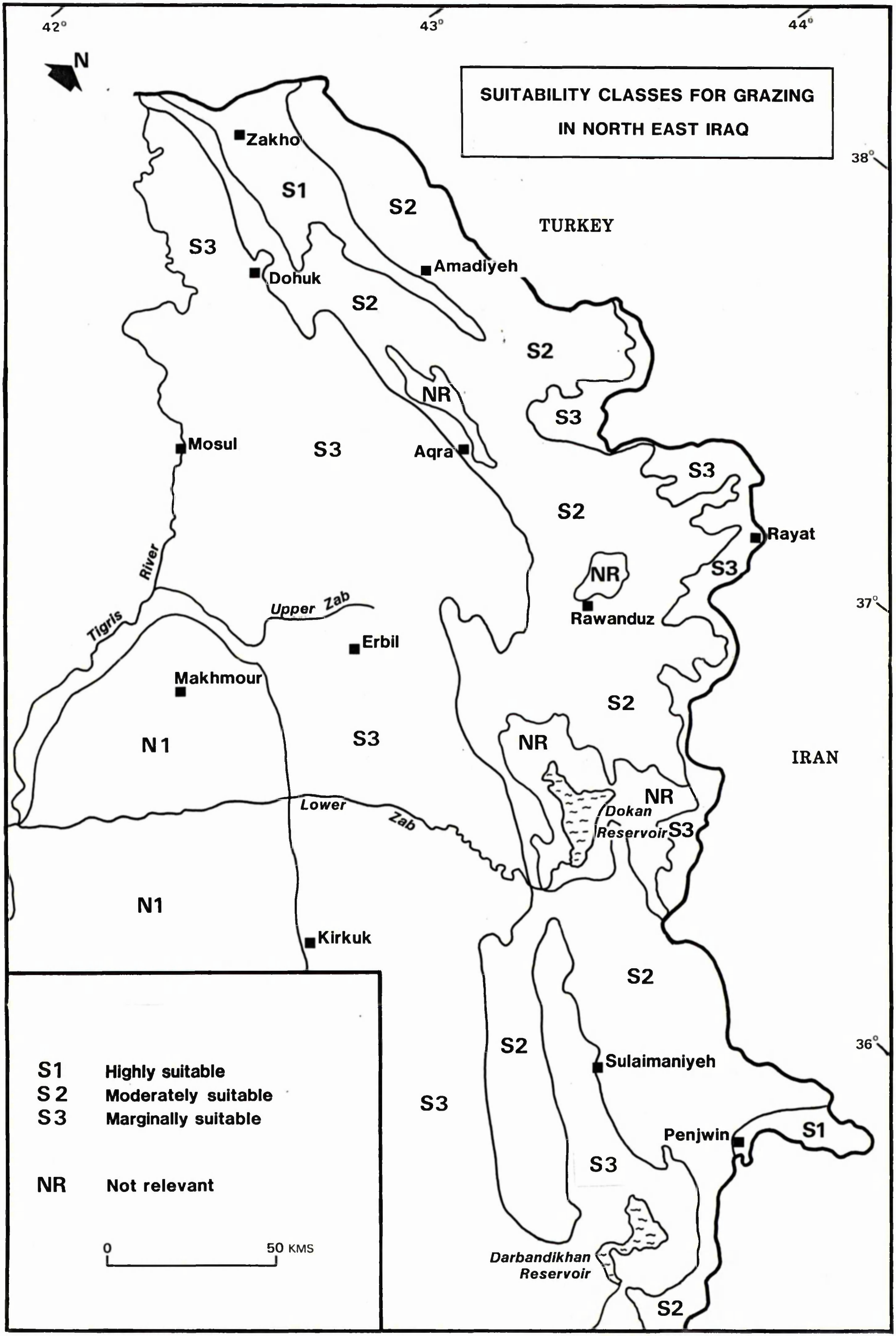
SOIL UNIT (X): LITHOSOLIC SOILS IN LIMESTONE
Major soil groups: Lithosols
Minor soil groups: Brown soils
land form: Hilly and steep
Parent material: Limestone
Soil depth: very shallow

SOIL UNIT (XI): LITHOSOLIC SOILS IN SAND AND GYPSUM
Major soil groups: Lithosols
Minor soil groups: reddish Brown and Brown soils
Land form: hilly and steep
Parent material: sand and mudstone
Soil depth: very shallow



SOIL MAP OF NORTH EAST IRAQ
(ADAPTED FROM FAO 1974)
N
42°
43°
44°
38°
37°
36°
TURKEY
IRAN
DOHUK
MOSUL
ERBIL
KIRKUK
SULAIMANIYEH
UPPER ZAB
LOWER ZAB
TIGRIS
Vc1-3a
I-Be-c
Xk29-ab
I-E-Xk-bc
I-Rc-Xk-c
I-E-bc
Vc1-3a
Kk16-2b
Jc-2a
I-Rc-Xk-c
I-E-bc
I-E-Xk-bc
Vcl-3a
Yy10-2ab
Xk28-b
Vc50-3ab
Xk28-b
Xk26-2/3a
I-Rc-Xk-c
I-E-Xk-bc
Vc50-3ab
Vc50-3ab
0
50 kms
E RENDZINA
I LITHOSOL
J FLUVISOL
R REGOSOL
V VERTISOL
X XEROSOL
Y YERMOSOL
K KASTANOZEM
1 Coarse texture
2 Medium texture
3 Fine texture
a Level terrain
b Rolling terrain
c Steep terrain


SUITABILITY CLASSES FOR RAINFED AGRICULTURE IN NORTH EAST IRAQ
42°
43°
44°
38°
37°
36°
N
TURKEY
IRAN
Zakho
S3t
N1
Amadiyeh
Dohuk
Tigris
N1
S2t
S1/S2
N2
Mosul
Aqra
N2
N1
Rayat
Rawanduz
S2t
Upper Zab
Baradost
Erbil
NR
Makhmour
N1
N1
S3c
S1/S2
S2/S3
Dokan Reservoir
Lower Zab
N2
S3c
Kirkkuk
S3t
S3t
Sulaimaniyeh
S1/S2
S3t
Qaradagh
Penjwin
S2t
S2t
Darbandikhan Reservoir
S2t
S1 Highly suitable
S2 Moderatley suitable
S3 Marginally suitable
N1 Currently unsuitable
N2 Permanently unsuitable
t Terrain limitation
c Climate (rainfall) limitation
NR Not relevant
0
50 KMS



42°
43°
44°
N
SUITABILITY CLASSES FOR GRAZING
IN NORTH EAST IRAQ
38°
37°
36°
TURKEY
IRAN
Zakho
Dohuk
Amadiyeh
Mosul
Aqra
Rayat
Rawanduz
Erbil
Makhmour
Kirkuk
Sulaimaniyeh
Penjwin
Tigris River
Upper Zab
Lower Zab
Dokan Reservoir
Darbandikhan Reservoir
S1
S2
S3
NR
N1
S1 Highly suitable
S2 Moderately suitable
S3 Marginally suitable
NR Not relevant
0
50 KMS

APPENDIX III :

COMPUTER PROGRAM

& COMPUTER RESULTS

APPENDIX III

LAND EVALUATION SYSTEM

```
10  PR# 3: NOTRACE
20  CALL 1002
30  GOTO 2780
40  ONERR  GOTO 2710
50  GOSUB 2700
60  HTAB 35: VTAB 5: PRINT "M E N U"
70  PRINT "     ____________________________________________________________":
      PRINT
80  HTAB 15: PRINT "I.....INITIATE NEW EXPERT FILE"
90  HTAB 15: PRINT "E.....INPUT EXAMPLES"
100  HTAB 15: PRINT "B.....BOOST CURRENT EXPERT"
110  HTAB 15: PRINT "R.....RUN CURRENT EXPERT"
120  HTAB 15: PRINT "D.....DIRECTORY"
130  HTAB 15: PRINT "L.....LOAD FILE"
140  HTAB 15: PRINT "S.....SAVE FILE"
150  HTAB 15: PRINT "P.....PRINT RESULTS"
160  PRINT
170  PRINT "     ____________________________________________________________"

180  SPEED= 255
190  PRINT : PRINT : HTAB 15: PRINT "CHOOSE AN OPTION PLEASE  ";: GET Z$
200  IF O = 1 THEN 290
210  IF Z$ = "I" THEN 370
220  IF Z$ = "R" THEN 1040
230  IF Z$ = "E" THEN 1470
240  IF Z$ = "B" THEN 1670
250  IF Z$ = "L" THEN 1780
260  IF Z$ = "S" THEN 2090
270  IF Z$ = "D" THEN 2360
280  IF Z$ = "P" THEN 2450
290  IF Z$ = "I" THEN 370
300  IF Z$ = "R" THEN 640
310  IF Z$ = "E" OR Z$ = "B" THEN : HOME : HTAB 25: VTAB 10: PRINT "N O T
       N E C E S S A R Y": HTAB 20: VTAB 13: PRINT "PRESS ANY KEY TO RETUR
     N TO MENU   ";: GET E$: GOTO 50
320  IF Z$ = "L" THEN 1780
330  IF Z$ = "S" THEN 2090
340  IF Z$ = "D" THEN 2360
350  IF Z$ = "P" THEN 2450
360  GOTO 50
370  HOME : HTAB 30: VTAB 10: PRINT "ARE YOU SURE ? (Y/N) ";: GET W$: IF W
     $ <  > "Y" THEN 50
380  CLEAR
390  GOSUB 2700: INPUT "HOW MANY VARIABLES HAVE YOU ? ";V
400  DIM M(2,V),VC(V),RV(V),V(V),V$(V)
410  PRINT : PRINT : PRINT "PLEASE NAME THESE VARIABLES:": PRINT
420  FOR I = 1 TO V
430  PRINT "NAME VARIABLE ";I;: INPUT "          ";V$(I): PRINT : PRINT
440  INPUT "ENTER ITS MINIMUM VALUE: ";M(1,I): INPUT "ENTER ITS MAXIMUM VA
     LUE: ";M(2,I)
450  PRINT : PRINT
460  NEXT : GOSUB 2700
470  PRINT : INPUT "HOW MANY OUTCOMES HAVE YOU ? ";Q: DIM D(Q),QC(Q),R(V,Q
     ),Q$(Q)
480  PRINT : PRINT : PRINT "PLEASE NAME THESE OUCOMES:": PRINT
490  FOR I = 1 TO Q
500  PRINT " NAME OUTCOME ";I;: INPUT "          ";Q$(I)
510  PRINT
520  NEXT
530  GOSUB 2700: HTAB 15: VTAB 15: PRINT "DO YOUR DATA CONSIST OF PERIODS
     ?  (Y/N)   ";: GET L$
540  IF L$ <  > "Y" THEN 1010
550 O = 1: REM : PERIODS-WORK LABEL CODE
560  DIM B(2,Q,V)
570  GOSUB 2700: PRINT : PRINT : PRINT
580  FOR I = 1 TO V
590  PRINT "For variable  ";V$(I);" :"
```

```
600  FOR J = 1 TO Q: PRINT "                              Input beginning of peri
     od   ";Q$(J);: INPUT "   ";B(1,J,I): INPUT "                              In
     put end of period   ";B(2,J,I): NEXT
610  PRINT : PRINT
620  NEXT I
630  GOTO 1010
640  GOSUB 2700: PRINT : PRINT
650  PRINT : INPUT "HOW MANY CASES DO YOU WISH TO EXAMINE:  ";U: PRINT : PRINT

660  IF U > 0 THEN 680
670  DIM W(V,U),T(U)
680  FOR H = 1 TO U: PRINT "NAME CASE No.  (";H;")";: INPUT ":   ";U$(H): NEXT

690  FOR H = 1 TO U
700  PRINT : PRINT : PRINT "CASE:   ";U$(H): PRINT
710  FOR I = 1 TO V
720  PRINT : PRINT "What is the value of variable  ";V$(I);" ";: INPUT W(I
     ,H)
730  IF W(I,H) > M(2,I) OR W(I,H) < M(1,I) THEN : GOSUB 2720: GOTO 690
740  NEXT I
750  NEXT H
760  PRINT : PRINT
770  FOR H = 1 TO U:T(H) = 0: NEXT
780  FOR H = 1 TO U
790  FOR I = 1 TO V
800  FOR J = 1 TO Q
810  IF W(I,H) >  = B(1,J,I) AND W(I,H) <  = B(2,J,I) THEN :T(H) = T(H) +
     J
820  NEXT J
830  NEXT I
840  NEXT H
850  FOR H = 1 TO U:T(H) = T(H) / V: NEXT
860  GOSUB 2700: PRINT : PRINT
870  FOR H = 1 TO U
880  PRINT "CASE:   ";U$(H): PRINT
890  FOR J = 1 TO Q
900  IF J <  > T(H) THEN : PRINT "THE OUTCOME CANNOT BE:   ";Q$(J)
910  NEXT J
920  PRINT : PRINT
930  IF T(H) >  INT (T(H)) THEN : PRINT "THE OUTCOME SHOULD BE:   ";Q$( INT
     (T(H)));"/";Q$( INT (T(H) + 1))
940  IF T(H) =  INT (T(H)) THEN : PRINT "THE OUTCOME SHOULD BE:   ";Q$(T(H
     ))
950  IF H = U THEN 990
960  PRINT : PRINT
970  PRINT : PRINT "PRESS ANY KEY TO CONTINUE   ";: GET A$: PRINT : PRINT
     : PRINT
980  NEXT H
990  PRINT : PRINT
1000  PRINT "PRESS ANY KEY TO GO TO MENU   ";: GET J$: GOTO 50
1010  GOSUB 2700
1020  PRINT "VARIABLE";: HTAB 15: PRINT "MIN. VALUE";: HTAB 30: PRINT "MAX
     . VALUE": PRINT : FOR I = 1 TO V: PRINT V$(I);: HTAB 20: PRINT M(1,I)
     ;: HTAB 35: PRINT M(2,I): NEXT
1030  PRINT : PRINT "INITIALISING COMPLETED...PRESS ANY KEY TO RETURN TO M
     ENU   ";: GET C$: GOTO 50
1040  GOSUB 2700: HTAB 35: VTAB 5: PRINT "EXPERT READY": PRINT : PRINT "TO
      OBTAIN EXPERT DECISION, FEED VALUE OF THE FOLLOWING VARIABLES:"
1050  FOR I = 1 TO V:VC(I) = 1:V(I) = 0: NEXT : FOR J = 1 TO Q:D(J) = 0:PD
     (J) = 0:QC(J) = 1: NEXT
1060 RV = 0:VV = 1: FOR I = 1 TO V:RV(I) = 0: FOR J = 1 TO Q:RV(I) = RV(I)
      +  ABS (M(1,I) - M(2,I)) *  ABS (R(I,J)) * VC(I) * QC(J): NEXT : IF
     RV(I) > RV THEN :VV = I:RV = RV(I)
1070  NEXT
1080  PRINT : PRINT
1090  PRINT "WHAT IS THE VALUE OF THE VARIABLE:     ";V$(VV);: INPUT "
              ";V(VV)
```

```
1100  IF V(VV) > M(2,VV) OR V(VV) < M(1,VV) THEN : GOSUB 2720: GOTO 1090
1110  PRINT
1120 VC(VV) = 0
1130  FOR J = 1 TO Q
1140 D(J) = D(J) + V(VV) * R(VV,J)
1150  NEXT
1160 D = D(1)
1170  FOR J = 1 TO Q
1180  IF D(J) >  = D THEN :D = D(J):HJ = J
1190 PD(J) = D(J)
1200  NEXT J
1210  FOR J = 1 TO Q
1220  FOR I = 1 TO V
1230  IF VC(I) = 1 THEN : IF R(I,J) > R(I,HJ) THEN :PD(J) = PD(J) + (R(I,J
     ) - R(I,HJ)) * M(2,I)
1240  IF VC(I) = 1 THEN : IF R(I,J) < R(I,HJ) THEN :PD(J) = PD(J) + (R(I,J
     ) - R(I,HJ)) * M(1,I)
1250  NEXT I
1260  NEXT J
1270 H2 = PD(HJ):HI = HJ: FOR J = 1 TO Q
1280  IF PD(J) > H2 THEN :H2 = PD(J):HI = J
1290  IF PD(J) < PD(HJ) THEN :QC(J) = 0: PRINT "It cannot be:       ";Q$(J
     )
1300  NEXT
1310  IF PD(HI) <  > PD(HJ) THEN : GOTO 1060
1320  PRINT : PRINT "PRESS ANY KEY TO OBTAIN OUTCOME   ";: GET G$
1330  GOSUB 2700: PRINT : PRINT
1340  PRINT : PRINT "THE OUTCOME SHOULD BE ( ";Q$(HI);" )": PRINT
1350  PRINT : PRINT "IS THE OUTCOME REASONABLE IN YOUR OPINION?": PRINT "I
     F YOU HAVE THE SLIGHTEST DOUBT, ANSWER NO (N IS SUFFICIENT)"
1360  PRINT : PRINT "ENTER YES OR NO (Y/N)   ";: GET T$: IF T$ <  > "N" THEN
     50
1370  GOSUB 2700
1380  PRINT : PRINT "SORRY !": PRINT "I WILL NEED EXAMPLES"
1390  PRINT : PRINT : PRINT
1400  FOR J = 1 TO Q: PRINT J;".  ";Q$(J): NEXT : PRINT : PRINT : INPUT "W
     HICH OUTCOME IS IT   ";P
1410  FOR I = 1 TO V: PRINT : PRINT "WHAT WAS THE VALUE OF VARIABLE      (
     ";V$(I);")     ";: INPUT V(I)
1420  NEXT
1430  FOR J = 1 TO Q: IF D(J) >  = D(P) AND J <  > P THEN : FOR I = 1 TO V
     :R(I,J) = R(I,J) - V(I): NEXT
1440  NEXT
1450  FOR I = 1 TO V:R(I,P) = R(I,P) + V(I): NEXT
1460  PRINT : PRINT : PRINT "PRESS ANY KEY TO RETURN TO MENU  ";: GET X$: GOTO
     50
1470  HOME : HTAB 30: VTAB 15: PRINT "ARE YOU SURE ?  (Y/N)   ";: GET E$: IF
     E$ <  > "Y" THEN 50
1480  IF N > 0 THEN 1510
1490  IF V >  = Q THEN : DIM E(V + 1,V + 50)
1500  IF V < Q THEN : DIM E(Q,Q + 50)
1510  GOSUB 2700
1520  INPUT "HOW MANY EXAMPLES DO YOU WANT TO INPUT   ";N
1530  PRINT : PRINT
1540  FOR K = 1 TO N
1550  PRINT "EAMPLE NO.  ";K
1560  PRINT : PRINT
1570  FOR I = 1 TO V
1580  PRINT "VARIABLE (";V$(I);")  ";
1590  INPUT E(I,K)
1600  IF E(I,K) > M(2,I) OR E(I,K) < M(1,I) THEN : GOSUB 2720: GOTO 1570
1610  NEXT I
1620  PRINT : PRINT : FOR J = 1 TO Q: PRINT J;" . ";Q$(J): NEXT
1630  PRINT : INPUT "ENTER NUMBER OF THE OUTCOME ON THE LIST  ";E(V + 1,K)
```

```
1640  IF E(V + 1,K) > Q OR E(V + 1,K) < 1 THEN : GOSUB 2720: GOTO 1620
1650  PRINT : PRINT
1660  NEXT K
1670  GOSUB 2700: HTAB 20: VTAB 15: PRINT "PLEASE WAIT ... EXPERT IS EXERC
     ISING  DATA"
1680 F = N * 30
1690  FOR R = 1 TO F
1700 K =  INT ( RND (1) * N + 1)
1710  FOR J = 1 TO Q
1720  FOR I = 1 TO V
1730  IF J = E(V + 1,K) THEN :R(I,J) = R(I,J) + E(I,K)
1740  IF J <  > E(V + 1,K) THEN :R(I,J) = R(I,J) - E(I,K)
1750  VTAB 20: HTAB 30: PRINT "% exercised:   ";: INVERSE : PRINT  INT (R /
     F * 100): NORMAL
1760  NEXT : NEXT : NEXT
1770  GOTO 50
1780  HOME : HTAB 20: VTAB 15: PRINT "ARE YOU SURE YOU WANT TO LOAD ?   (Y
     /N)  ";: GET F$: IF F$ <  > "Y" THEN 50
1790  CLEAR
1800  GOSUB 2700: VTAB 15: INPUT "NAME FILE YOU WANT TO LOAD: ";M$
1810 D$ =  CHR$ (4)
1820  PRINT D$;"OPEN";M$
1830  PRINT D$;"READ";M$
1840  INPUT V
1850  INPUT Q
1860  INPUT O
1870  FOR I = 1 TO V
1880  INPUT V$(I): INPUT M(1,I): INPUT M(2,I)
1890  NEXT I
1900  FOR J = 1 TO Q
1910  INPUT Q$(J)
1920  NEXT J
1930  IF O = 1 THEN 1990
1940  FOR J = 1 TO Q
1950  FOR I = 1 TO V
1960  INPUT R(I,J)
1970  NEXT : NEXT
1980  IF O = 0 THEN 2020
1990  FOR I = 1 TO V
2000  FOR J = 1 TO Q: INPUT B(1,J,I): INPUT B(2,J,I): NEXT
2010  NEXT I
2020  PRINT D$;"CLOSE";M$
2030  GOSUB 2700
2040  HTAB 30: PRINT "CONTENTS OF FILE  (";M$;")": PRINT : PRINT
2050  PRINT "VRIABLE";: HTAB 15: PRINT "MIN. VALUE";: HTAB 30: PRINT "MAX.
      VALUE": PRINT : FOR I = 1 TO V: PRINT V$(I);: HTAB 20: PRINT M(1,I);
     : HTAB 35: PRINT M(2,I): NEXT
2060  PRINT : PRINT
2070  PRINT "LOADING COMPLETED - PRESS ANY KEY TO  MENU  ";: GET H$
2080  GOTO 50
2090  HOME : HTAB 20: VTAB 15: PRINT "ARE YOU SURE YOU WANT TO SAVE ?  (Y/
     N)  ";: GET R$: IF R$ <  > "Y" THEN 50
2100  GOSUB 2700: VTAB 15: INPUT "INPUT NAME OF FILE FOR SAVING:   ";N$
2110 D$ =  CHR$ (4)
2120  PRINT D$;"OPEN";N$
2130  PRINT D$;"WRITE";N$
2140  PRINT V
2150  PRINT Q
2160  PRINT O
2170  FOR I = 1 TO V
2180  PRINT V$(I): PRINT M(1,I): PRINT M(2,I)
2190  NEXT I
2200  FOR J = 1 TO Q
2210  PRINT Q$(J)
2220  NEXT J
2230  IF O = 1 THEN 2290
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2240  FOR J = 1 TO Q
2250  FOR I = 1 TO V
2260  PRINT R(I,J)
2270  NEXT : NEXT
2280  IF O = 0 THEN 2320
2290  FOR I = 1 TO V
2300  FOR J = 1 TO Q: PRINT B(1,J,I): PRINT B(2,J,I): NEXT
2310  NEXT I
2320  PRINT D$;"CLOSE";N$
2330  PRINT : PRINT
2340  PRINT "SAVING COMPLETED - PRESS ANY KEY TO MENU   ";: GET B$
2350  GOTO 50
2360  GOSUB 2700
2370  HTAB 30: PRINT "D I R E C T O R Y": PRINT : PRINT
2380  PRINT  CHR$ (4);"CATALOG": PRINT : PRINT
2390  PRINT "USEFUL INFORMATION:": PRINT
2400  PRINT "1. File names are preceded by T. (WARNIING!: do NOT tamper wi
     th any file": PRINT "   not preceded by T.  The system will be destro
     yed if you do that)"
2410  PRINT "2. Use the commands: LOCK, UNLOCK, DELETE (as appropriate) to
      amend files."
2420  PRINT "3. When finished, type  GOTO 50  to go to menu."
2430  PRINT : PRINT
2440  END
2450  HOME : HTAB 30: VTAB 15: PRINT "ARE YOU SURE ? (Y/N)";: GET P$: IF P
     $ <  > "Y" THEN 50
2460  PR# 1
2470  PRINT  CHR$ (9)"80N"
2480  PRINT "THE CURRENT VARIABLES ARRAY IS:": PRINT : PRINT
2490  PRINT "VARIABLE";: HTAB 15: PRINT "MIN. VALUE";: HTAB 30: PRINT "MAX
     . VALUE": PRINT : FOR I = 1 TO V: PRINT V$(I);: HTAB 20: PRINT M(1,I)
     ;: HTAB 35: PRINT M(2,I): NEXT : PRINT : PRINT
2500  IF O = 1 THEN 2570
2510  FOR J = 1 TO Q
2520  IF PD(J) < PD(HJ) THEN : PRINT "THE OUTCOME CANNOT BE:   ";Q$(J)
2530  NEXT
2540  PRINT : PRINT
2550  PRINT : PRINT "THE SUITABLE OUTCOME IS:  ";Q$(HI)
2560  IF O = 0 THEN 2670
2570  FOR H = 1 TO U
2580  PRINT "CASE:   ";U$(H): PRINT
2590  FOR J = 1 TO Q
2600  IF J <  > T(H) THEN : PRINT "THE OUTCOME CANNOT BE:   ";Q$(J)
2610  NEXT J
2620  PRINT : PRINT
2630  IF T(H) >  INT (T(H)) THEN : PRINT "THE OUTCOME SHOULD BE:   ";Q$( INT
     (T(H)));"/";Q$( INT (T(H) + 1))
2640  IF T(H) =  INT (T(H)) THEN : PRINT "THE OUTCOME SHOULD BE:   ";Q$(T(
     H))
2650  PRINT : PRINT
2660  NEXT H
2670  PR# 3
2680  CALL 1002
2690  GOTO 2760
2700  HOME : HTAB 29: INVERSE : PRINT " LAND EXPERT SYSTEM ": NORMAL : PRINT
     : PRINT : RETURN
2710  HOME : VTAB 10: HTAB 10: PRINT "YOU MADE A WRONG ENTRY...PLEASE STAR
     T AGAIN   ";: GET F$: GOTO 50
2720  HOME : HTAB 20: PRINT "YOUR ENTRY IS OUT OF RANGE": PRINT : PRINT : PRINT
     "THE CURRENT RANGE ARRAY IS:": PRINT : PRINT
2730  PRINT "VARIABLE";: HTAB 15: PRINT "MIN. VALUE";: HTAB 30: PRINT "MAX
     . VALUE": PRINT : FOR I = 1 TO V: PRINT V$(I);: HTAB 20: PRINT M(1,I)
     ;: HTAB 35: PRINT M(2,I): NEXT
2740  PRINT : PRINT : PRINT "PRESS ANY KEY TO START AGAIN   ";: GET R$: HOME

2750  RETURN
2760  PRINT : PRINT : PRINT : PRINT : PRINT
2770  PRINT "          PRINTING IS OVER...PRESS ANY KEY TO GO TO MENU   ";
     : GET M$: GOTO 50
```

```
2780  HOME : PRINT : PRINT
2790  SPEED= 150
2800  PRINT "                              LAND EXPERT SYSTEM"
2810  PRINT : PRINT
2820  PRINT "                          Copyright (c) Munir Nasser"
2830  PRINT "                               September, 1985"
2840  PRINT : PRINT : PRINT : PRINT : PRINT
2850  PRINT "                        PRESS ANY KEY TO START THE SYSTEM   ";: GET
     C$: GOTO 40
```

COMPUTER RESULTS OF WHEAT YIELD REGRESSION MODEL

OBS.:	ARIDITY (X):	YIELD (Y):	IP (Z):
1	8.8	1043	63
2	8.4	995	59
3	4.6	536	13
4	6.3	741	33
5	5.1	597	19
6	8	946	54
7	5.4	633	22
8	6.7	790	38
9	4.2	488	8
10	4.2	488	8
11	5.9	693	28
12	7.7	910	50
13	8	946	54
14	6.3	741	33
15	8.4	995	59
16	6.7	790	38
17	6.8	802	39
18	6.6	778	37
19	5.6	657	25
20	5.9	693	28
21	6.2	729	32
22	7.7	910	50
23	5.5	645	24
24	6.8	802	39
25	8.1	958	55
26	7	826	42
27	7.6	898	49
28	4.3	500	9
29	7.4	874	47
30	7.9	934	53
31	8.5	1007	60
32	6.8	802	39
33	5.1	597	19
34	4.9	573	16
35	4.5	524	12
36	5.9	693	28
37	8.8	1043	63
38	4.2	488	8
39	8.7	1031	62
40	7.7	910	50
41	4.3	500	9
42	5.3	621	21
43	8.8	1043	63
44	6.3	741	33
45	5.2	609	20
46	8.5	1007	60
47	7.9	934	53
48	7.9	934	53
49	7.6	898	49
50	7.1	838	43
51	6.2	729	32
52	7.5	886	48

Coefficient B1 = 1.7
Coefficient B2 = 0.1
Calculation origin (A) = 767

REGRESSION EQUATION: Y = 767 + 1.7 X + 0.1 Z

Multiple correlation coefficient:
Rx yz = 0.99999832
Ry xz = 0.99999827
Rz xy = 0.999825526